



PLANT SCIENCE



Textbook

Kalenska S. M., Novytska N. V., Bachynskyi O. V., Kovalenko R. V.

PLANT SCIENCE

Textbook

**The textbook is designed for bachelor's degree
applicants in specialty 201 "Agronomy"**

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The textbook covers the morphological and biological characteristics of field and fodder crops. It describes intensive cultivation techniques for major agricultural crops, as well as techniques for growing root and tuber crops, melons, oilseeds and essential oils, fiber crops, narcotic and intermediate crops, and hops. It examines issues related to seed preparation for sowing, crop care, harvesting, and the basics of seed science. Attention is paid to the role of soil ecological factors in alternative crop production, issues of biotechnology, agrotechnical and biological methods of weed control, the importance of crop rotation, soil cultivation, and fertilization in regulating the agroecological conditions of field crop vegetation. Environmentally friendly, energy-saving technologies for growing major grain and industrial crops are considered.

For training specialists in agricultural of accreditation for bachelor's degrees in the specialty 201 “Agronomy”

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INTRODUCTION

Agriculture is developing in one way or another in almost all countries. The largest producers of agricultural products are the countries with the largest size and number of consumers, such as the United States, Canada, Brazil, China, and India. However, in developing countries, domestic consumption of products prevails, while economically developed countries are the largest exporters of agricultural goods. At the same time, economically developed countries are the largest importers of agricultural products, as they have an extremely large consumer market.

Plant science is the science of cultivated plants and their cultivation. Plant science studies various types, varieties, and breeds of field crops and the most rational methods of their cultivation. From a production point of view, Plant science is the study of technically perfect and economically profitable cultivation of high yields of agricultural crops of the best quality. Scientific crop production is based on the principles of modern biological science, which studies the characteristics of plant growth and development and their requirements for environmental conditions. Based on the study of the biological characteristics of plants, measures and methods are developed to optimize environmental factors for maximum realization of the productivity potential of agricultural crops.

The yield of agricultural crops depends on the physical and chemical characteristics of the soil, its fertility, cultivation methods, the use of appropriate types and doses of fertilizers, bacterial preparations, plant protection products, agricultural machinery and mechanisms, etc. Therefore, crop production is based on such basic sciences as soil science, microbiology, plant physiology, agriculture, agrochemistry, botany, phytopathology, entomology, mechanization of crop production processes, selection, land reclamation, etc. In turn, crop production is fundamental to such sciences as economics and the organization of agricultural production.

The transition to new forms of land use and economic management methods creates real opportunities for improving crop production efficiency in the coming years. This will be facilitated by improvements in material and technical support and the introduction of intensive technologies for growing high-yield varieties and hybrids of agricultural crops.

The main tasks of the crop production sector at the present stage are: production of high-quality, environmentally friendly products with minimum energy and labor costs and maximum yield per unit of time per unit of area, which requires the widespread introduction of varietal, intensive, energy- and resource-saving, environmentally sound technologies; timely and effective replacement of field crop varieties and their rational placement in crop rotation, aimed at improving growing conditions; combining intensive crop production with a set of agrotechnical, agrochemical, and land reclamation measures to preserve and restore soil fertility and crop production based on modern, sophisticated, and highly productive agricultural machinery and its highly efficient operation; combating crop losses during cultivation, harvesting, and transportation, highly efficient use of fertilizers, plant protection products, irrigation water, erosion control measures, etc.; high professional qualifications of employees in the agro-industrial complex and a clear system of

organizational, economic, and operational measures, as well as operational information for the timely and high-quality performance of a range of agricultural work, prevention of the occurrence and elimination of negative situations in the process of crop production.

The educational material develops the student's:

- ability to solve complex specialized tasks and practical problems in agronomy, which involve the application of theories and methods of the relevant science and are characterized by complexity and uncertainty of conditions.
- knowledge and understanding of the subject area and professional activities.
- ability to apply knowledge in practical situations.
- ability to apply fundamental knowledge of key areas of agricultural science, including crop production, farming systems, plant breeding and seed production, agrochemistry, fruit growing, vegetable production, soil science, forage production, mechanization in crop production, and plant protection.
- knowledge and understanding of core biological and agrotechnological concepts, principles, and theories related to the cultivation of agricultural and other plant species.
- ability to apply knowledge and understanding of physiological processes in agricultural crops to solve production-related technological problems.
- ability to manage complex activities or projects, assuming responsibility for decisionmaking under specific production conditions.

Students with skills compare and evaluate current scientific and technological achievements in the field of agronomy. Demonstrate knowledge and understanding of fundamental disciplines to the extent necessary for acquiring practical skills in agronomy. Demonstrate knowledge and understanding of the principles of plant physiological processes at a level sufficient for mastering fundamental and professional disciplines. Possess operational-level skills in observation, description, identification, classification, as well as cultivation of biological objects and maintenance of agroecosystem stability while preserving natural biodiversity.

Besides, analyze and integrate knowledge from general and specialized professional training to the extent necessary for specialized professional work in agronomy. Initiate timely and appropriate solutions to production problems in accordance with local agroecological conditions. Design and organize crop production measures to ensure high-quality agricultural products in compliance with current standards. Integrate and improve production processes for crop cultivation in accordance with current regulations and best practices. Plan economically efficient agricultural production. Organize effective and safe working conditions.

Personal contribution of co-authors in writing the textbook: **Kalenska S. M.** – Section 1. Fundamentals of crop production and yield programming (1.1-1.3, 1.6); **Novytska N. V.** – Section 1. Fundamentals of crop production and yield programming (1.6), Section 2. Cereal crops (2.1-2.5), Section 3. Industrial crops (3.1); **Bachynskyu O. V.** – Section 1. Fundamentals of crop production and yield programming (1.4), Section 2. Cereal crops (2.6), Section 3. Industrial crops (3.2-3.7); **Kovalenko R. V.** – Section 1. Fundamentals of crop production and yield programming (1.5).

1. FUNDAMENTALS OF CROP PRODUCTION AND YIELD PROGRAMMING

1.1 Crop production as a branch of agricultural production

There is no doubt that the level of productivity of an agricultural plant is generally determined by the level of its supply of resources of the main factors. It is known that such factors, the resources of which may be limiting in certain cases, are moisture, heat and the level of mineral nutrients. At the same time, moisture and heat are extremely dynamic natural factors, and the problem is to determine both the probability of optimal conditions for the plant and the actual conditions that most often occur. In this case, it may involve assessing both the growing season as a whole and individual periods. Thus, the yield determined by the resources of natural factors can be considered resource yield. At the same time, under conditions of natural moisture, weather conditions and, consequently, yields are predictable.

The level of supply of basic nutrients to agricultural plants is a complex factor. Its complexity is explained by the fact that it is characterised by the natural fertility of soils and the system of fertiliser application. It is clear that the yield for which the required amount of fertiliser is calculated can be considered programmable, but it cannot exceed its resource value. At the same time, the establishment of fertiliser rates for a particular plant is determined by both economic feasibility and the need to maintain or improve the quality of the soil itself.

The main indicators of economic efficiency are profit (pro forma or estimated) and profitability. Since market conditions imply that all manufactured products are sold, the notional or estimated profit is a purely market and technological basis and represents the difference between the cost of all products and technological costs. The level of profitability is generally defined as the percentage ratio of this profit to technological costs. This definition is possible both when assessing the entire technological process of growing a plant and when assessing its part - the use of fertilisers. There is no doubt that the established norms of fertilisers that ensure the best economic performance depend on the ratio of prices for fertilisers and the products obtained. This statement is more relevant in today's environment, when prices for mineral fertilisers are constantly rising and the price of products is not fully predictable.

With regard to maintaining or improving soil fertility, the problem is primarily to ensure that after each plant (crop rotation or crop rotation in general) is grown, the condition of no deficiency of both basic nutrients and humus is ensured.

All of the above shows that the essence of a comprehensive justification of the yield level should generally be carried out at three levels or stages.

1. They establish the hydrothermal conditions (moisture and heat supply) that are most common in a given area and determine the resource yields of agricultural plants.
2. Determine the required rate of fertiliser to achieve a yield level that does not exceed the resource yield, while establishing the necessary price ratio for fertiliser and products.

Calculate the deficit of basic nutrients (N, P, K) and humus in the soil, with the establishment of possible compensation rates for individual elements.

The above calculation scheme is very generalised and, depending on the specific conditions and limitations, can be significantly supplemented or clarified by other definitions. Some of the possible conditions and methodological approaches that are currently relevant and can be used in making such determinations are presented in this paper.

There is no doubt that, all other things being equal, the yield of an agricultural plant is determined by the technology of its cultivation and the natural conditions of each zone and even field. The purpose of this paper is not to evaluate a particular agricultural technique for growing a particular plant or its individual elements, but rather to identify current trends in its improvement. In general, it can be argued that at the current stage of development, we are talking about minimising technological costs, on the one hand, and increasing yields, on the other. Natural conditions that have a significant impact on plant yields are undoubtedly weather conditions in a particular growing season and natural soil fertility. Therefore, one of the essential measures for the formation of high and sustainable crop yields is to provide enterprises with operational forecasts of growth and development conditions and crop yields, and to develop scientifically based measures for their application in connection with emerging weather conditions.

1.2 Ecological and biological foundations of crop production.

Ecological and biological foundations support of agriculture is carried out according to a programme that defines the types, forms, regularity, frequency of agrometeorological information, the list of consumers, etc. Agrometeorological support is the regular provision of comprehensive information to the agricultural sector on the most complete and rational use of weather, agrometeorological and agroclimatic conditions in order to

- obtaining high and sustainable yields of agricultural plants; - minimising crop losses from adverse conditions, as well as during harvesting, transport and storage. To achieve these goals, it is necessary to carry out:

- Assessment of agrometeorological conditions (actual and expected), taking into account the specialisation of agricultural production (agriculture);

- agro-climatic justification of the structure of agricultural production;

- agro-climatic justification of farming systems;

- selection of the most productive varieties; - scientific justification of the structure of sown areas;

- a rational soil cultivation system;

- efficient use of mineral and organic fertilisers; - measures to control pests and diseases of plants and animals; - determination of compliance of agricultural plants and animals with the climatic conditions of the area;

- justification for the rational use of climate resources;

- differentiated application of reclamation and agronomic measures;

- warnings of adverse weather events for agriculture.

The primary task of agrometeorological support is to establish the degree to which current and expected conditions meet the needs of agricultural plants, as well as possible losses from droughts, dry winds, frosts, severe frosts, ice crusts and other adverse weather events. An integral part of this information is the analysis of agrometeorological data as the main factors that determine the yield.

Establish the most likely weather conditions

All of the above suggests that to assess the possible yield of an agricultural plant, it is necessary to establish the values of the hydrothermal regime (precipitation and temperature) that most often occur in a particular area in a particular period, which is defined as modal (Fig. 1.1).

Such an assessment of conditions is possible either with a representative series of actual data (at least 20-25 years) or by implementing the special nomograms proposed in this paper. From the point of view of moisture and heat availability as resources, such definitions may be sufficient, but in the case of clearly defined optimal values for some plants, calculations of the expected yield become somewhat more complicated (Fig. 1.2).

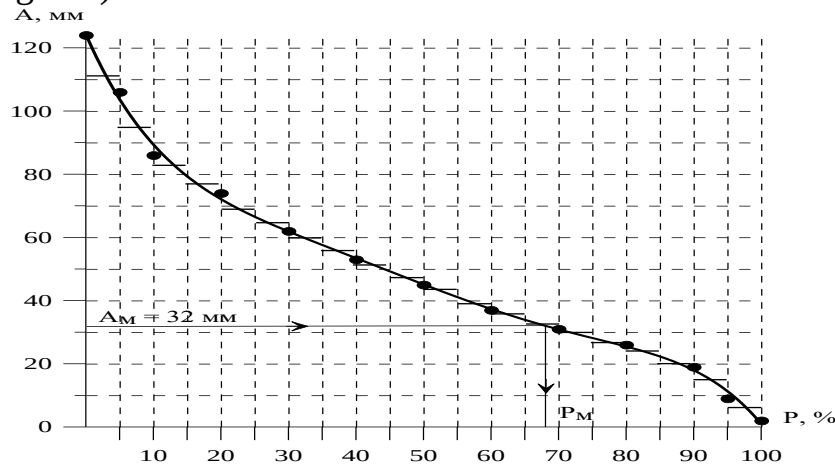


Fig. 1.1. Probable curve of precipitation in May (MS Sumy)

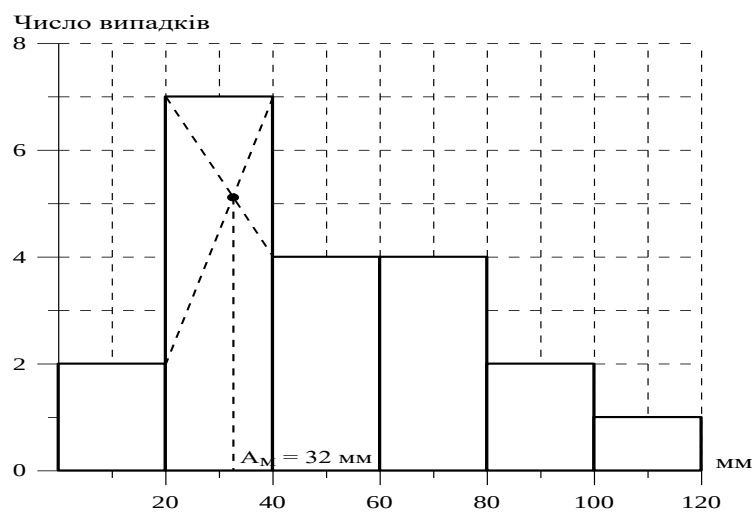


Fig 1.2. Scheme for determining the modal value of precipitation in May (Sumy Met Office)

As mentioned earlier, the amount of precipitation may not always be an unambiguous assessment of the moisture availability of crops, as the problem is functionally the availability of the required amount of productive moisture in the soil. The amount of this moisture is known to be determined by the amount of precipitation during the pre-vegetation period and the moisture-holding capacity of soils, which, in turn, depends on their capillarity.

Similar calculations can be made based on the average monthly air temperature and productive soil moisture reserves at the beginning of the growing season.

1.3 Agrobiological foundations of intensive cultivation technologies for agricultural crops.

Agrometeorological forecasts are one of the most important types of agrometeorological information for agricultural production. ***Agrometeorological forecasting is the*** prediction of the most important indicators of weather and climatic conditions or phenomena that most significantly affect the growth and development of plants and their yields. They can be long-term and current.

All agrometeorological forecasts are divided into the following main groups:

1. Forecasts of agrometeorological conditions. This group includes: forecasting the heat supply for the growing season; forecasting the timing of soil thawing and freezing; forecasting productive soil moisture reserves; forecasting agrometeorological conditions for the growth and development of agricultural plants; and forecasting grain harvesting conditions.
2. Phenological forecasts. This includes: forecasting the optimal time for the start of spring field work; forecasting the timing of the main phases of plant development, etc.
3. Forecast of yields of major crops and crop quality.
4. Forecasting the timing of the emergence and spread of plant diseases and pests.
5. Forecasting the condition of winter plants in winter.
6. Special forecasts. These include the forecast of grass growth on pastures; forecast of water-charging irrigation; forecast of irrigation rates; forecast of optimal timing and rates of irrigation; forecast of optimal doses of nitrogen fertilisers for seed plants; forecast of lodging of grain plants, etc.

All of these forecasts were developed for different zones, described in the specialised literature [28; 40] and in some cases refined for the conditions of specific regions.

Simultaneously with the forecast of weather conditions, agrometeorological recommendations are formulated, which are a reasonable list of agrotechnological or organisational and technological measures that need to be taken in connection with the expected weather conditions. A significant difference between these recommendations and zonal technologies is that they specify and detail the feasibility of only certain technological operations (pre- and post-emergence harrowing, inter-row cultivation, nitrogen fertiliser doses, elements of harvesting technology, etc.) The purpose of this is to optimise the conditions for growing the plant by increasing the efficiency of the use of key resources, since in any case, a high level of agricultural technology significantly reduces the negative impact of unfavourable conditions (for example, a

strong root system created in previous periods can significantly reduce the dependence of plant yields on the lack of precipitation in the future).

Methods for forecasting crop yields take into account biological characteristics (plants, varieties) and availability of natural resources (heat, moisture). In this case, the initial data for current forecasts is the state of the crop, which is determined, directly or indirectly, in addition to all of the above, by the cultivation technology, including natural soil fertility, nutrition and sowing density.

In this regard, yield programming is relevant as a targeted management of the processes of plant productivity formation with known conceptual conditions:

1. In any case, such management is possible only if the existing natural resources are taken into account, with their frequency in a certain area or their predicted values.
2. The programming itself is carried out taking into account the resources of technological factors (fertiliser rates, sowing density, depth and methods of basic soil cultivation, etc.)

There is no doubt that the most effective and reliable programming is in the conditions of reclaimed land (irrigation or drainage), i.e. when the resource of one of the main growth factors - moisture - is optimised.

However, as noted by a number of scientists [31], such a process can also be considered under natural moisture conditions with the assessment of the crop as a resource (heat, moisture) with probabilistic analysis of these resources [40]. This indicates that in conditions of natural moisture, programming is based on the forecast indicators of natural conditions or yields.

The growth and development of agricultural plants is influenced by environmental factors, which are characterised by the following indicators: solar radiation, thermal factor (air, soil, plant temperature), moisture factor (precipitation, productive moisture reserves, moisture availability, total evaporation, evapotranspiration, moisture coefficients, etc.), damage by adverse weather events to agricultural plants, damage by pests and diseases, etc.

1.4. Agrotechnological foundations of crop production

Ukraine's territory covers 60.1 million hectares and stretches from 22 to 40° east longitude (1300 km) and from 52 to 45° north latitude (900 km). It is characterised by three natural zones: Steppe, Forest-Steppe, Polissya, as well as part of the Carpathians and Crimea. The area of agricultural land is 69 per cent (41.4 million hectares), of which 81 per cent is arable land (33.4 million hectares).

The nomenclature of soils includes about 650 types, but the structure of arable land is dominated by chernozem (60.6%, or 20.1 million hectares) and grey forest (21.3%, or 7.0 million hectares). The area of eroded land is 11.3 million hectares, including 8.1 million hectares of arable land [4].

Soil productivity and fertility. Fertility is the ability of the soil to meet the needs of agricultural plants for water and mineral nutrients. It is characterised by the following indicators: humus content, saturation with bases, nutrient content, acidity, density, structural composition, etc. At the same time, both fertility in general and individual indicators correlate with yields. Soil productivity is a broader concept and

depends not only on fertility but also on weather and climate conditions. At the same time, the concept of productivity also includes the effectiveness of various agrotechnical and agrochemical measures (Tab.1.1). For example, the effectiveness of the same rate of fertiliser varies from one soil to another. For example, consider winter wheat as a plant grown in almost all zones of the country.

Table 1.1

**Efficiency of fertilisers on winter wheat
crops under different soil conditions [2]**

Soils	Average yield, c/ha	Maximum yield, c/ha
No fertiliser		
Sod-podzolic	22,1-23,2	31,5-33,5
Black soil	27,0-30,0	46,0-50,4
With fertilisers		
Sod-podzolic	30,4-32,3	39,9-54,0
Black soil	36,9-39,0	58,4-61,9

Yields based on natural soil fertility. It is well known that the yield of agricultural plants without the use of fertilisers, i.e. which can be generated by natural soil fertility, is a prerequisite for assessing the efficiency of growing them in general and the efficiency of using fertilisers in particular. This value is determined by a large number of factors and conditions that can be defined as agrobiological and technological (plant species, variety, sowing density, pest and disease infestation, weed infestation, etc.), agrochemical (humus and nutrient content in the soil and reaction of the soil solution), agrophysical (soil particle size distribution, density, thickness of the root layer, etc.) and agroclimatic (supply of heat and moisture during the growing season in general and during certain periods of plant development in particular).

When designing a fertiliser system, the first step is to calculate the fertiliser doses to achieve the planned yield. The student must first analyse the soil data available to him or her and choose a method for calculating fertiliser doses. If the data allow for more than one method, then they should be used.

After selecting the method(s), calculate the dose of each of the nutrients. Present the calculations in the project.

The most common method is the balance method of calculating the fertiliser dose per planned yield. For this purpose, the following formula is used (1.1):

$$D = \frac{Y \cdot e - \Pi_{ГЗ} \cdot K_{ГЗ} - D_O \cdot C_O \cdot K_O - D_{ПО} \cdot C_{ПО} \cdot K_{ПО} - D_{МП} \cdot K_{МП}}{K_M}, \quad (1.1)$$

where D is the dose of the nutrient, kg/ha;

Y is the planned yield, c/ha;

c - nutrient removal per 1 tonne of crop, kg/tonne;

$\Pi_{ГЗ}$ - soil reserves of the available form of nutrient in the calculation layer, kg/ha.

Calculated by the formula (1.2) :

$$P = p_{ГЗ} \cdot M_{об} \cdot h, \quad (1.2)$$

K ; $K_{ГЗО}$; K ; $K_{МПО}$; $K_{МП}$ - nutrient use coefficients in fractions of a unit according to soil reserves, organic and mineral fertilisers, organic and mineral fertilisers in the aftereffect;

D_O ; C_O - respectively, the dose of organic fertilisers, t/ha, and the content of a nutrient in 1 tonne of organic fertilisers (on average, 5 kg of nitrogen, 2.5 kg of phosphorus, 6 kg of potassium);

$D_{ПО}$; $C_{ПО}$ - respectively, the dose of organic fertilisers applied to the place in the crop rotation, t/ha; the content of a nutrient in 1 tonne, kg;

$D_{МП}$ - dose of mineral fertilisers applied to the place in the crop rotation, kg/ha;

n - nutrient content in the soil, mg/100 g of soil;

$M_{об}$ - soil density (bulk density), g/cm³ ;

h - depth of the calculated soil layer, cm (usually 20 cm).

The effect of crop residues is taken into account only in terms of nitrogen if the crop rotation included perennial and annual legumes or legume-grasses, seed and leguminous plants, taking into account that for every tonne of hay harvest, 10-15 kg of nitrogen remains in the soil, and after seed and legumes, approximately half of the nitrogen of the marketable mass of the crop. It should be borne in mind that no more than half of this amount is nitrogen fixed from the air. Therefore, the coefficient should be taken into account not 0.5, but 0.25. For example, the yield of a pea plant was 30 centners per hectare. If the nitrogen removal is 6 kg per 1 tonne of grain, then the amount of nitrogen fixed in the soil is $30 \cdot 6 \cdot 0.25 = 45$ kg. Its utilisation rate is the same as that of organic fertilisers.

The calculation of fertilizers for the planned crop is shown in Table 1.2.

Table 1.2

Calculation of fertilisers for the planned crop

Indicators.	N	P ₂ O ₅	K ₂ O
1	2	3	4
1. Planned yield, tonnes per hectare			
2. Removed with the harvest, kg/tonne			
3. The planned yield, kg/ha			
4. 4. Content in the topsoil (20-30 cm): *			
mg per 1 kg			
kg per 1 ha			
5. Soil nutrient utilisation rate			
6. Nutrients to be used from the soil, kg/ha			
7. Additional organic and mineral fertilisers required, kg/ha			
8. Plants will receive nutrients from organic fertilisers:			

The end of the table 1.2			
1	2	3	4
- organic fertilisers applied, t/ha			
- nutrient content in manure, percentage			
- the amount of nutrients in the recommended dose of manure	0,5	0,2	0,8
- nutrient utilisation rate from manure, per cent (Annex 14)			
- nutrients from manure will be used, kg/ha			
9. Required to be absorbed from mineral fertilisers, kg/ha			
10. Nutrient utilisation rate from mineral fertilisers, per cent (Annex 13)			
11. Nutrients to be applied with mineral fertilisers, kg/ha			

* With a topsoil weight of 3000 t/ha (30 cm), 1 mg of nutrients per 1 kg of soil equals 3 kg/ha.

In the course work, based on the literature, you should independently determine the methods of fertilisation, forms and doses for the main, row and top dressing fertilisation. The total dose of fertiliser for different application periods should correspond to the calculated dose for the programmed crop.

A number of coefficients (Tables 1.3, 1.4, 1.5, 1.6) are used to make preliminary calculations:

Table 1.3

Specific removal of mineral nutrients by field plants per one centner of main product with the corresponding amount of by-products, kg (generalised data)

Plant	Batteries		
	N	P ₂ O ₅	K ₂ O
1	2	3	4
Winter wheat	3,0-3,5	0,9-1,2	1,8-2,5
Winter spring wheat	3,3-4,0	1,0-1,3	1,9-2,7
Winter rye	2,9-3,3	1,1-1,4	2,2-3,0
Barley	2,3-2,7	0,9-1,1	1,7-2,2
Oats	2,9-3,5	1,2-1,5	2,4-2,9
Millet	3,0-3,5	0,9-1,2	2,0-2,7
Corn (seed)	3,0-3,5	0,9-1,2	2,0-2,7
Soriz plants	3,4-3,8	1,0-1,2	1,5-1,9
Rice	2,6-3,0	1,2-1,5	3,2-3,6
Buckwheat	2,9-3,5	1,3-1,6	3,6-4,2

The end of the table 1.3			
1	2	3	4
Peas	6,0-6,8	1,3-1,6	1,9-2,2
Lupine	6,0-6,9	1,8-2,0	4,0-5,0
Soybeans	6,5-7,5	1,3-1,7	1,8-2,2
Potatoes	0,5-0,7	0,2-0,4	1,3-1,6
Sugar beet (root crops)	0,5-0,7	0,15-0,2	0,7-0,8
Sunflower (seed)	5,0-7,0	2,5-2,8	15,5-19,5
Plants Long Flax (seed)	7,0-8,5	3,5-4,5	6,5-7,5
Plants Long Flax (straw)	1,15-1,35	0,8-0,9	1,6-1,9
Rapeseed	4,6-5,2	4,2-4,4	5,8-7,0

Table 1.4**Coefficients of mineral nutrient use by field plants from soil (generalised data)**

Plant	Batteries		
	N	P ₂ O ₅	K ₂ O
Winter wheat	0,20-0,35	0,05-0,15	0,08-0,20
Winter spring wheat	0,20-0,30	0,05-0,10	0,06-0,18
Winter rye	0,20-0,35	0,05-0,15	0,07-0,19
Barley	0,15-0,35	0,05-0,15	0,06-0,12
Oats	0,20-0,35	0,05-0,15	0,08-0,16
Millet	0,15-0,35	0,05-0,13	0,06-0,12
Corn (seed)	0,25-0,40	0,06-0,18	0,08-0,30
Soriz plants	0,15-0,40	0,06-0,15	0,07-0,17
Rice	0,25-0,45	0,08-0,18	0,08-0,18
Buckwheat	0,15-0,35	0,05-0,15	0,06-0,12
Peas	0,30-0,55	0,09-0,18	0,06-0,19
Lupine	0,30-0,65	0,08-0,18	0,07-0,36
Soybeans	0,30-0,45	0,09-0,15	0,06-0,15
Potatoes	0,20-0,35	0,07-0,15	0,09-0,40
Sugar beet	0,25-0,50	0,06-0,15	0,07-0,40
Sunflower	0,30-0,45	0,07-0,17	0,08-0,24
Plants Long Flax (seed)	0,25-0,35	0,03-0,14	0,07-0,20
Plants Long Flax (straw)	0,22-0,32	0,03-0,12	0,06-0,18

Table 1.5**Coefficients of nutrient utilisation by field plants from mineral fertilisers (generalised data)**

Plant	Batteries		
	N	P ₂ O ₅	K ₂ O
1	2	3	4
Winter wheat winter wheat	0,55-0,85	0,15-0,45	0,55-0,95
Winter spring wheat	0,45-0,75	0,15-0,35	0,55-0,85

The end of the table 1.5			
1	2	3	4
Winter rye	0,55-0,80	0,25-0,40	0,65-0,80
Barley	0,60-0,75	0,20-0,40	0,60-0,70
Oats	0,60-0,80	0,25-0,35	0,65-0,85
Millet	0,55-0,75	0,25-0,40	0,65-0,85
Corn (seed)	0,65-0,85	0,25-0,45	0,75-0,95
Soriz plants	0,55-0,80	0,25-0,35	0,65-0,85
Rice	0,60-0,85	0,25-0,30	0,75-0,90
Buckwheat	0,50-0,70	0,30-0,45	0,70-0,90
Peas	0,50-0,80	0,30-0,45	0,70-0,80
Lupine	0,50-0,90	0,15-0,40	0,55-0,75
Soybeans	0,50-0,75	0,25-0,40	0,65-0,85
Potatoes	0,50-0,80	0,25-0,35	0,85-0,95
Sugar beet	0,6-0,85	0,25-0,45	0,70-0,95
Sunflower	0,55-0,75	0,25-0,35	0,65-0,95
Plants Long Flax (seed)	0,55-0,7	0,15-0,35	0,65-0,85
Plants Long Flax (straw)	0,55-0,65	0,15-0,30	0,65-0,80

Table 1.6

**Coefficients of nutrient utilisation by field plants from organic fertilisers
(generalised data)**

Plant.	Batteries		
	N	P ₂ O ₅	K ₂ O
Winter wheat	0,20-0,35	0,30-0,50	0,50-0,70
Winter rye	0,20-0,35	0,30-0,50	0,50-0,70
Barley	0,20-0,25	0,25-0,40	0,50-0,55
Oats	0,20-0,25	0,25-0,40	0,50-0,60
Corn (seed)	0,35-0,40	0,45-0,50	0,65-0,75
Potatoes	0,20-0,30	0,30-0,40	0,50-0,70
Sugar beet	0,30-0,40	0,45-0,50	0,60-0,70

In terms of assessing crop yields due to natural soil fertility, there are three existing soil bonuses:

1. Overall plant yield bonus.
2. Agrochemical background.
3. Ecological and agrochemical background.

The first method is based on identifying the soil in a particular natural and economic zone where the yield of a plant without fertiliser is maximum. Such soil is considered a reference soil, and its bonus is equated to 100 points. The bonuses of the other soil agro-groups in a particular region are calculated in relation to the reference soil. The main indicators are the humus content (percentage), the thickness of the

humus horizon (cm) and the physical clay content (percentage). Based on these indicators (for each of them), the bonita score of all other soils in the condition is set for each plant: $\hat{A}_s = \frac{\hat{I}_s}{\hat{I}_s^A} \cdot 100$, point, (1.3)

where. Π_i - the content of a *particular* indicator in such soil;
 Π_i^E - the content of this indicator in the soil used as a reference.

In addition to these indicators (as the main ones), the following are also taken into account: salinity, acidity, glaze, leaching, content of mobile forms of phosphorus and potassium. The total score for one plant is calculated as a weighted average:

$$\hat{A}_{\zeta\hat{E}} = (\hat{A}_1 \cdot \hat{E}_1 + \hat{A}_2 \cdot \hat{E}_2 + \dots + \hat{A}_s \cdot \hat{E}_s) / (\hat{E}_1 + \hat{E}_2 + \dots + \hat{E}_s), \text{ score,} \quad (1.4)$$

where. B_{3K} is the total score of the plant's bonita for one plant;
 $B, B_{12} \dots B_i$ - points of the bonus for individual soil properties for one plant, point;
 $K, K_{12}, \dots K_i$ are the coefficients of determination between the values of individual soil properties and plant yield.

The price of a soil bonanza point for a plant's yield is determined as follows:

$$\ddot{O}_A = \frac{\ddot{O}_\phi}{\hat{A}_{\zeta\hat{E}}}, \text{ c/points,}$$

where. In_ϕ - actual plant yield on a field with a certain total yield, c/ha.

Soil agrochemical bonita is determined based on the main indicators of natural fertility.

These indicators usually correlate with the yield of the plant when grown without fertilisers, are often zonal in nature and most often contain the following indicators:

- humus reserves in the 0-100 cm layer (500 t/ha is considered the benchmark and is assessed at 100 points);
- the content of mobile phosphorus compounds in the soil (260 mg/kg for 100 points - Kirsanov method, 200 mg/kg - Chirikov method, 60 mg/kg - Machigin method);
- the content of mobile potassium compounds in the soil (170 mg/kg is estimated out of 100 points - Kirsanov method, 200 mg/kg - Chirikov method, 400 mg/kg - Machigin method).

Speaking of yields, one should take into account the existing point of view that they can be represented by statistical data on the actual size of the crop in production crops, experimental data and as calculated. All of these methods have their drawbacks. For example, statistical data on yields in production crops are not very reliable, and their dependence on agrobiological, technological and weather conditions can be much more significant than on soil bonuses. Research data can be significantly larger than production data, and their dependence on the same factors is obvious.

The optimum value of the maximum possible reserves of productive moisture in the one-metre layer of soil is 200 mm, which corresponds to 100 points.

The soil score in points for each of these indicators is determined according to the dependence, with the prerequisite that $B_\Pi \leq 100$.

The environmental conditions of the soil are assessed based on the following indicators: agro-climatic conditions, salinity, acidity, waterlogging, contamination with radionuclides, heavy metals, and pesticide residues. All these conditions are

assessed by special reduction factors. The resulting aggregate environmental and agrochemical soil rating is a characteristic of soil productivity. The price of 1 point of such a grade (C_B) is expressed in centners of grain units per hectare, can be determined on the basis of field experiments and is generally 0.41 centners of grain units per hectare for Ukraine (Table 1.7).

Table 1.7**Conversion factors for products to seed units**

Plant.	K_{30}	Plant.	K_{30}
Winter wheat	1,00	Sugar beet	0,26
Winter barley	0,90	Fodder beetroot	0,13
Winter rye	0,90	Sunflower	2,00
Corn for seeds	1,00	Rapeseed for seed	2,00
Spring barley	0,80	Soybeans	1,80
Oats	0,70	Potatoes	0,30
Peas	1,40	Corn for silage	0,13
Buckwheat	1,40	Alfalfa (w/m)	0,15
Millet	0,90	Oil radish (w/m)	0,12
Soriz plants	1,20	Vegetable	0,50
Legume	1,20	Peas on the s/m	0,12
Winter spring wheat	1,00	Corn for maize, stubble	0,13

In conclusion, it should be noted that all of the above interpretations do not take into account, in our view, an essential feature of the modern development of agriculture. The essence of this is the widespread introduction of new high-intensity varieties and hybrids of agricultural plants and elements of their cultivation technology. In a general sense, the more intensive a variety is, the more productive it is. However, from the point of view of agrochemical assessment, provided that there are insignificant differences in the values of removal of the main elements per unit of yield, the more intensive the variety is, the greater the coefficient of use of these elements from the soil.

Freezing of winter plants, perennial grasses and fruit trees. Winter hardiness and frost resistance of plants, their hardening

For plants whose normal development is related to wintering conditions, such concepts as winter hardiness and frost resistance are used.

Plant winter hardiness is a biological property of overwintering plants that allows them to withstand a range of adverse weather conditions during cold weather. Winter hardiness is a mobile, unstable and not always characteristic property of the same plant. It is determined by the direction of physiological and biological processes that occur in plants during the cold season. Winter hardiness as a quality develops in plants as a result of the hardening process in late autumn.

Winter hardiness is the ability of plants to withstand adverse winter conditions (severe frosts, sharp temperature fluctuations, etc.). This concept also includes frost resistance, which is the ability of plants to withstand low negative temperatures. Plants

develop winter hardiness as a result of the hardening process in late autumn. Under the influence of meteorological factors, hardening and preparation of plants for wintering takes place in two phases.

The first phase of hardening for most temperate zone plants is observed at temperatures from 5°C to 0°C, when a large amount of organic reserves (including sugar) are accumulated. The best meteorological conditions at this time are sunny, cloudless weather with sufficient soil moisture.

The second phase of hardening takes place at temperatures from 0°C to -5°C and is characterised by the fact that the protoplasm dehydrates and the concentration of protective substances in the cell increases; the best weather conditions are sunny, dry, with a slight decrease in soil moisture. Under favourable meteorological conditions for hardening, woody plants can withstand frosts down to -50 °C and below.

The winter hardiness of winter plants also depends on soil moisture during the autumn growing season. For example, winter plants become more frost-resistant if the soil moisture content during the hardening period is 50-70 per cent of the full moisture capacity. Excessive moisture (more than 80 per cent of the total moisture capacity) has a negative impact on hardening of winter crops.

The frost resistance of plants does not remain constant during the winter, but changes in accordance with temperature changes. During winter frosts, it is maximum, and during thaws it decreases sharply. And then, if the frost intensifies slowly, it increases again. Prolonged and deep thaws are unfavourable for overwintering plants because they cause them to wake up and use up the accumulated sugar in the process of increased respiration. The frost resistance of plants decreases, and they can be damaged by frosts of lesser intensity. Particularly dangerous are sharp fluctuations in temperature during the day or frequent sudden changes in weather from thaw to frost. Therefore, sudden frosts are the most dangerous factor of the winter period for forests. Many tree species with a sharp drop in temperature experience trunk cracking and frost holes. The damaged parts of the trees overgrow, but the wood becomes worthless. All woody plants at a young age have lower frost resistance and are more often damaged by frost (buds and shoots freeze, and sometimes freeze out completely).

The condition of winter crops after the end of the growing season in autumn is very important for overwintering. Winter plants in the second and third leaf stage are the least winter-hardy. Overgrown plants in autumn have a height of up to 25 cm and more than six lateral shoots. The winter hardiness of such plants is sharply reduced compared to plants with 3 to 5 shoots. According to many researchers, the greatest winter hardiness occurs when plants form 3 to 5 shoots before the end of the growing season.

The agrometeorological conditions of wintering of winter plants are a complex of meteorological elements that directly or indirectly affect plants in winter, determine their winter hardiness and condition at the beginning of the spring growing season.

The air temperature determines not only the conditions but also the duration of the plant wintering period, which begins with the date of a stable transition of the air temperature through 0°C in autumn and ends with its transition through positive values in spring. Air temperature in winter has a particularly negative impact on the wintering of winter plants in the absence of snow.

Snow cover. The timing of snow formation and melting, spatial and temporal variability of snow depth and density are of great importance for plant wintering. Late snow formation on fields in areas with persistent winters and severe frosts increases the likelihood of plant freezing.

The snow depth in the fields gradually increases throughout the winter. It is highest in northern farming areas at the end of March and in the south in February. The snow on the fields is very uneven.

Under the influence of the wind, snow is significantly transferred from one area of the field to another in open fields. Scientists have found that the unevenness of snow distribution is greater the lower the average snow depth. It has been found that a snow depth of 10 cm is sufficient to preserve winter crops in severe frosts and it occurs throughout the field with an average snow depth of 30 cm.

Depth of soil freezing. The timing of snow formation in the fields and its thickness significantly affect the depth of soil freezing, which also has significant spatial and temporal variability, but is still less than the thickness of the snow. The depth of soil freezing is influenced by the mechanical composition of the soil, its moisture content, topography, agricultural practices, vegetation cover, etc.

Soil temperature at the depth of the tillering node is a complex indicator of agrometeorological conditions for wintering of winter plants. Its value is influenced by the heat capacity and thermal conductivity of the soil, air temperature, snow depth, soil moisture, and soil freezing depth.

The winter hardiness of plants depends on the timing of sowing, soil moisture, biological characteristics of winter plant varieties and agrometeorological conditions during the autumn growing season, at the end of which the plant hardening process takes place. The main causes of plant damage in winter are freezing, rooting, soaking, bulging and blowing out of plants. In addition, the presence of a crust of ice aggravates the effects of all the above factors. The death of plants in winter often occurs under the influence of not one, but several factors.

Winter hardiness of plants is their overall resistance to adverse winter conditions. It is determined by the biological characteristics of plants, the condition of crops before the end of the growing season, the degree of hardening of plants and overwintering conditions. The winter hardiness of plants gradually increases from autumn to mid-winter, and begins to decrease in the second half of winter.

Plant frost resistance is the resistance of plants to frost. It is characterised by the critical freezing point of plants. The critical freezing point is the temperature at which more than 50 per cent of the plants die from freezing. The value of the critical freezing temperature is closely related to the average minimum soil temperature at the depth of the tillering node over the past wintering period. Unfavourable wintering conditions for fruit plants. In winter, fruit plants are most often damaged during severe frosts, when the air temperature drops below the critical temperature. This can damage both the above-ground organs and the root system. The winter hardiness of different fruit plants and their individual organs varies. The root system, which is protected by soil and snow cover, is not adapted to low temperatures, and therefore, in severe frosts during winters with little snow, it is damaged or even freezes, leading to the complete

death of the tree. Of the aboveground parts, fruit buds are the most sensitive to low temperatures.

The frost resistance of fruit trees decreases sharply during long winter thaws, when fruit buds begin to grow. Sharp fluctuations in temperature, especially on sunny days, in the second half of winter cause damage called winter burns and frost holes. To protect fruit plantations from freezing, a number of measures are used, the nature of which is determined by the type of plantation and climatic conditions. For example, snow retention, hilling trunks with earth, whitewashing, covering with earth (vineyards), and heating (citrus) are reliable measures to prevent freezing of berry and climbing orchards.

Technological measures to combat hazardous phenomena during the period of overwintering of agricultural plants. Assessment of weather hazards. The experience of farms confirms the enormous role of organic and mineral fertilisers in ensuring favourable conditions for wintering of winter crops. Among mineral fertilisers, phosphorus and potassium fertilisers have the best effect. Research shows that a certain ratio between air temperature and snow cover is required for winter crops to survive the winter. The death of winter crops is directly related to these two factors, as their ratio creates a particular temperature regime in the soil and is crucial for overwintering. If frosts come and there is no snow cover of the required height, after three decades the winter wheat is severely damaged and dies completely by spring. To prevent winter wheat from drying out, it should be sown at the optimum time, avoiding thickening of the crops.

Winter crops, which grow rapidly in autumn, need to be fertilised with phosphorus-potassium fertiliser. When overgrown, winter crops are sometimes mowed down. If snow falls on unfrozen soil, it is compacted to accelerate soil freezing and stop plant growth. In late winter and early spring, when there is a threat of plants damping out due to the slow melting of a large snow cover, it is sprinkled with dark-coloured substances - soil, mineral fertilisers, ash, peat, etc. - to speed up melting. Among winter crops, winter wheat is better able to withstand aging, while rye is worse.

To prevent soaking, furrows should be cut in autumn, and drainage ditches and wells should be dug to drain meltwater in possible places of accumulation. In the spring, observation and cleaning of furrows, ditches and wells should be organised. Closed drainage gives the best results in the fight against soaking. The use of ridge and bed sowing methods is also of great importance. One of the measures to combat bulging can be rolling the areas of winter crops that have been affected by bulging in early spring. Snow retention, drainage and harrowing also yield positive results.

To prevent the blowing of plants, it is necessary to use all agricultural techniques aimed at increasing soil moisture, snow cover and reducing wind speed: forest belts, wings, ploughing, etc. In addition, deeper seed placement, sowing, etc. is necessary.

Recent studies have shown that the crust is harmful to winter wheat plants only when it lasts for four decades or more and its average thickness exceeds 1 cm. This suggests that we need to combat ice crust, while developing new methods and techniques. The best way to deal with the crusted ice is snow retention. It can also be destroyed by sprinkling various dark materials to accelerate ice melting. Peat, ash, etc. are used for this purpose.

Hanging crust is easier to deal with, and can be mechanically destroyed, for example with rollers. However, when the ice is broken, it causes severe damage to the plants, and they die. In addition, rolling during repeated thaws and frosts does not prevent new crust formation.

A very important measure to combat ice crusts in a timely manner is to drain meltwater from fields and to slough the soil. The latter measure has been proposed recently. Preliminary studies have shown that tilling the soil to a depth of 3 to 5 cm prevents crusting and at the same time provides better resistance of winter plants to spring frosts, while additional moisture accumulation contributes to a significant increase in yields.

Requirements of main agricultural plants to hydrothermal conditions of the growing season

All of the above indicates that the main indicator of the weather of each growing season is hydrothermal conditions, i.e. those determined by the ratio of moisture and heat resources. The impact of this factor on plant yields and, consequently, on the efficiency of using the main nutrients from the soil and fertilisers is undeniable. It is known that the requirements of different agricultural plants to these conditions at different stages of development are determined primarily by their biological characteristics and, to some extent, by the natural and climatic conditions of the zone. In addition, it should be noted that the degree of detail of these conditions depends primarily on the economic importance of the plant and its distribution in the country.

For example, it was found that the requirements of spring barley plants to the hydrothermal weather regime are limited to the earing phase (Table 1.8).

Table 1.8

Threshold values of agrometeorological characteristics of the growing season of spring barley plants

Characteristics	Terms.	
	unfavourable	favourable
Amount of precipitation for the pre-vegetation period (P_0), mm	< 70	150-175
Precipitation during the sowing - earing period (P_3), mm	< 30	120-150
Spring productive moisture reserves in the one-metre soil layer (W_1), mm	< 80	160-180
Productive moisture reserves as of the date of mass earing (W_3), mm	< 40	110-130
Total moisture consumption during the period of sowing - earing (B_3), mm	< 70	180-200
Total moisture consumption during the growing season ($from_5$), mm	< 110	220-250
Air temperature in the decade of massive earing ($t\text{ }^{\circ}\text{C}$) ⁰	> 23	17-19
Air humidity deficit in the decade of massive earing (d), mb	> 18	8-10

It has been established that significant fluctuations in the yield of winter wheat plants over the years are primarily due to different conditions of natural moisture. Therefore, the main inertial factor, i.e. the one that determines not only the current but also the future conditions for the formation of the crop yield of this plant, is the reserves of productive moisture. Its amount in a particular phase of plant development allows to determine the conditions of plant development in advance (Table 1.9).

Table 1.9

Indicators for assessing the reserves of productive moisture of the metre soil layer in the main periods of spring and summer vegetation of winter wheat plants

Period	Productive moisture reserves, mm			
	good	satisfactory	insufficient	bad
Restoration of vegetation	150-200	120-150	100-120	< 100
Stem growth	140-180	100-140	80-100	< 80
Spikelets	80-140	60-80	40-60	< 40
Filling grain	80-100	40-80	30-40	< 25

Of particular importance for winter wheat plants is the supply of productive moisture for the period of spring inspection of crops, i.e. 10 days after the resumption of vegetation in spring (Table 1.10).

Table 1.10

Optimal values of hydrometeorological parameters by periods of the vegetation cycle of winter wheat plants

Periods of the vegetation cycle	Month	Productive moisture reserves at the beginning of the period, mm		Air temperature, °C		Precipitation, mm	
		0-20 cm	0-100 cm	average	amount	sum	average per day
Pre-sowing	VII-VIII	-	-	18	-	130	2,1
Sowing - rooting	IX-X	26	70	13	793	170	2,8
Shoot growth	XI	30	120	5	150	120	4,0
Winter tranquillity	XII-II	30	130	-0,5	-	160	1,8
Formation of generative bodies	II-V	30-40	190	8	736	170	1,9
Grain formation	VI	25	110	17	510	17	0,6
Achievements	VII	15	70	22	682	10	0,3

For a seed corn plant, the phase of panicle emergence is critical in terms of optimal conditions for yield formation, when the optimal supply of productive moisture in the half-metre soil layer is 60-80 mm, and the average daily air temperature for a month afterwards should be 21-23° C.

According to A.M. Polevyi and L.Y. Bozhko, the requirements of this plant to hydrothermal conditions vary by developmental stages (Table 1.11).

Table 1.11

**Optimal values of precipitation (ΣA) and average air temperature ($t C^0$)
for an early maturing maize plant [25]**

Developmental stages (months)	ΣA , mm	$t C^0$
Pre-sowing (XII-III)	210-230	-
Sowing - rooting (IV-V)	100-120	11,0-11,3
Formation of vegetative organs (VI-VII)	180-200	17,4-18,3
Formation of generative organs (VIII)	50-70	17,4-18,3

The same data was used to determine the optimum precipitation values for sunflower plants and potato plants (Table 1.12, 1.13).

Table 1.12

**Optimal values of precipitation (ΣA) and average air temperature
($t C^0$) for sunflower plants**

Developmental stages (months)	Forest-steppe		Steppe	
	ΣA , mm	$t C^0$	ΣA , mm	$t C^0$
Pre-sowing (XII-III)	160-200	-	160-210	-
Sowing - sprouting (IV)	40	6,3-7,5	40	8,3-9,5
Formation of vegetative organs (V-VI)	90-120	15,3-16,5	110-120	16,3-17,5
Establishment of generative bodies (VII)	70-90	18,3-19,5	50-70	18,3-19,5
Achievements (VIII)	50-70	18,3-19,5	50	19,3-20,5

Table 1.13

**Optimal values of precipitation (ΣA) and average air temperature
($t C^0$) for potato plants**

Month	Steppe		Forest-steppe		Polissya	
	ΣA , mm	$t C^0$	ΣA , mm	$t C^0$	ΣA , mm	$t C^0$
IV	80-90	11,0-11,8	-	-	-	-
V	70-90	14,8-15,8	70-90	14,8-15,8	50	14,8-15,8
VI	90-100	17,8-18,8	90-100	16,8-17,8	70-80	16,8-17,8
VII	90-100	18,8-19,8	120-150	17,8-18,8	90-100	17,8-18,8
VIII	60-70	16,8-17,8	110	16,8-17,8	100-110	16,8-17,8
IX	50-60	12,8-13,8	50-60	11,8-12,8	60-80	10,8-11,8

For sugar beet, a prerequisite is, first and foremost, moisture availability of crops, which requires constant maintenance of soil moisture within the optimal range (HB-0.6HB).

The resource yield levels determined by actual moisture and heat reserves, as resource yield levels (see above), may differ significantly from the actual ones, since in certain periods of plant development the actual ratio between temperature and precipitation may be far from optimal, and therefore significantly affect the yield itself. Since the actual weather values are not always optimal for a particular crop, there is a need to clarify their impact on yield. Currently, one of the most well-known methods for determining such an impact is the statistical models first developed for winter wheat plants and rye plants by V.P. Dmitrenko and subsequently developed for corn plants, sunflower plants and potato plants.

The essence of such models is that for each period of the entire plant's growing season, a weighting factor or coefficient is set ($b_{0,i}$), which takes into account the contribution of this period to the yield. In this case, the sum of these coefficients for the growing season is equal to one. In general, during the growing season, the impact of these factors is determined by the sum of such indicators for all periods. It should be noted that such an impact can be determined both by actual weather values, i.e. after harvesting, and by forecast data, or as a forecast for a specific period of plant development.

1.5 Fundamentals of crop yield programming

The main source of energy for almost all processes occurring on Earth and in the atmosphere is the Sun's radiant energy. Solar energy is the main condition for the existence of the biosphere and one of the most important climate-forming factors. Due to the fact that the soil is covered by a continuous shell of the atmosphere, the sun's rays pass through the entire thickness of the atmosphere, which partially reflects or scatters these rays. Reflection and scattering of the rays changes the quantity and quality of light reaching the Earth. The Sun's radiant energy is divided into fluxes: direct solar radiation, scattered, total, reflected solar radiation, the Earth's own radiation and the average atmospheric radiation.

Solar radiation intensity is the flux of radiation received per unit time per unit surface. In the international system (SI), the intensity of solar radiation flux is expressed in W/m^2 [$1 \text{ cal}/(\text{cm}^2 \text{ min}) = 698 \text{ W/m}^2$]. Radiation amounts are expressed in $\text{J}/(\text{m}^2 \text{ h})$, $\text{J}/(\text{m}^2 \cdot \text{d})$, etc. ($1 \text{ cal}/\text{cm}^2 = 4.19 \cdot 10^4 \text{ J/m}^2$).

The distribution of radiant energy by wavelength is called a *spectrum*. The spectrum of sunlight is divided into three parts:

- invisible ultraviolet rays with a wavelength of $l < 0.40 \mu\text{m}$;
- visible rays with wavelengths of $0.40 < l < 0.75 \mu\text{m}$;
- invisible infrared rays with wavelengths of $0.76 \leq l \leq 4 \text{ microns}$.

In biophysical terms, the radiation spectrum of the Sun and sky is divided into four intervals.

Ultraviolet radiation (wavelength $0.29 < l < 0.38 \mu\text{m}$) promotes cell and tissue differentiation, inhibits their growth, but accelerates the stages of reproductive organs formation in plants. The amount of ultraviolet radiation received at altitudes close to

sea level is small. In high mountainous areas (above 4 km), the energy of ultraviolet rays is two to three times higher than at sea level.

Photosynthetically active radiation (PAR). In the process of photosynthesis, not the entire spectrum of solar radiation is used, but only a part of it, which is in the wavelength range $0.38 < \lambda < 0.71$ microns. In the process of photosynthesis, up to 10 per cent of the FAR can be used to create organic matter. FAR is one of the most important factors in the productivity of agricultural plants.

Near-infrared radiation (NIR) $0.71 < \lambda < 4.0$ microns, is consumed by water, leaves and stems of plants and creates a thermal effect.

Infrared radiation (IR) $4.0 < \lambda < 100.0$ microns. The effect of far-infrared radiation on plants is very insignificant. In high mountainous areas, the energy of infrared rays increases. This largely compensates for the insufficient amount of heat that plants receive from the environment. For the biological processes of living organisms and plants, radiation with a wavelength of less than 4 microns, including ultraviolet, photosynthetically active and near-infrared parts of the spectrum, is of the greatest importance. The plant world receives mostly direct and scattered solar radiation, and much less reflected radiation.

It has been proven that plants respond to the duration of sunlight, its intensity and spectral composition. The reaction of plants to the duration of light is called *photoperiodism*.

Plants are divided into three groups according to the duration of sunlight:

- *long-day plants* - their development is accelerated by 20-24 hours of light (winter wheat, rye, oats, barley, flax, peas, lentils, china, lupins, fodder beans, etc.);
- *plants of short daylight hours* - their development is delayed when daylight hours increase beyond 12 hours (millet, soybeans, beans, rice, cotton, etc.);
- *neutral* - their development is not affected by the length of daylight hours (buckwheat, chickpeas).

The intensity of solar radiation determines the nature of vegetation.

Three groups of plants are distinguished by their response to the intensity of solar radiation:

- *light-loving* (winter wheat, millet, maize, sorghum plants, beetroot, castor oil);
- *shade-tolerant* (soybeans, beans, peas, fodder beans);
- *transitional*.

In shade-tolerant plants, maximum photosynthesis occurs at a relatively low intensity of solar radiation, while in light-loving plants it is optimal at high intensity. It has been established that the predominance of a certain spectral composition in the radiant flux is necessary for plant flowering.

For example, plants with short daylight hours develop faster when blue-violet rays predominate in the total light flux, and plants with long daylight hours develop faster when red rays predominate. Solar radiation affects the chemical composition of plants. For example, the sugar content of beetroot and grapes, and the protein content of wheat grain are closely related to the number of sunny days. The sugar content of apples and a number of other fruits is related to the intensity of solar radiation. Thus, the amount of oil in sunflower and flax seeds increases with the increase in solar

energy. Exposure of farm animals to ultraviolet rays in winter is successfully used both for therapeutic purposes and to increase productivity.

The biological effect of different types of radiation on plants is different. Ultraviolet radiation slows down growth processes, but accelerates the stages of reproductive organ formation in plants. Near-infrared radiation is absorbed by the water of plant leaves and stems and creates a thermal effect.

Among short-wave radiation, *photosynthetically active radiation* (PAR) has the most active biological effect on plants. This is solar radiation that is limited to a wavelength of 0.38 to 0.78 microns and is directly used by green plants in the process of photosynthesis.

Under the influence of PAR, plants synthesise complex organic compounds and accumulate plant mass. The radiant energy of this radiation is the source of energy for all photochemical processes in plants and is used by them both for photosynthesis and for the regulation of many phytophysiological processes.

The share of the FAR in the total radiation flux varies depending on the height of the Sun above the horizon, cloud cover, moisture content, and atmospheric dusting. For example, in temperate latitudes, at noon, the PAR makes up an average of 43 per cent of direct radiation, and during sunrise and sunset, only 10-20 per cent. In the scattered radiation, the FAR content is more stable throughout the day and is about 60 per cent.

The effect of far-infrared radiation on plants is very small. In the process of plant photosynthesis, only 1 to 3 per cent of FIR is used to create various organic substances. The intensity of the FAR is calculated from the data of direct (S') and scattered (D) or total radiation (Q) using the coefficients proposed by B.I. Gulyaev, H.G. Tooming and N.O. Efimova:

$$Q_{FAR} = 0.43 S' + 0.57D, \quad (1.5)$$

$$Q_{PAR} = 0.52 Q \quad (1.6)$$

The efficiency of solar radiation use by phytocoenoses is characterised by *the* solar radiation efficiency (SRE). It is determined by the ratio of the amount of energy accumulated in the products of photosynthesis or the yield formed in the phytomass to the amount of absorbed radiation:

$$U = qV 100 / Q_{PAR} \quad (1.7)$$

where q is *the* calorific value of plants, kJ/g;

V - biological yield of total phytomass, g/cm² ;

UQ_{FAR} is *the* sum of FAR during the growing season, MJ/m² .

The average calorific value of dry biomass in different plants ranges from 16.7 to 20.5 kJ/g. Crop efficiency depends on the timing of sowing and sowing density, the amount of fertiliser applied, weather conditions, etc. According to the values of crop efficiency (O.O. Nychporovych), crops are divided into groups: those that are observed - 0.5 - 1.5 per cent, good - 1.6 - 3 per cent, record - 3.1 - 5 per cent, theoretically possible - 6 - 8 per cent. Solar radiation also affects the chemical composition of agricultural products. Some crop diseases develop most actively in low light conditions.

The length of daylight hours (astronomical day length) depends on the time of year and geographical latitude. At the equator, the length of the day is 12 hours $\pm$ 30

minutes and increases after the vernal equinox (21.03) when moving north and decreases when moving south. After the autumnal equinox (23.09), it is the other way round. With the increase in day length in northern latitudes, the period of plant photosynthesis is extended during the growing season. The duration of light is also important for the quality of the crop and affects the development of plant diseases. As day length increases, plant resistance to disease increases.

In the plain part of Ukraine, the maximum FAR energy illumination is observed in June - July and averages 296 - 306 MJ/m in the northern regions and 348 - 364 MJ/m in the southern regions². The annual amount of FAR varies from 1994 (Kovel) to 2409 (Odesa) MJ/m².

To estimate the FAR resources, information on its receipt for the period of the year with average daily temperatures above 50-100°C is used. Within Ukraine, the total FAR at temperatures above 50⁰ C is 1665 - 1937 MJ/m², at temperatures above 100⁰ C - 1432 - 1671 MJ/m².

The level of photosynthetic activity of any biocenosis is marked by the *indicators of PAR intensity, PAR efficiency and leaf index*.

The intensity of the PAR. The rate of photosynthesis is directly proportional to the intensity of the PAR, but within certain limits from the compensation point to the saturation point. For the accumulation of organic raw materials, plants need an intensity of PAR that exceeds the corresponding value of the compensation point. The *compensation point is the* amount of PAR at which the amount of organic matter produced by photosynthesis is equal to the amount of matter consumed by plants for their vital activity.

Below the compensation point (20 - 35 W/m²), the consumption of organic material for respiration is higher than their production during photosynthesis. Above the compensation point, photosynthesis increases as the PAR increases, but up to a certain limit, which is called the saturation point. The *saturation point* is the amount of PAR from which an increase in solar radiation does not cause an increase in photosynthesis.

The saturation point is about 10 times higher than the compensation point and is 250 - 350 W/m². The dependence of the photosynthetic rate on the intensity of the PAR has the form of a logarithmic curve.

The efficiency of the FAR. The ratio of the proportion of FAR spent on photosynthesis and biomass formation to the total FAR flux absorbed by the biocenosis is called the *efficiency* of the biocenosis. It is determined by the formula:

$$K_{\phi AP} = \frac{ПБУ \cdot q}{\sum Q_{\phi AP} \cdot 10^4}, \quad (1.8)$$

where is the biological yield;

q - calorific value of absolutely dry plant biomass, kJ/kg,

$\sum Q_{\phi ap}$ is the total intake of FAR during the period of active vegetation of the plant, kJ/cm²;

DBU is the planned biological yield of absolutely dry biomass, c/ha (main and by-products). It is calculated by the formula:

$$\dot{I}AO = \frac{O \cdot (100 - \tilde{N}_f) \cdot a}{100}, \quad (1.9)$$

where. Y is the projected (planned) yield of the main product of standard moisture content, c/ha;

C_O - moisture content of the main products, percent;

a - the sum of the parts of the main and by-products in the harvest, Y - the amount of PAHs that entered the biocenosis during the growing season.

For most types of vegetation cover, the average efficiency is 1 to 2 per cent, for well-maintained agricultural crops - 1.5 to 3.0 per cent, and for forests - 2 to 4 per cent. An efficiency of 5-8 per cent is considered theoretically possible. The somewhat higher efficiency of forests compared to other types of vegetation cover is explained by their multi-tiered structure.

Leaf index. This is the ratio of the total area of plant leaves to the unit area of the field occupied by them. For an agricultural field, it averages 3-4 hectares.

Vegetation cover uses FAR with very low efficiency, and therefore even a slight increase in it can significantly increase the productivity of phytocenoses. The efficiency of agrocenoses depends on the leaf area, groundwater and agricultural practices. With an increase in leaf area, the efficiency increases rapidly, but only up to a certain point, after which it decreases. This is because the amount of solar radiation received per unit area remains constant, while the leaf surface area is continuously increasing. Researcher A. A. Nechiporovich gives the following classification of fields depending on their efficiency: ordinary (0.5 - 1.5 per cent), good (1.5 - 3.0 per cent), record (3.0 - 5.0 per cent), theoretically possible (6 - 8 per cent).

It should be borne in mind that maximum use of FAR resources is possible only if photosynthesis is not limited by other factors. In other words, it is important to maintain optimal water and thermal conditions of soil and air, as well as sufficient supply of nutrients to plants.

The spectral composition of the PAS is also of great importance for plants. The plant leaf selectively absorbs the FAR depending on the wavelength. The chlorophyll of the leaf absorbs blue-violet rays with a wavelength of $\lambda = 0.39 - 0.48$ microns (92 - 95 percent), followed by orange-red rays with $\lambda = 0.64 - 0.68$ microns (87 - 93 percent). Under these conditions, photosynthesis proceeds at the highest rate. Green rays ($\lambda = 0.5 - 0.6$ microns) have the lowest photosynthetic activity.

In Ukraine, the measurement of FAR is not carried out due to the lack of standard instruments. Information on the total NPV during the growing season of agricultural plants allows us to estimate the energy resources of the plant world in Ukraine and can be used to calculate photosynthesis, crop productivity, and crop yields. Taking into account the arrival of FAR in different zones is the basis for increasing plant productivity and calculating the crop efficiency.

Photosynthetic potential (PP) of plants. The patterns of formation of the energy regime in the surface air layer without vegetation differ significantly from the energy regime in the vegetation cover itself. Therefore, a complete and physically sound understanding of the peculiarities of the solar radiation regime in the plant environment can be obtained by knowing, first, the solar radiation intake to the upper boundary

(forest and agroecosystems); second, the peculiarities of the transformation of flows by the phytocenosis itself.

The amount of solar radiation that penetrates deep into the *grass stand* is determined by the type and density of the stand, the relative leaf area, and the height of the Sun above the horizon. Within the agrocenosis, each type of agricultural plant forms a different radiation regime depending on the ability of solar radiation to penetrate the soil. For example, on average, about 15-20 per cent of the amount of solar radiation that reaches the surface of the crops of winter wheat plants reaches the depth of the crops; soybeans and potatoes transmit up to 10 per cent of the radiation.

With a high density of plants with a developed plant leaf surface (e.g. corn for silage), the soil receives a small amount of solar radiation. Often, its energy illumination does not exceed the compensation point during the daylight hours. Therefore, the lower parts of the plant sustain itself at the expense of the upper parts and thus weaken the entire plant.

Unclosed crops (e.g. sunflower plants) receive up to 50 per cent of solar radiation in the upper layers, 20 per cent in the middle layers, 5 per cent in the lower layers, and 20 per cent of radiation penetrates even to the soil surface.

Radiation in different regions of the spectrum is attenuated in crops unequally. The upper tiers of crops, where fewer leaves are concentrated, absorb half of the FAR, while the lower tiers receive little radiation (about 5 per cent). This is where the "light starvation" zone is located. Inside the stem, infrared radiation prevails, which is not involved in the process of photosynthesis.

Depending on the height of the Sun above the horizon, the greatest relative weakening of the radiation flux and changes in its spectral composition are observed at low altitudes. Some plants can regulate the intake of solar radiation to their individual parts within certain limits. For example, sunflower, alfalfa, and cotton plants direct their flowers towards the sun during the day.

The photosynthetic potential of plants (PP) is defined as the product of the leaf surface area and the number of days during the period from the appearance of the 3rd leaf to the end of active leaf work (technical ripeness:

$$\Phi\Pi = \frac{[(L_1 + L_2) \times T_1 + (L_2 + L_3) \times T_2 \dots]}{2}, \quad (1.10)$$

where $L + L_{12}$ is the sum of leaf area by periods in thousand m²/ha;

$T_1, T_2 \dots$ - the duration of the leaves, days;

Mathematically, FP is the integral of the growth rate of leaf area over the growing season or the sum of daily leaf area (as the main working unit of crops). In practice, the FP can be determined by adding the values of leaf area (m²/ha) for each day during the growing season. It has been established that the yield is most closely correlated with the FP indicator, since the size of the assimilation surface is of the greatest importance for the formation of biological and economic yield of agricultural plants.

It is known that one thousand FPs produce 2.3 - 4.0 kg of grain, 11.4 - 15.3 kg of potato plants, and 1.9 - 2.3 kg of perennial grass hay. On irrigated soils, for a grain harvest of 100 c/ha of corn, it is necessary to form FPs equal to 3.0-3.3 million units.

Methods to increase the use of FAR by plants. To increase the use of solar radiation due to the growth of PAR and increase the intensity of photosynthesis, it is necessary to:

- adjust the crop density and the associated leaf area;
- take *agrotechnical measures*: thinning crops, reducing or increasing seeding rates, creating backdrops of tall-stemmed plants, conducting compatible sowings, screening plants with protective film, using additional artificial lighting, changing the direction of sowing relative to the horizon, conducting special pruning of tree crowns, etc;
- use new varieties and hybrids with higher efficiency of the spraying equipment;
- to carry out gas fertilisation of plants in greenhouses, in particular, to increase the CO₂ content in the air to a certain limit in order to increase the intensity of photosynthesis and, consequently, plant productivity.

Technological measures to improve the efficiency of solar radiation use in agriculture. Today, humans are unable to change the resources of solar radiation to a large extent and in the direction they want. In agriculture, a number of scientifically based agrotechnical measures are used to regulate (increase or decrease) the amount of solar radiation received by a single plant. Most of the above measures are very simple and self-explanatory. Below is a description of only some of the measures that are of great practical importance.

In recent years, so-called *compatible crops have been increasingly* used. They can be *single-species* (two or more varieties of the same plant species are combined in one crop) and *mixed* (different plant species are combined). In Ukraine, corn-soybean crops deserve a lot of attention. Adding soybeans to corn plants dramatically increases protein yields. However, it should be remembered that for compatible crops, it is necessary to select the right plants, as not all plants can grow in such conditions.

Under the leadership of V.G. Vitkevych, field studies were conducted to determine the effect of sowing direction on the yield of winter wheat plants. The experiments showed that the wheat yield was highest when sown in the north-south direction. Repeating similar experiments with barley, potatoes, and oats confirmed the results with winter wheat. With the meridional direction of sowing, the yield increase was 13.9 per cent for barley plants, 8 per cent for potato plants, and up to 19 per cent for oat plants. At the same time, barley and potatoes contained more starch than when sown in the west to east direction.

The direction of sowing affects the quality and quantity of flax and hemp yields. For example, flax sown from west to east is taller and has a higher yield of quality fibre, although the quality of the seed is lower. The choice of sowing direction requires further research, taking into account important factors such as nutrition, specific weather conditions, microclimate, etc. In improving the use of solar energy by plants, the density of crops and the associated leaf area are of great importance.

Scientists have noted that irradiation of certain plant organs - seeds, potato tubers - with pulsed concentrated sunlight increases germination and germination energy, enhances growth, accelerates development, and increases productivity.

Plants ripen earlier and accumulate more organic matter. Product quality improves. It increases the content of protein, sugars, vitamins, etc. Here are some

examples. Under the influence of solar stimulation of sugar beet seeds, the weight of the roots grown from them increases by 15-20 per cent, and the sugar content by 1-1.5 per cent. This means an additional 700-1,000 kg of sugar per hectare.

One of the practical measures to improve the illumination of field plants is timely thinning of crops and weed control.

Moisture conditions are a very important factor in plant growth and development. At the same time, this factor can often be limiting for the formation of a crop, even in the Forest-Steppe region. The peculiarity of this factor is that in some cases, when applying agrotechnical or reclamation measures, its resource can be significantly regulated (minimisation of tillage, harrowing, rolling, planting forest belts), or even eliminated (irrigation). In general, this factor can be characterised in terms of three components: air humidity, precipitation and soil moisture.

Air humidity has a significant impact on agricultural production, determining the intensity of water evaporation from the underlying surface and plant transpiration. At high temperatures and low air humidity, the evaporation rate increases, and there is a mismatch between water supply and water consumption, which slows down plant growth and development.

At excessive humidity (= 80 per cent on wet days), transpiration is poor, flowering is delayed, pollination is insufficient, and plant productivity is reduced. Excessively high humidity promotes large-cell structure of plant tissues, which subsequently causes lodging in grain plants.

During the flowering period, high air humidity delays the flowering and fruiting of plants, prevents normal pollination of plants, and in the warm season, promotes the development of fungal and bacterial plant diseases (powdery mildew, white rot, late blight, various types of rust) and the reproduction of certain pests, which leads to a decrease in yield.

At optimum humidity (= 50-60 per cent), the transpiration apparatus of plants functions correctly, moisture exchange between plants and air is normal, and a high increase in organic mass is observed. High humidity during the ripening period delays the onset of full ripeness, increases the moisture content of grain and straw, which, firstly, makes harvesting bread more difficult, and secondly, causes grain germination. When the saturation deficit is reduced to 3 hPa, grain harvesting is stopped. Low humidity causes even more trouble for plants.

At low humidity (= 30 per cent on dry days), transpiration increases, organic mass growth decreases, and dry winds can cause deformation of fruiting organs and even death of plants from desiccation. A decrease in relative humidity causes a loss of turgor in the leaves, and if this phenomenon is observed for several days, the leaves dry out, the photosynthetic surface decreases and part of the yield is lost. The decrease in air humidity is particularly harmful during the flowering and grain filling periods of cereals. Low humidity causes pollen to dry out, which contributes to incomplete fertilisation. In addition, low humidity during the grain filling period causes grain shrinkage and a decrease in yield.

Air humidity is the content of water vapour in the atmosphere. Water vapour is constantly released into the atmosphere as a result of the evaporation of water from the

surface of bodies of water, soil, snow, ice and vegetation. The content of water vapour and water in the atmosphere is $1.29 \cdot 10^3$ per cent.

Air humidity has a significant impact on agricultural production. Air humidity largely determines the intensity of plant transpiration. High humidity during the period of bread ripening delays the onset of full ripeness, increases the moisture content of grain and straw, which, firstly, makes harvesting bread more difficult, and secondly, causes grain germination. Reducing the saturation deficit to 3 hPa causes a complete cessation of grain harvesting. A value of $d \geq 8$ hPa is conducive to harvesting.

High humidity in summer causes the emergence and spread of fungal diseases of plants: powdery mildew, white rot, late blight, various types of rust, and mildew on grapes. Low humidity causes even more trouble for plants. Low humidity combined with a lack of soil moisture is particularly dangerous. If the relative humidity is 30 per cent or less, and the reserves of productive moisture in the tilth layer are no more than 5 mm, and in the metre layer - no more than 30 mm during the grain filling period, the seeds become shrivelled and their quality deteriorates. High air temperatures (above 25°C), low relative humidity (≤ 30 percent) and low productive moisture reserves (≤ 30 mm in the 1 m layer) cause the phenomena of "firing" and "grabbing" of grain.

"*Fervour*" - incomplete grain filling due to high temperatures and high air dryness. "*Fascination*" - incomplete filling due to high temperatures and low reserves of productive moisture or rapid drying of grain under the influence of dry winds.

It has been established that the optimal conditions for plants are when the relative humidity is 60-80 per cent. At less than 60 per cent, the intensity of photosynthesis decreases significantly, and at 30 per cent (air drought), the absorption of carbon dioxide by plants stops. Conditions when humidity exceeds 90 per cent also have a negative impact on photosynthetic performance.

Atmospheric precipitation. *Precipitation, its classification, distribution and importance in the soil water balance. Efficiency of precipitation. The role of precipitation in the formation of soil moisture reserves.* *Precipitation is water in liquid or solid form that falls to the soil surface and ground objects from clouds (rain, snow, hail, cereal, drizzle, etc.) or settles from the air as a result of condensation of vapour in it (dew).*

The formation of precipitation requires a number of processes to take place in the atmosphere. As upward movements occur, due to the adiabatic decrease in temperature, the air reaches a state of saturation, water vapour condenses, and clouds form. During condensation, small droplets are formed and suspended in the atmosphere. In order for them to fall from the cloud to the earth's surface, their size must be much larger. The droplets float in the atmosphere under the influence of air movement, and when they meet, they merge into one, i.e. the process of coagulation takes place. Coagulation is facilitated by the different charges of the droplets. It is important that the droplets are of different sizes. Larger drops fall faster, which helps to promote coagulation. The development of turbulent movements also contributes to the collision of droplets. As a result of coagulation, the largest droplets fall from layered clouds in the form of drizzle. Small, light rain can fall from powerful cumulonimbus clouds, especially in tropical latitudes where clouds have a high water content. There is no real rain as a result of coagulation.

There are *liquid, solid and mixed precipitation*. Liquid precipitation includes rain and drizzle, solid precipitation includes snow, snow grit and grains, freezing rain, hail, and mixed precipitation includes sleet.

Atmospheric precipitation is divided into precipitation, storm precipitation, and drizzle precipitation.

Siege precipitation falls mainly from layered rain, layered cumulonimbus and highly stratiform clouds, continuously, for a rather long time and covers a large area; it is usually well absorbed by the soil.

Storm precipitation - falls from cumulonimbus clouds for a relatively short time, covers a relatively small area, follows a "streak" and is often accompanied by strong winds. The soil does not have time to absorb moisture during such precipitation, and the moisture is transferred mainly to runoff, causing soil erosion on slopes, sometimes even washing away plants with poorly developed root systems.

Drizzle is precipitation consisting of very small droplets that do not form a circle when they fall on a water surface. Drizzle usually falls from dense, layered clouds.

Precipitation is classified according to the *synoptic conditions of formation*. They can be intra-mass and frontal.

Intra-mass precipitation - formed in homogeneous air masses. Stable warm air masses are characterised by precipitation in the form of drizzle from layered clouds or in the form of light rain (drizzle) from dense layered cumulus clouds. Unstable cold air masses are characterised by heavy rainfall.

Frontal - associated with the formation of atmospheric fronts. Warm weather is characterised by siege precipitation, while cold weather is characterised by heavy rainfall; if the first type of cold weather is observed, then heavy rainfall is observed first, turning into siege precipitation.

The important characteristics of precipitation falling from clouds are its *amount* and *intensity*. *Precipitation* is defined as the thickness (in mm or cm) of the layer of water that would form on the earth's surface if precipitation did not run off, evaporate, or seep into the soil. It is measured to the nearest 0.1 mm.

In agronomic practice, data on precipitation is often used in units of volume (m³/ha) or mass (t/ha). A 1 mm layer of precipitation on an area of 1 ha corresponds to a volume of $0.001 \text{ m} \times 100000 \text{ m}^2 = 10 \text{ m}^3$ of water (or its mass of 10 tonnes). The *intensity of precipitation* is determined by the amount of precipitation in millimetres falling per unit of time (mm/min).

The maximum intensity of individual rains and snowfalls is calculated from pluviograph tapes. The intensity of precipitation is one of the most important characteristics that affects the formation of flood runoff.

Precipitation is an important characteristic of moisture. On the globe, the annual amount of precipitation is equal to evaporation and amounts to 1,130 mm. It is the main source of water and soil moisture replenishment.

Precipitation is the main source of moisture for agricultural plants in the soil. The direct effect of precipitation on plants can be either positive or negative. The absorption of precipitation by the soil depends on the intensity and duration of precipitation, as well as on the terrain, soil structure and moisture, and the nature of the underlying surface. Precipitation is most favourable for agricultural plants, as it is well

absorbed by the soil. Storm precipitation is often less productive. Heavy precipitation causes crops and grasses to lie down and interferes with agricultural work. Rainy weather delays the maturation of all plants. At the same time, a prolonged lack of rainfall causes drought. This leads to a delay in the accumulation of organic matter by plants, gradual wilting of plants and their death. Fluctuations in crop yields are largely related to fluctuations in precipitation during the growing season. The precipitation regime determines the means of harvesting grain plants. Accounting for the precipitation regime is necessary to substantiate the agricultural technology of growing various agricultural plants, to determine the timing and methods of their harvesting.

The daily precipitation course is determined by the course and nature of cloud cover. In the middle latitudes, there are two maximums and two minimums of precipitation during the day. The main maximum usually occurs in the afternoon, the main minimum - at midnight. The second maximum is in the early morning, and the second minimum is in the afternoon. In maritime (coastal) climates, the maximum is at night and the minimum is in the afternoon. The correct daily precipitation pattern is disrupted by the intrusion of air masses and associated frontal precipitation.

Precipitation in different regions of Ukraine varies significantly in terms of quantity, distribution, annual course, intensity, duration, etc. The largest amount of precipitation falls in the Ukrainian Carpathians and Crimean Mountains. The influence of the Donetsk, Volyn, Podillia, Prydniprovya and Azov Uplands is insignificant due to their low altitude. Waterlogging (650 - 700 mm) is observed in the northwestern part, including the foothills of the Ukrainian Carpathians. In the forest-steppe, the amount of precipitation per year is 550-650 mm, in the north-east, in the Desna basin - 600 mm, and on the border between forest-steppe and steppe - 500 mm. Ukraine has a continental type of annual precipitation pattern, with warm-season precipitation being three times higher than cold-season precipitation.

The most favourable precipitation for plants is prolonged rainfall. These large plant species usually vary the most over the years. For example, in Sumy MS, the highest annual precipitation is 735 mm, the lowest is 349 mm, with an average of 540 mm. For MS Mykolaiv, these values are respectively: 695 mm, 199 mm and 422 mm [10]. In this regard, it is very important to establish the likelihood of certain conditions and determine their most frequent occurrence.

If there is no precipitation for 8-10 days (in June - August) in the topsoil, where there are a lot of roots (and sometimes the bulk of them are located there), a significant moisture deficit is created, and in the case of high temperatures, plant growth and development is delayed, wilting and subsequent drying of the leaves.

Soil moisture.

Low humidity in combination with a lack of soil moisture is particularly dangerous. If the relative humidity is 30 per cent or less, and the reserves of productive moisture in the tilth layer are no more than 5 mm, and in the metre layer - no more than 30 mm during the grain filling period, the seeds become shrivelled and their quality deteriorates. The combination of low air humidity, high temperatures and low reserves of productive moisture leads to the formation of small fruits and berries, reduces their yield and quality and causes poor budding for the next year's harvest.

However, low air humidity during the ripening period of grapes and sugar beet increases the sugar content of berries and root crops. Humidity also affects the timing of agricultural operations: grain drying, silage laying, weed control, etc. Humidity also affects the physiological processes in farm animals, primarily thermoregulation. High humidity impedes heat transfer, which can lead to overheating or heatstroke, and at low temperatures - to hypothermia, colds and skin diseases.

Agrometeorological indicators of plant water requirements, methods of their determination. Critical periods in plant development. The degree to which the need of plants for soil moisture to form high yields corresponds to the available reserves of productive moisture in the soil is called *plant water availability*. The assessment of plant moisture availability is given in points depending on the condition of the plants: 1 point - very poor moisture availability; 2 points - poor, low, insufficient; 3 points - sufficient, optimal.

The problem of water availability for plants is extremely complex, as not only physiological and physical aspects, but also the peculiarities of such a complex system as soil must be taken into account in the process of plant nutrition. That is why it is currently impossible to clearly define the most effective criteria for assessing water availability. The complexity of the problem makes it necessary to use not just one, but several assessment indicators, including *precipitation*.

One of the most common characteristics of the incoming part of the water balance. The water availability of plants according to this indicator is determined by comparing its value in a particular year with the climatic norm. The closeness of the values indicates that the moisture availability in a particular year corresponds to the climatic potential of a particular area. Therefore, it is necessary to remember that with the same amount of precipitation in different areas, in different periods of plant development, the availability of moisture will be different.

Least moisture capacity (LMC) is the upper limit of optimal soil moisture for plants. For chernozem soils, the optimum moisture availability is considered to be a value of WC = 180 - 200 mm, for loamy soils - 170 - 180 mm, for sandy loam - 150 - 160 mm, and for sandy loam - 80 - 120 mm. A decrease in soil moisture to 70 - 80 percent of the HB (for chernozems to 140 - 160 mm) characterises satisfactory moisture availability.

The hydrothermal coefficient of Selyaninov directly depends on the amount of precipitation and inversely on the possible evapotranspiration of moisture by plants. This coefficient is based on the premise that the degree of moisture in a territory directly affects evapotranspiration. The Selyaninov hydrothermal coefficient is determined by the formula:

$$DTC = r/0.1 U_{t > 10^{\circ}C}, \quad (1.11)$$

where r is the amount of precipitation that fell during the period with a temperature above $10^{\circ}C$;

$U_{t > 10^{\circ}C}$ is the sum of active temperatures above $10^{\circ}C$.

The multiplier $0.1 U_{t > 10^{\circ}C}$ characterises evapotranspiration. If the value of the GTC is less than 0.5, the period is considered dry; 0.5 - 0.9 - arid; 1.0 - 1.3 - normally moist; 1.4 - 1.6 - wet; more than 1.6 - excessively moist.

Productive soil moisture is an important complex indicator of agricultural field and plant moisture, including precipitation, evaporation, vertical soil moisture exchange, and runoff. Despite the complexity of its definition, it is the most accurate indicator of moisture availability. By linking this value and the moisture needs of plants for different periods of development, the *soil moisture reserves are estimated* for the following soil layers:

- topsoil 0 - 20 cm deep - moisture reserves are very low - 5 mm or less; insufficient - 19 - 5 mm, satisfactory - 29 - 20 mm, optimal - 40 - 30 mm;
- soil layer 0 - 50 cm - insufficient moisture reserves, less than 30 mm, optimal 80 - 60 mm;
- soil layer 0 - 100 mm - insufficient moisture reserves 130 - 80 mm, optimal 180 - 160 mm.

With very low (less than 5 mm) reserves of productive moisture in the tilth (0-20 cm) soil layer, seedlings do not appear. Nine dry ten-day periods during the growing season practically lead to the death of grain. With excessive soil moisture, it is not the amount of moisture and nutrients that plays a decisive role in plant development, but the amount of air in the soil. It is known that the intensity of gas exchange between the soil and the atmosphere required for plants is observed at an air content in the soil of 13-35 per cent of the PV and depends on the needs of the plants. Lack of oxygen is more harmful to plants than lack of moisture.

Excessively wet soil is harmful not only during the period of plant growth and development, but also before sowing, as microbiological processes in the soil slow down, leading to a decrease in soil fertility. Excessively moist soils have a negative impact on plants not only because of the amount of moisture, but also because of the duration of the waterlogging period. For example, five waterlogged days during the germination and tillering period reduce grain yields by up to 70-80 per cent.

Evaporation, transpiration, transpiration coefficient. Influence of meteorological factors on evaporation and transpiration.

The Earth's water resources - atmospheric moisture, surface water, groundwater and groundwater - are closely interconnected with the water cycle. The main factors affecting the water cycle in nature are heat energy and gravity. Heat causes evaporation and condensation of water vapour, and gravity causes rain drops to fall, rivers to flow, and surface and groundwater to move.

Soil moisture is an indicator that has a significant impact on plant growth and development. The most common characteristics of soil moisture are evaporation, evapotranspiration and reserves of productive moisture in the soil

Evaporation is the process of substances changing from a liquid or solid state to a gaseous state. Quantitatively, evaporation is characterised by the *rate of evaporation of a mass of water (its layer thickness) that evaporates per unit of time*. A 1 mm layer of water evaporated from an area of 1 m^2 corresponds to a mass of water of 1 kg or 1 litre (1 mm layer of water = $10 \text{ m}^3 / \text{ha} = 10 \text{ t/ha}$). The dependence of the evaporation rate on wind speed is explained by the turbulent diffusion of water vapour, which increases with increasing wind speed. The rate of evaporation from the soil surface depends on its surface condition, physical properties, temperature and humidity, relief, presence and type of vegetation cover, air humidity, wind speed, etc. Evaporation is

greater from wet and dark soils, as well as from uneven field surfaces (ploughing). Therefore, in the spring, in arid areas, to reduce evaporation, the ploughed field is tamped down with rollers.

Sandy soils evaporate water less than clay soils. The larger the sand particles, the less evaporation. If the diameter of the sand particles is 2 mm or more, evaporation is almost non-existent. Evaporation is also affected by the depth of the groundwater. Evaporation will be greater where the groundwater is closer to the surface.

The evaporation of water by plants is called *transpiration*. By consuming water from the soil, plants provide themselves with nutrients and enhance photosynthesis.

The amount of water that plants need to produce a unit mass of dry matter is called the *transpiration rate*. The value of the transpiration coefficient depends on the plant species and variety, the state and phase of its development, and the environmental conditions.

Total evapotranspiration includes transpiration, evaporation from the soil and evaporation of moisture retained by plants during precipitation. Evaporation varies throughout the day and throughout the year. Total evaporation reaches its highest values at 13-14 hours. In the warm season, the daily course of evapotranspiration is clearer than in winter. The annual value of total evaporation depends on the course of temperature and air and soil humidity. In a dry year, the integral value of total evaporation, despite the significant energy inputs, is much lower than in wet years, when the evaporation rate is much higher due to high moisture reserves.

Evapotranspiration is the potential evaporation, not limited by water reserves, in a given area from a wetted soil or water surface under existing meteorological conditions. Evapotranspiration, like evaporation, is measured in mm of water layer. In the CIS, evapotranspiration varies from northwest to southeast from 320 to 1200 mm. In agrometeorology, evapotranspiration is equated to the moisture demand of plants, i.e. the amount of water a plant consumes under given meteorological conditions with an uninterrupted supply of water by the roots. *Total evapotranspiration* is the water consumption, or otherwise the amount of water that is consumed from a field occupied by plants under natural moisture under given meteorological conditions. Evaporation from the soil surface is measured using lysimeters or soil evaporators GGI-500-50 or GGI-500-100. These are soil monoliths with an undisturbed structure inside metal cylinders. The most advanced device for measuring evaporation is a hydraulic soil evaporator (HSE). To measure evapotranspiration from the water surface, evaporators GGI-3000 (0.3 m² area, 60 cm depth) are used or evaporation pools with an area of 20 m² are built. Large-scale evaporation and evapotranspiration rates are of great importance for solving many problems, among which the leading ones are water supply, irrigation, drainage, etc. Therefore, in practice, various empirical methods are used to determine evaporation and evapotranspiration.

To calculate the total evaporation and evapotranspiration, we also use calculation methods such as water balance, turbulent diffusion, complex methods of M.I. Budyko - L.I. Zubenko, S.I. Kharchenko, Penman, Thorntveit, O.R. Konstantinov, etc. One of the most important tasks of agricultural technology is to reduce unproductive evaporation from the soil and weeds. The solution to this problem is achieved by various measures.

Total moisture, in turn, consists of unavailable and available moisture for plants. Unavailable moisture is moisture that cannot be used by plants. It is numerically equal to the hygroscopic moisture content (available at Γ). Hygroscopic moisture depends primarily on the particle size distribution of soils and the degree of their humification. Thus, for sand, it is 0.5-1.0 per cent, for clay 9.0-15 per cent, and for peat 26-33 per cent. However, on the other hand, there is a limit to soil moisture at which irreversible processes in plants begin (the moisture content of stable wilting - MW). This is the lower limit of soil moisture. It is $(1.5-1.34) V_{\Gamma}$. In this case, the practically inaccessible amount of moisture (HW) is: for sand 1.5 per cent, clay 12-20 per cent, peat 40-50 per cent. The difference between the actual moisture (W) and the VM is called productive moisture.

Productive moisture is studied by the agrometeorological service in separate layers every 10 days under the main plants.

It should be noted that this value varies over the years within a very wide range, and, for example, at the end of the third decade of August (Hlukhiv) in the one-metre soil layer, it is: the highest value is 183 mm, the lowest is 36 mm, and the average is 102 mm. Thus, in this case, too, the problem is to establish the most likely conditions, or the conditions that occur most often (Fig. 1.3, 1.4).

All of the above suggests that the main moisture resources that can be relied on when assessing the moisture availability of a plant are the reserves of productive moisture in the soil at the beginning of the growing season (PV_{Γ}) and the expected precipitation during the growing season, taking into account the coefficient of their use ($m\Sigma A$).

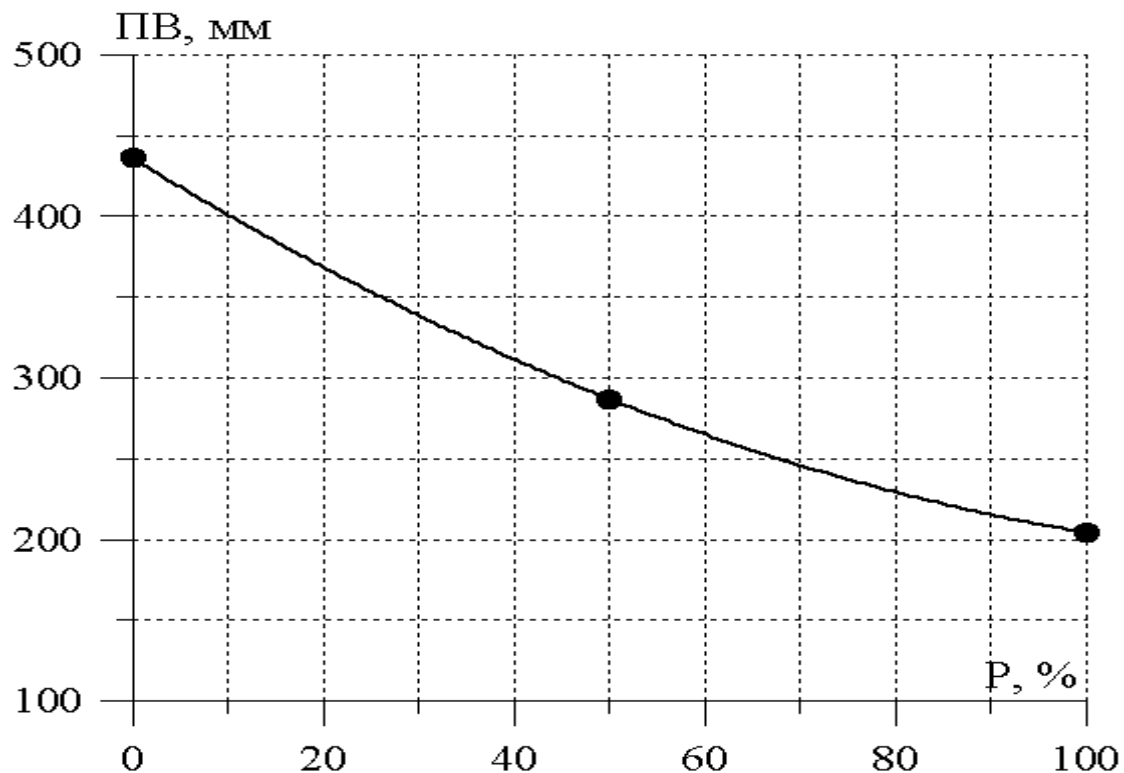


Fig. 1.3. Probabilistic curve of productive moisture of the growing season of spring barley plants

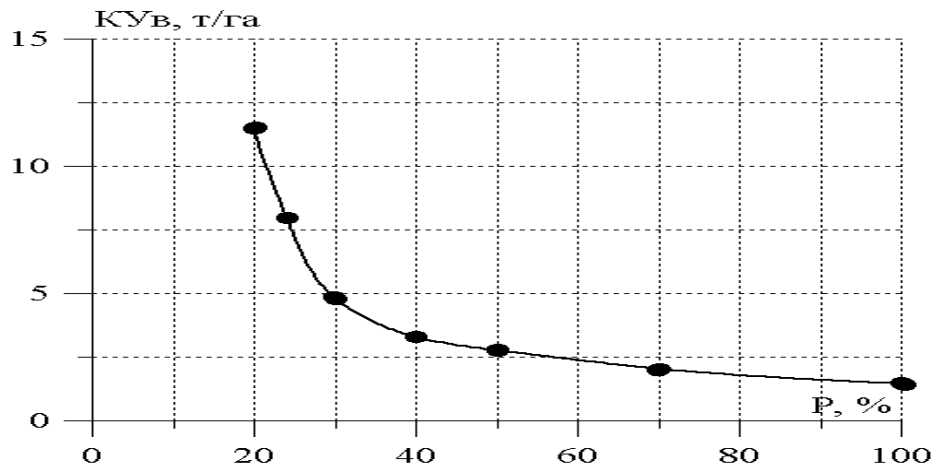


Fig. 1.4. Probabilistic curve of climatically provided spring barley yield with moisture resources

There is no doubt that in this case, only the total moisture resource and its possible realisation by plant yields are assessed. The work of V.V. Medvedev and I.V. Plisko emphasises the importance for spring cereal plants of productive moisture reserves in the tilth layer for the sowing - germination period and in the metre layer for the period of formation of generative organs. According to these data, favourable conditions are created in the first case when they are 30-40 mm, and in the second case when they are 130-160 mm. Under the first condition, the area of arable land with favourable and very favourable conditions is about 40 per cent, and under the second - only about 11 per cent.

Methods for determining soil moisture. The main method for measuring soil moisture is the thermostat-weight method, which is generally considered the benchmark for evaluating other methods. According to this method, soil samples are taken every 10 cm to a depth of 100-150 cm with an AM-16 soil drill, which are then transferred to aluminium bins. In the laboratory, they are weighed to the nearest 0.1 g, then placed in a thermostat for 7 to 8 hours to dry completely at a temperature of 100 to 105°C and weighed again.

Other devices used to determine soil moisture are radiometric moisture meters. Its principle of operation is based on the effect of scattering and slowing down fast neutrons by hydrogen atoms contained in water molecules. The moisture meter records the total flux of neutrons and gamma radiation. The total moisture reserves, measured in millimetres of the water layer, are obtained from the conversion charts provided with each device.

There are aerial methods for measuring soil moisture. The principle of determining soil moisture is based on the effect of soil moisture attenuating gamma radiation from natural radioactive elements contained in the soil. The gamma-ray method determines the soil moisture content of the upper 0-30 cm soil layer with an error of 1 to 2 percent. The device is placed on aircraft and helicopters.

The soil moisture regime is characterised by the presence of different categories of moisture in the soil, which have different properties. The nodal points where the

properties and availability of soil moisture to plants change dramatically are called *agrohydrological constants (properties)*.

Sustainable wilting moisture (SWM) is the amount of soil moisture that starts the irreversible process of plant wilting, namely, the internal pressure decreases and turgor is not restored. This is a critical amount of moisture. The soil moisture reserve depends on the soil's mechanical composition. In sandy soils, it is 1.5-4 per cent. In clay soils, it increases to 20 per cent, and in marsh soils - 40-50 per cent. Moisture that is below the wilting point and is insufficient for plants is called *unproductive moisture* (dead space). This moisture is retained in the soil by hygroscopic forces, surface tension forces and molecular forces if it is bound. These forces are only the osmotic pressure in plant cells. The heavier the soil, the more moisture it contains that is not available to plants.

Water in the capillary spaces of the soil is called *capillary water*. The pores are 2 mm in diameter. The movement of capillary water is governed by the laws of capillarity.

Total moisture capacity (TMC) - is observed when water fills all the gaps and pores in the soil, which negatively affects plants.

The lowest moisture capacity is the amount of water that the soil can hold at most, provided it drains freely. At this moisture content, optimal soil moisture reserves are formed.

Productive moisture. The soil moisture regime is characterised by the presence of different categories of moisture in the soil, which have different properties. Of the total amount of moisture contained in the soil, the most important is the part that provides water for plants.

Productive moisture is expressed by the height of the water layer in millimetres, which allows comparing its reserves with the evaporation and precipitation losses, which are also measured in millimetres.

Total and productive soil moisture reserves. Productive soil moisture is an important complex indicator of agricultural field and plant moisture, which includes precipitation, evaporation, runoff, and vertical soil moisture exchange.

Productive moisture is the part of the soil moisture that plants use for their vital functions and crop production. It is mobile water that moves in the soil under the influence of gravity. The productive moisture is subtracted from the *stable wilting moisture* (SWM), i.e. the moisture corresponding to the wilting coefficient is taken as 0.

Optimum productive moisture content is a prerequisite for plant growth and development. A lack of moisture in the soil disrupts the water balance of plants, reduces transpiration, inhibits photosynthesis and other vital processes, and disrupts normal metabolism. As a result, the length of the annual shoot and the width of the radial growth are reduced, and the leaves dry out prematurely. In habitats with a constant lack of moisture, sparse, stunted stands are formed. Excessive moisture in the soil worsens aeration, and thus the conditions for root breathing deteriorate. In such conditions, low-growing stands with a weak root system are formed, which are often damaged by strong winds (windbreaks).

The thermal regime of the atmosphere is the nature of the distribution and change of temperature in the atmosphere. The thermal regime of the atmosphere is determined mainly by its heat exchange with the environment. The surface layer of the atmosphere plays an important role in the development of processes related to the interaction between the atmosphere and the green surface. It is several tens of metres thick, and its condition has a major impact on flora and fauna, and on the living conditions of all living things.

The main source of heating of the surface layer is heat from the active surface. Heat transfer between the active surface and the atmosphere, as well as in the atmosphere itself, is carried out through convective and turbulent flows.

Heat flux is the volume of heat transferred by air flow over a unit area per unit time in a direction perpendicular to the area. Convective and turbulent heat fluxes cause changes in the temperature of the surface air layer both during the day and throughout the year. The daily course of air temperature has a maximum at 14-15 h and a minimum before sunrise.

The amplitude of temperature fluctuations depends on weather conditions, time of year, terrain, and physical properties of the soil and is an important characteristic of the climate. In clear weather, the amplitude of the temperature fluctuations is higher than in cloudy weather, as clouds retain radiation and thus increase the nighttime temperature. The annual variation of air temperature in different geographical zones is different and depends on the latitude of the place, its continentality, location and altitude. A characteristic of the annual variation of air temperature is the amplitude of annual fluctuations in air temperature (the difference between the average monthly temperature of the warmest and coldest month).

Indicators of heat supply conditions can be divided into major categories that characterise the level of thermal conditions and the availability of heat energy in the territory.

The thermal regime is determined by the peculiarities of solar radiation, atmospheric circulation and the nature of the underlying soil surface. It is one of the main factors that determines the nature of weather processes and regulates physiological and biochemical processes in plants and soil. Plant productivity depends significantly on the level of temperature in the range of biological maximum and minimum. The dynamics of the thermal regime of the air determines the beginning and end of the growing season and, as a result, field work. Thus, the dates of transition (in spring and autumn) of air temperature through $+5^{\circ}\text{C}$ are considered to be the limits of the growing season of winter wheat plants (or the standard period). This period is very different in different zones of Ukraine. Thus, while in Lutsk the average period is 213 days (6.04-30.10), in Simferopol it is 239 days (27.03-20.11), or 26 days longer.

The dates when the temperature passes $+10^{\circ}\text{C}$ limit the period of active vegetation. According to the same meteorological stations, this period lasts 161 days (27.04-03.10) and 189 days (19.04-23.10), respectively, i.e. the difference is 28 days.

The dates when the temperature crosses $+15^{\circ}\text{C}$ limit the growing season of heat-loving plants. According to the same weather stations, this period is 105 and 129 days, respectively, with a difference of 24 days.

Thus, the difference in the length of the growing season with different

restrictions in different zones is 24-28 days, which indicates a significant difference in the conditions for the formation of crops and their possible value.

The sum of active temperatures is the sum of average daily temperatures above 10°C . This period is also called the active growing season. This sum varies significantly across the country's zones. For example, the lowest average value of this sum was recorded in Rivne (2580), and the highest in Klepenyne (3440), i.e. the difference is on average 860°C . This clearly indicates that cultivation techniques, as well as plants and their varieties, should have differences.

It should also be noted that fluctuations in this amount over the years in the same zone are even greater than in the zones. For example, the difference between the highest and lowest values of this large plant in the Rivne MS is 1076, in the Klepenine MS - 1134, in the Sumy MS - 1022°C . This clearly indicates that even in a particular zone, both technology elements and plant varieties can be differently effective.

It is known that the requirements of agricultural plants of a short growing season (April - July) vary by $500\text{-}1800^{\circ}\text{C}$ depending on the plant and variety. It is generally accepted that the availability of the required amount of active temperatures of 80-90 per cent is quite high, as the risk of incomplete maturation of the plant is only 10-20 per cent, and if the availability is 50 per cent, growing the plant is not worthwhile. It is believed that the dependence of yield on the sum of active temperatures is directly proportional, which clearly indicates that any increase in the heat resource ensures an increase in yield.

However, this relationship exists only for a specific temperature range, which is determined by the characteristics of the plant. The same data shows that the vast majority of the country's arable land (55 per cent) is rated as very favourable and favourable in terms of heat resources, and only about 8 per cent is rated as unfavourable and very unfavourable.

Plants with a 45-60 day longer growing season have higher heat requirements. The essence of this is to compare the existing resource in a particular zone with the requirements of individual plants. Thus, the sum of temperatures during the active growing season in Polissya is $2400\text{-}2600^{\circ}\text{C}$, in the Forest-Steppe $2400\text{-}2900^{\circ}\text{C}$, in the Steppe $2800\text{-}3500^{\circ}\text{C}$. At the same time, for the maturation of late-ripening varieties and hybrids of corn for seed, the required temperature is 3200°C , sugar beet - 2800°C , sunflower plants - 2700°C . It was found that in Ukraine, the area of arable land with very favourable and favourable conditions for providing heat to plants with a long growing season is 45 per cent.

All of the above suggests that the first problem is to determine how often certain conditions occur, because it is known that varieties and hybrids of a plant require different amounts of temperature to form a full-fledged crop. It is also known that the earlier the variety, the less heat it needs, but it is less productive than medium or late varieties. This makes it necessary to grow varieties with different growing seasons on the farm, which is especially true for heat-loving plants (e.g., maize for seed).

As an example, the probability curve of the sum of temperatures during the active vegetation period in Sumy metropolitan area is shown in Fig. 1.5.

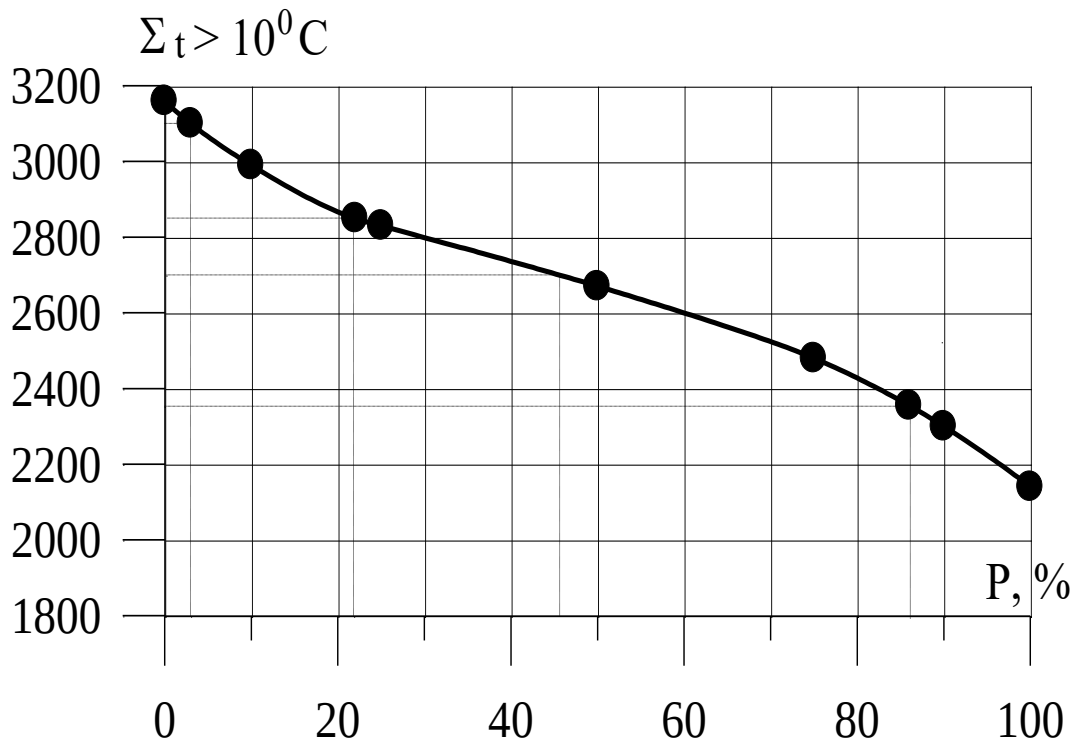


Fig 1.5. Probability curve of the temperature sum for the period of active vegetation (MS Sum)

From the above data, it can be argued that if a particular variety (hybrid) of corn plant requires a temperature of 2800°C to form a full grain harvest, the probability of these conditions is only 28 per cent, i.e. the risk in this case is 72 per cent. In general, it can be argued that in these conditions it is advisable to grow such varieties (hybrids), for the formation of the crop, the sum of temperatures should not exceed 2670°C ($P = 50$ per cent).

As a rule, in this case, it is necessary to establish the yield that can be provided by a particular heat resource

Currently, there are several ways to determine the climate-supported yield by heat resources (KU_t). However, given that heat and moisture as growth factors, on the one hand, and weather characteristics, on the other, are quite closely related, existing calculation methods take them into account. At the same time, sowing productivity can be limited by both moisture and heat resources. This approach is all the more appropriate because each specific growing season is characterised by a specific moisture and heat ratio, and thus allows for a particular crop to be produced.

One possible way to determine this is to calculate the resource-supplied yield by the hydrothermal index (absolutely dry biomass), which is calculated by the formula of A.M. Ryabchikov:

$$CG_{\Gamma\text{TH}} = 2.2GTP - 1.0, \text{ t/ha}, \quad (1.12)$$

where. $CU_{\Gamma\text{TH}}$ is the yield that can be obtained due to hydrothermal potential in absolutely dry biomass, t/ha;

The analysis of the above dependencies shows that the value of this yield depends on the heat (R) and water (W) factors and is determined in each case by their

ratio. Given that this ratio can be any, it should be considered inappropriate to consider such a plant yield (CG_{III}) in the entire possible range of changes in growth factors (R , W). On the other hand, the relatively small fluctuation over the years of FAR values, and hence R , and a rather large fluctuation of VP values suggest that the fluctuation of plant yield, which is determined by hydrothermal potential, depends more on the water factor than on the thermal one.

All of this suggests that the definition of such a yield (CG_{III}) can only be appropriate for the conditions of a specific growing season with its own specific R and PV values.

Another method that takes into account the thermal factor to some extent is the method of calculating the possible yield by bioclimatic potential (BKP):

$$BKP = K_{zv} \frac{\sum t > 10^0 \text{C}}{1000^0}, \text{ points}, \quad (1.13)$$

where. $\sum t > 10^0 \text{C}$ - is the sum of active temperatures;

1000^0C is the sum of active temperatures at the northern boundary of field farming;

Wt is the moisture coefficient, which is equal to 1 in conditions of sufficient moisture, <1 in conditions of insufficient moisture, and excessive moisture > 1 .

It should be noted that this relationship allows us to directly, rather than indirectly, as in the previous method, establish the dependence of the possible yield of a plant on the thermal factor, i.e. the sum of active temperatures recorded at each weather station.

Thus, all of the above allows us to assert that a climate-secure crop in terms of bioclimatic potential (CG_{BKII}) is actually a climate-secure crop in terms of heat resources (CG_t), and the formula can be written as

$$KU_{BKII} = KU_t = KZ \frac{\sum t > 10^0}{1000^0} : KC, \text{ t/ha}. \quad (1.14)$$

When considering this issue, it should be noted that the sum of temperature during the active growing season fluctuates within very wide limits and the difference between its highest and lowest values reaches 1000 degrees or more. In this regard, it is advisable to consider the climate-secure yield by heat resources (KU_t) in the entire possible range of changes in the temperature sum. This makes it possible to construct a probability curve of both the sum of active temperatures and the yield provided by them.

However, these methods of calculating the climate-secure yield by heat resources do not take into account the condition that the $CU \leq PU$, i.e. the yield by heat resources, by definition, cannot exceed the potential capabilities of the variety.

To match the potential yield that has been or can be obtained under these conditions and is the maximum possible for a given variety in a particular zone, the method of taking into account the bioclimatic potential can be used as a basis. This means, first of all, that this coefficient should quantitatively take into account the level of plant cultivation that allowed to obtain the yield of a given variety ($Y_{\max} = PU = PU_{\phi}$). On the other hand, although indirectly, it takes into account the degree to which

the variety of this plant uses the period of active vegetation, which is determined by its growing season. In addition, this coefficient depends on the biological characteristics of the plant itself [40].

From the point of view of heat supply, frosts are a harmful and dangerous phenomenon - a decrease in air and soil temperature to 0°C and below at a steady state of positive temperatures. They are known to occur:

- Advective, resulting from the intrusion of cold Arctic air (spring, autumn). This causes a decrease in the temperature throughout the surface air layer. The amplitude of the daily course of the tempest is insignificant. They spread over large areas, last for several days, and have little dependence on local conditions.
- Radiation - intensive cooling of the soil surface and the adjacent layer on clear cold nights at low temperatures. In this case, the field surface is $2.5\text{--}3.0^{\circ}\text{C}$ colder than the air (at a height of 2 m)⁰.
- Mixed frosts - the intrusion of cold air plus further cooling of the field surface (late spring, early summer, early autumn).

Critical temperatures of damage to field, fruit and berry plants. Classification of agricultural plants according to their resistance to frost. The degree of damage to plants by frost depends on its intensity and duration, as well as on the condition of the plant, its species, variety, developmental stage, sowing structure, etc.

Soil temperature.

Soil temperature is significantly affected by the topography and the presence of vegetation. In spring and autumn, southern slopes are warmer during the day and northern slopes are colder than an open, flat area. This is due to the distribution of total solar radiation.

Soil temperature is of great importance for the overwintering of winter plants. Soil temperature is particularly important at a depth of 3 cm . At this depth, the tillering node of winter plants is mostly located - the main organ that accumulates substances necessary for plants in harsh winter conditions. O.M. Shulgin found that the main indicators of wintering conditions for winter crops are soil temperature at a depth of 3 cm , snow depth, and soil freezing depth. In spring, soil temperature is also an important factor in plant life. With increasing soil temperature and good soil moisture, all processes are accelerated. A decrease in soil temperature in the spring leads to seed decay and damage, which in turn causes crops to thin out.

Seeds of cereal plants germinate at temperatures of $0 - 5^{\circ}\text{C}$; sunflower plants, potato plants - $5 - 8^{\circ}\text{C}$; corn and cabbage plants - $8 - 10^{\circ}\text{C}$; rice plants - $10 - 12^{\circ}\text{C}$; tomatoes, eggplants, peppers - $12 - 15^{\circ}\text{C}$; cotton, pumpkins - $13 - 15^{\circ}\text{C}$; melons, cucumbers - $15 - 18^{\circ}\text{C}$. Soil temperature plays an important role in biological and chemical processes that determine the direction and rate of transformation of specific substances in the soil. It has been established that at a soil temperature of 5°C , the supply of nitrogen and phosphorus to plants is 3 times less than at a temperature 20°C .

The conversion of nutrients into a form available to plants is facilitated by microorganisms, whose activity increases with increasing temperatures. The spread of pests and diseases is closely related to temperature. In thermophilic plants, diseases and damage to seedlings increase in cold springs. In cold soil ($t \ll 5^{\circ}\text{C}$), the number

of wireworm larvae increases. In warm soil ($t = 10 - 12^{\circ}\text{C}$), the number of beet weevils, cabbage flies, winter scoops, etc. increases.

Soil temperature affects the timing of sowing, seed germination rate, root growth, nutrient supply to plants, and the rate of development of pests and diseases of agricultural plants. The thermal regime of the soil and the surface air layer determines not only the pace of plant development, but also the size of the crop as a whole.

The influence of temperature on sowing dates. The optimum sowing time is determined by the biological characteristics of the crop and agrometeorological conditions, primarily soil temperature.

For spring plants, the temperature of seed germination is of great importance, as well as the ability of seedlings to withstand possible spring frosts. Seeds of most agricultural plants begin germinating at temperatures of $3 - 5^{\circ}\text{C}$, thermophilic plants at $13 - 15^{\circ}\text{C}$, and temperatures of $10 - 12^{\circ}\text{C}$ and $20 - 25^{\circ}\text{C}$ are considered optimal for these plants, respectively.

If the sowing dates deviate from the optimal ones, the plants develop in a different rhythm of meteorological conditions, which is different from the biological needs of the plant. For example, early crops have better moisture availability, but the risk of frost damage to their seedlings also increases. Early crops are more sensitive to fertilisers. Therefore, a one-month delay reduces the effectiveness of fertilisers and reduces yields by 38-44%.

Late sowing reduces the risk of frost damage to seedlings, but due to intensive evaporation of productive moisture and soil, reduced precipitation, their moisture availability may decrease to critical levels.

Late crops fall under the period of mass oviposition of pests (favourable temperature of $18 - 30^{\circ}\text{C}$) at an early stage of development, which affects the main stem, which in turn has a more intense effect on yield reduction.

Thus, in the climatic conditions of the East and South of Ukraine, early sowing of early spring crops is considered to be the best time, especially in years with dry summers.

Seed germination rate. With the increase in soil temperature, the processes of seed germination become more active. And each subsequent phase of development requires a higher minimum temperature compared to the previous phase.

Root system growth. When sowing in cold soil (early stages), the temporalis grows slowly, and the growth of the root system outstrips the development of the aerial part. At later dates, when the temporalis grows intensively, the aerial part of the plants is formed more rapidly, and the root system retreats in growth. Plants with a more developed root system are able to use moisture from deeper soil layers, which can insure them against the effects of drought. This is achieved with very early sowing in cold soil. If it is necessary to have a more developed above-ground part, sowing is delayed in order to destroy weeds that have sprouted before sowing.

The activity of microorganisms, the intensity of organic matter decomposition, and the ability of plants to absorb nutrients depend on soil temperature. With increasing temperature, these processes become more active. For example, at a soil temperature

of 5° C, the supply of nitrogen and phosphorus to the plant is three times less than at a temperature of 20° C.

Along with light, heat is one of the main factors in plant life and the necessary conditions for biological, chemical and physical processes. The thermal regime of the soil and the surface air layer determines not only the pace of plant development, but also the size of the crop as a whole.

Soil temperature affects the development of plants at the beginning of their life. At low temperatures, seeds fail to germinate and rot during prolonged cold weather. But too high soil temperatures are also harmful during this period. Therefore, sowing should be done at the optimum and shortest possible time, taking into account soil temperature along with other factors.

Soil temperature also affects the length of the growing season, the effectiveness of mineral fertilisers, and the start of certain agricultural operations. Soil temperature affects the gas exchange between soil and atmospheric air and the spread of crop pests. It also determines the moisture supply of plants. At temperatures below 0° C, water in the soil freezes, so it cannot be absorbed by plant roots.

Low soil temperatures reduce the yield of reproductive organs (grain), but increase the yield of total mass (straw, roots) in cereal plants. To a lesser extent, low soil temperatures affect the yield of plants that form vegetative mass (grasses, potatoes, root crops).

To improve the thermal properties of the soil, targeted *methods of influence* are used:

a) to increase the temperature of the surface soil layers and to use them more rationally;

b) to protect the soil from excessive overheating.

Measures aimed at increasing the temperature of surface soil layers:

- loosening the topsoil in the spring (reduces thermal conductivity and accumulates energy in the topsoil);

- rolling crops (compacted soil conducts heat better and cools down less at night);

- ridge and bed planting (solar radiation falls on ridges at a greater angle than on a horizontal surface, so they receive more heat);

- backstage crops (protecting the main plants from the wind, which reduces air exchange, resulting in soil and air temperatures rising above the crops by 3°C or more during the daytime);

- snow retention in winter;

- irrigation in the autumn (latent heat of vapour formation is released);

- mulching with dark mulch (coal powder, bitumen, which reduces albedo);

- applying organic fertilisers (energy is released during the decomposition of organic matter), etc;

Measures to protect the soil from excessive overheating:

- ploughing;

- irrigation (in spring and summer), watering with sprinklers;

- mulching with white mulch (chalk, straw, peat, which increases albedo);

- shading of crops, etc.

Other effective materials for mulching include polymer films and special papers, as well as various low-cost oil products and oil industry waste. Mulching as an agronomic measure should only be used after detailed field experiments have been carried out.

Shelterbelts create a special microclimate in the fields, reduce the daily and annual amplitude of temperature changes, and influence the thermal regime of soils. Indoor soil temperature is regulated by various types of structures (greenhouses, greenhouses, etc.) and soil insulation. The source of heat in such structures is solar radiation and artificial heating systems (winter greenhouses). Soil insulation is achieved by applying large amounts of organic fertiliser. For example, when 1 tonne of manure is fully decomposed, up to 125.7-167.6 million MJ/m² of heat is released. This method is widely used in greenhouses. Spring irrigation increases the radiation balance of the soil by reducing the albedo (by 5-8 per cent). Irrigated soil absorbs the sun's heat more intensively, but at the same time evaporates more water, which causes it to cool. The high thermal conductivity of wet soil ensures better heat penetration into deeper layers, which also reduces soil heating. In autumn, along with reduced evaporation, soil temperature fluctuations and cooling at night decrease, and the likelihood of frosts increases. When ploughing agricultural land, the soil temperature rises by 3 to 4°C, when applying coolers, the temperature increases by 3 to 4°C at night and by 8 to 10°C during the day, and mulching the soil increases its temperature by 5 to 10°C. An increase in soil temperature by 1-2°C simultaneously increases the total temperature by 50-200°C, which is equivalent to moving the plant south by 100-200 km.

1.6 Fundamentals of seed science

The Crop Science course begins with students learning the scientific fundamentals of **seed science**, as seeds are one of the most important irreplaceable means of agricultural production. By sowing high-quality seeds of new zoned and promising varieties (hybrids), it is possible to increase the yield and gross harvest of agricultural plants by 20-25 per cent.

Seed science is a science that studies the peculiarities of seed development and life, the impact of environmental conditions on seed quality and ways to improve it, as well as methods of preparing seeds for sowing and methods for determining the quality of seed material. The main task of seed science is to improve the quality of seed material. It is important to distinguish between the concepts of seed science and seed production. Seed production studies ways to propagate varietal seeds, maintain their purity and provide them to farms.

Seed production is a special branch of agricultural production that implements the achievements of breeding through the propagation of seeds of new high-yielding varieties and their introduction into production. Adherence to the scientific basis of seed production in farms of various forms of ownership will allow them to provide their own seed material by propagating high-quality varietal seeds; preserve all morphological characteristics, varietal qualities and biological features inherent in this variety during the reproduction process; and form high yielding and sowing qualities of seeds by special methods of growing, harvesting and post-harvest seed treatment.

Seed production of agricultural plants is regulated in Ukraine: The Law of Ukraine "On Seeds and Planting Material", state standards "Seeds of agricultural plants. Varietal and sowing qualities. Technical conditions" (DSTU - 2240-93) and "Seeds of agricultural plants. Methods of quality determination" (DSTU 4138-2002).

The purpose of the laboratory work of the content module "Fundamentals of Seed Science" is to improve students' skills in working with educational and scientific literature, laboratory equipment, consolidation and generalisation of knowledge gained during the lecture course.

After studying the section "Fundamentals of Seed Science", students should be able to apply the acquired theoretical knowledge to the practical determination of varietal and sowing qualities of seeds, and to the preparation of documents on seed quality.

State seed control is carried out by a single service, the State Seed Inspection of Ukraine, and its regional, city and district divisions.

The main executive link in the system of state seed control is the district seed inspectorates, which control the quality of seeds in farms, research institutions and other organisations. The district seed inspections are responsible for monitoring the cultivation, harvesting, post-harvest processing, storage and use of seed, as well as compliance by producers with state standards for seed varietal and sowing qualities. In their work, state regional and district seed inspections are guided by the Law of Ukraine "On Seeds and Planting Material", and determine the sowing qualities of seeds in accordance with state standards: DSTU 4138-2002, DSTU 2240-93.

The terms used in the Law of Ukraine "On Seeds and Planting Material" and Selection of combined (initial) and formation of average seed samples for analysis

Objective. To learn how to correctly form average seed samples and draw up documents for them when submitting them to seed control inspections for sowing quality analysis.

Task. Collect and prepare the first, second and third average samples of seeds for sending to the seed control inspection and fill in the act of taking average samples.

Procedure. 1) Familiarise yourself with the content of the work and learn the procedure for taking spot and average samples.

2. Consider the structure of probes and samplers.

3. Conduct spot sampling.

4. Draw up a scheme for taking spot samples and take spot samples of seeds of one of the agricultural plants, analyse them visually for homogeneity.

5. Make a combined sample.

6. Separate the first, second and third middle samples from the combined sample and place them in a bag, bottle and paper bag, respectively.

7. Fill in the sampling report.

Content of the work. To objectively determine the sowing qualities of seeds, it is necessary to properly combine them into batches, and, if necessary, divide them into control units. A **seed lot is a** quantity of seeds of homogeneous quality, certified by the relevant documents, as specified in DSTU 4138-2002. These are seeds of one plant, one variety, reproduction, category of varietal purity, year of harvest, one origin, etc. If

the batch is large, it is divided into **control units**, from which separate average samples are taken. Each batch is assigned a number.

Control units are assigned the batch number and their own number (e.g., 25/1, 25/2). In the case of obvious heterogeneity of the seed lot, no samples are taken. If the seeds are stored in a single bin, spatial separation of the seed lot into separate control units is not necessary. **Average samples are taken** separately from each control unit, and the scheme of dividing the seed lot into control units and their numbering is attached to the act of taking average samples. The maximum sizes of control units for different plants are not the same and are normalised by the standard (Table 1.14).

Table 1.14

Norms of maximum weight of seed lots and samples (DSTU4138-2002)

Plant.	Maximum batch weight (control unit), kg (+,- 5 per cent)	Minimum sample weight, g			
		average		working	
		to determine			
		sowing qualities (+,- 10 per cent)	humidity	purity	content of other species
1	2	3	4	5	6
Amaranth	2000	50	50	1	10
Basil	2000	25	25	4	25
Aubergine	100	50	50	5	50
Vegetable beans	250	1000	100	200	100
Sweet clover	100	50	50	4	50
Table and fodder beetroot	200	500	500	20	500
Sowing vetch	250	1000	100	140	1000
Eastern galea (goat's milkweed)	100	250	50	20	200
Pumpkin	250	500	500	200	500
Mustard	100	40	50	4	40
Peas	250	1000	100	900	1000
Vegetable peas	250	1000	100	200	1000
Buckwheat	100	600	100	60	600
Raggedy team	100	30	50	2	30
Melon	100	100	100	25	100
Rye	250	1000	100	120	1000
Zucchini, squash, zucchini	100	250	250	50	250
Table watermelons	200	500	500	100	500
Cabbage	100	50	50	5	50
Beans	250	1000	100	1000	1000
Vegetable beans	250	1000	100	200	1000
Vegetable cumin plants	2000	50	50	4	50
White clover	100	25	50	2	20

The end of the Table 1.14					
1	2	3	4	5	6
Red clover	100	50	50	4	50
Meadow fescue	100	50	50	4	50
Sheep fescue (oatmeal fescue)	100	25	50	2	25
Red fescue	100	30	50	2	30
Watercress salad	2000	50	50	4	50
Dill	100	50	50	2	50
Corn	250	1000	100	900	1000
Sugar corn	250	1000	100	200	1000
Alfalfa	100	50	50	4	50
Flax	100	150	50	15	150
Poppy	100	25	50	1	10
Table carrots	100	50	50	4	50
Oats	250	1000	100	120	1000
Cucumbers	100	100	100	20	100
Fenugreek (ryegrass)	100	60	50	4	50
Pepper	100	50	50	5	50
Parsley	100	50	50	2	50
Millet	100	150	50	15	150
Winter wheat	250	1000	100	120	1000
Radish, radish	100	100	100	10	100
Rapeseed, rape	100	100	50	10	100
Salad	100	50	50	2	50
Sunflower	250	1000	50	200	100
Celery	2000	25	25	1	25
Sorghum plants	100	900	100	90	900
Soybeans	250	1000	100	500	1000
Awnless spikelet	100	90	50	5	50
Tymofiivka	100	25	50	2	10
Tomato	100	50	50	5	50
Triticale	250	1000	100	120	1000
Phacelia	100	50	50	5	50
Onions	100	50	50	5	50
Spinach	5000	100	100	20	100
Sorrel	100	50	50	2	50
Barley	250	1000	100	120	1000

In order to form the average samples for analysis, a pooled **sample is** first taken from a batch of seeds using spot samples.

Taking spot samples (notches). A spot sample is a small amount of seed taken at one time to form a pooled sample, Depending on the method of seed storage, spot samples are taken using: **different tools**:

- Depending on the size, a cylindrical probe is used to take samples from bins and containers;
- The bag probe is designed for taking samples from bags;
- The cone probe is used to take samples from mounds, vehicles, unsealed bags, etc;
- use the mechanical sampler according to the instructions for use (Fig. 1.6).

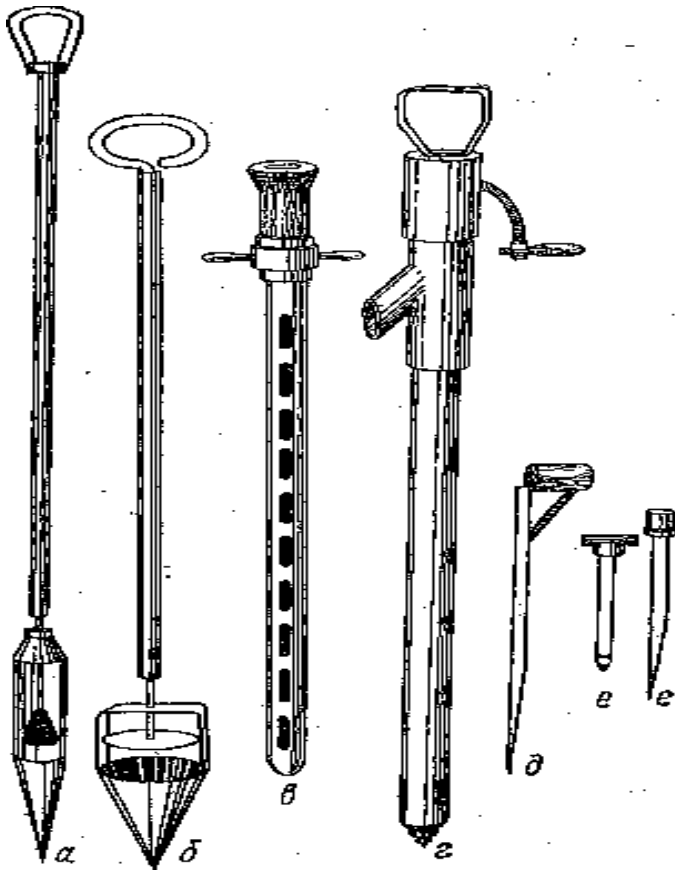


Fig. 1.6. Probes for taking point samples: *a*, *b* - cone; *c* - cylindrical; *d* - auger; *e* - clover; *f*, *g* - bag.

in different ways:

- bags and containers of similar capacity are selected without selection, and the selection points are alternated: top, middle and bottom of the packages;
- For seeds stored in bulk (or in large containers), spot samples are taken from different locations at different depths in each;
- from seeds with poor flowability, samples may be taken manually.

From seeds stored in bulk in bins, spot samples are taken in 5 places if the batch weight does not exceed 250 kg, and in 11 places if the batch weight is more than 250 kg, from three depths: 10-20 cm from the surface, in the middle of the bulk and near the floor (Fig. 1.7).

Spot samples are taken from unsealed bags with a cylindrical or conical probe, and from sealed bags with a bag probe, following the following rules. If the number of bags is up to 5, three samples are taken from each (top, middle and

bottom); from 6 to 30 - from every third, but not less than 5; 31-400 - from every fifth, but not less than 10; 401 and more - from every seventh, but not less than 80. Bagged probes are introduced to the sampling site by a chute downwards and then return the chute upwards.

Compilation of a pooled (original) sample. A pooled sample is a set of all spot samples taken from a batch of seeds or its part (control unit). Each point sample is poured separately on a smooth surface, checked organoleptically for homogeneity in terms of seed authenticity, contamination, smell, colour, gloss and other indicators. If there is no significant difference between the samples, they are combined (bulked) into the original (combined) sample. If some of the spot samples differ sharply from the others, the samples are not combined, but the sampling sites are checked and the parts

of the seed lot that correspond to these samples are removed. If this is not possible, the entire seed lot is processed and only then is a pooled sample taken.

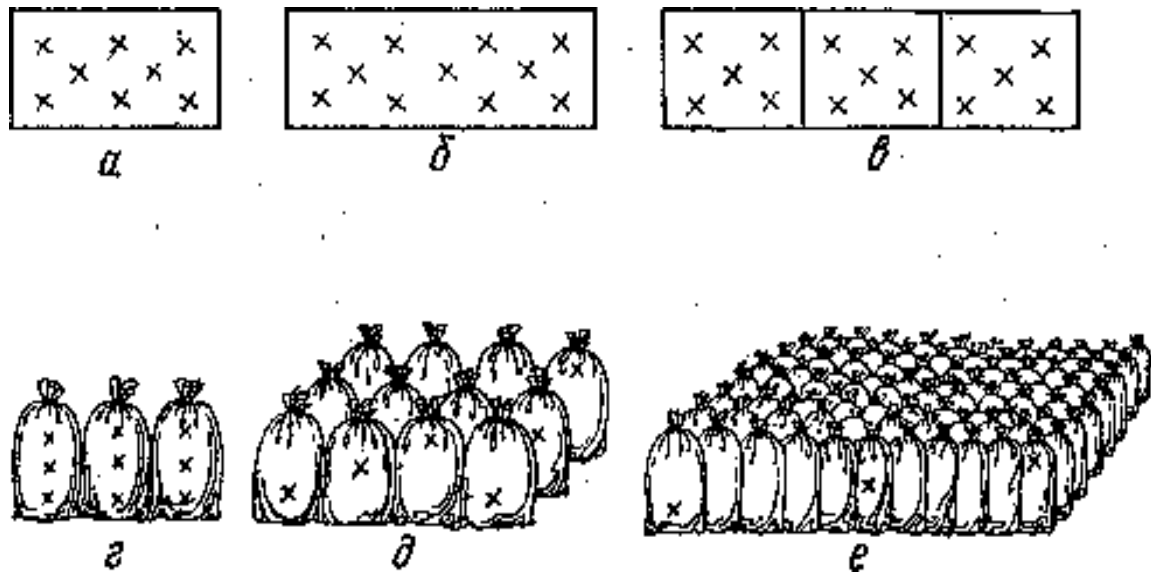


Fig. 1.7. Scheme of spot sampling: *a* - a batch of seeds not exceeding a control unit weighing up to 250 kg; *b* - a batch of seeds not exceeding a control unit weighing more than 250 kg; *c* - a batch of seeds larger than a control unit; *d* - in a batch of seeds up to 10 bags; *e* - in a batch of seeds 11-25 bags; *f* - in a batch of seeds 26-100 bags.

Formation of average samples. The middle sample is a part of the combined sample that is separated for laboratory analysis. When preparing seeds for analysis by the State Seed Inspectorate, **three middle samples are taken:**

- The first one is used to determine purity, waste, germination, viability, weight of 1000 seeds and other analyses. It is placed in a clean woven bag with a label with the characteristics of the batch; the bag is tied with twine, its ends are sealed, sealed or sealed with paper with the signature of the person who took the sample, and the outer label is glued.
- The second is for determining moisture content and pest infestation. It is packed in moisture-proof containers made of film (glass), sealed and labelled.
- the third is for phytotechnical examination (usually for seeds of corn, soya, flax). It is placed in a paper bag or cloth bag, sealed or sewn and labelled.

To separate the average samples, the method of **quarting** (cross-division) is used: the combined sample is thoroughly mixed and poured onto a flat, smooth surface; with two rulers (slats), it is spread in the form of a square with a layer up to 1.5 cm thick for small-seeded plants and up to 5 cm thick for large-seeded plants. The square is divided into four triangles along the diagonals; the first average sample is formed from the seeds of two opposite triangles, and the second and third from the other two (Fig. 1.8).

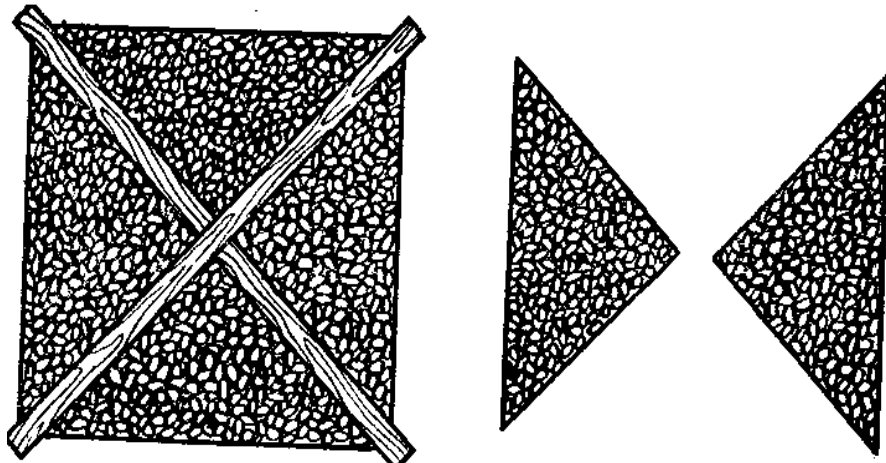


Fig. 1.8. Quartering method

The collection of average samples is documented in two copies: one remains with the seed owner, the other accompanies the samples to the State Seed Inspectorate, where they are delivered within 1-2 days. In the case of arbitration analysis of seeds intended for sale, a duplicate of the first sample marked "Duplicate" is taken at the same time. Duplicate samples are also recorded in an act. It is stored in the same room as the seed batch or in similar conditions.

Selection, formation, registration and delivery of average samples are carried out by full-time (for seeds sold within Ukraine) or part-time (allowed only for batches of seeds for on-farm use) inspectors authorised by the State Seed Inspection and having the appropriate certificate. Full-time inspectors must have personal stamps, seals and seals. The owner of the seed is obliged to provide the necessary conditions for carrying out these works and delivery of the selected samples to the State Seed Inspection.

Average samples received by the State Seed Inspection are weighed on scales with a division price of up to 5 g, and samples less than 250 g - with a division price of 1 g. Average samples are registered in a journal, the form of which is established by the State Seed Inspection of Ukraine. Registration numbers are put on packages, work forms and documents that will be issued to the seed owner. Working samples of flax seeds intended for phytosanitary examination are registered separately.

Analysis begins no later than the next day (exceptions are allowed for weekends and holidays). Samples are stored in a cool, well-ventilated area to ensure that the original quality is maintained. Remnants of samples, as well as components identified during the analysis of seed purity and waste, are stored for two months after the completion of sowing of the plant in question in the district, after which they are depersonalised in accordance with the procedure established by the state seed inspection.

Determination of purity and weight of 1000 seeds

Objective. To learn how to form a sample for analysis, identify the seeds of the main plant and waste, conduct purity analysis and determine the mass of 1000 seeds and calculate them based on the results of the analysis.

Task. From the first average sample of seeds of one of the agricultural plants, take a sample of seeds and determine the purity of the seeds and the mass of 1000 seeds using different methods.

Procedure. To determine the seed group of the main plant in the seed, in percentage by weight, it is necessary:

1. Pour the first middle sample onto a table and evaluate the seeds for organoleptic characteristics - colour, shine, smell, and the presence of mould;
2. Select the coarse impurities, weigh them and calculate their percentage in the sample. The result is then added to the average waste content of the sample;
3. Flatten the sample into a rectangle up to 1 cm thick. Using two scoops, stagger 16 recesses for the first sample. In the intervals between the places of the first sampling, select another 16 recesses for the second sample;
4. weigh the samples and if the initial mass of the first or second sample is 10 per cent or more greater than the specified mass, re-select the sample;
5. Sieve each sample through a laboratory sieve with the appropriate mesh shape and size for 1 minute.
6. The part of the sample that has passed through the sieve is considered to be foreign waste and is weighed;
7. Separate the seeds remaining on the sieve into the main plant and waste (impurities, defective seeds), weigh them to the nearest 0.01 g;
8. Determine the percentage of seeds of the main plant in the sample. Record the results in the "*Seed sample quality determination card*";
9. draw a conclusion on the compliance of the obtained seed purity value with DSTU 2240-93.

The physical purity of the seed is determined during the laboratory analysis of the first middle sample. *Seed purity is the content of seeds (the main plant) in the seed, determined as a percentage.* It is one of the main indicators of the seed's sowing qualities. When seeds with impurities are used for sowing, weed infestation, disease infection, and seed storage conditions deteriorate. In order to take timely measures to bring the seeds to condition, improve sowing qualities, prevent crops from being contaminated by quarantine weeds, determine the optimal seeding rate, etc., the degree and characteristics of seed contamination are of great importance. Seed purity is regulated by the standard according to its class (Addition 1).

Content of the work. The middle sample is poured onto a smooth surface, mixed thoroughly, and the condition of the seed is determined by colour, shine, smell, mould and other organoleptic characteristics. If large impurities (clods of soil, stones, stem fragments, etc.) are found that cannot be evenly distributed in the average sample, they are separated and weighed to the hundredth of a gram. Seeds treated with substances harmful to health are handled in a fume hood or with respirators.

Separation of samples for analysis. Samples for any analysis are prepared using the medium-sized **notch** method, which is the most suitable method for small-seeded plants. In this case, the seeds are poured on a flat surface, levelled in the form of a rectangle with a layer of 1 cm and small portions of seeds are taken with two scoops directed towards each other until they close:

X	O	X	O	X	O	X	O
O	X	O	X	O	X	O	X
X	O	X	O	X	O	X	O
O	X	O	X	O	X	O	X

O - places of seed collection for the first sample;
X - for reweighing, in case of repeated analysis.

Analysis of seed weight. To isolate small and tiny seeds, the sample is sieved on sieves with holes of different shapes and sizes depending on the plant (Table 1.15), and air classifiers and

diaphanoscopes are also used.

Analyse a sample or **working sample** divided into two halves - sub-samples (it is possible to analyse a complete sample without dividing it into halves if the seeds are well sorted), each of which is divided into three components:

I. Seed of the main plant - this includes all botanical varieties and cultivars:

- undamaged seeds (grains, achenes, fruits, etc.);
- achenes and similar fruits, regardless of the content of actual seeds;
- Seeds (fruits) that have lost less than half their size as a result of mechanical destruction or damage, as well as those with microtraumas;
- grains of cereal plants with flower scales;
- fallen seeds, in which half or more of the shell or scales have been lost;
- the seeds left on the sowing sieve.

II. Seeds of other plants. This includes seeds (fruits) and seed-like structures of botanical plant species that do not belong to the main plant, namely: *seeds of vegetable plants, seeds of weeds.*

Determination of the quantitative composition of seeds of other plants. The following groups of weed seeds are distinguished among the impurities: quarantine, poisonous, malicious, difficult to separate, and others. Quarantine inspection and examination of seeds is carried out in accordance with DSTU 3355-96. If quarantine or poisonous weeds are found in the sample during analysis, the purity analysis is stopped and the batch is transferred to the supervision of the quarantine inspection, and the owner is notified.

Poisonous weeds include:

- in all plants - heliotrope hair and trichodesma grey;
- in rapeseed and rape seeds - white hellebore, spotted hemlock, poisonous, caustic, creeping buttercup;
- in poppy seeds - black pallor.

The most harmful weeds in all plants include bristle thistle, branched oats and cinquefoil (wheatgrass), variegated elm, common comelina, Tatar spurge, vine spurge, pink and field thistle, creeping wheatgrass, tuberous sow, foxtail and thick-fruited sophora, and large-fruited horsetail.

Depending on the plant under analysis, seeds of plants and wild plants are considered to be difficult to separate according to DSTU 2240-93.

Table 1.15

Conditions for sieve analysis of seeds for determining purity

Plant.	Shape of the holes	Hole size, mm	Duration of manual sieving, min	Note
Winter wheat, barley, seed triticale	Elongated	1,7 x 20	1	-
Rye, triticale fodder	- " -	1,5 x 20	1	-
Oats	- " -	1,5 x 20	3	-
Rice by grain shape: - elongated, narrow, thin, - elongated, wide, rounded	- " -	1,5 x 20 1,7 x 20	3 3	-
Corn (except for split and self-pollinated lines)	- " -	3,0 x 20	3	-
Corn split and self-pollinated lines	- " -	2,5 x 20	3	-
Sunflower: - varieties and hybrids - mother forms of hybrids - parental forms of hybrids	- " -	2,2 x 20 2,0 x 20 1,5 x 20	3 3 3	Sharp vertical shaking after every minute
Hemp plants	- " -	2,0 x 2,0	3	-
Small-seeded legumes	Square	0,5	3	Metal woven sieve

Plant impurities include seeds of plants that are not specified by the owner as the main plant. Vegetative plants whose seeds do not differ in morphological characteristics from their respective wild-growing relatives are equated to weeds, namely:

- in cereals, seeds, legumes, oilseeds, and industrial crops - perennial legumes and cereals, caraway plants, poppy seeds, carrots, annual grasses (except for Sudanese grass, vetch, and annual lupine), parsnips, parsley, cabbage, chicory, sage, and sorrel;
- in vegetables, melons, gourds, fodder roots - caraway plants, poppy, camelina, sage, chicory, annual grasses (except Sudan grass), perennial legumes and cereals. Piecewise inclusion of impurities normalised by the standard (content of seeds of other plants and weeds, etc.) is expressed in pieces per kilogram; the content of sooty formations, sclerotia, ergot is calculated as a percentage of the weight of the seed sample. Permissible deviations between samples are given in Table 1.16.

Table 1.16

**Permissible deviations during the individual accounting of seed impurities,
pcs./subsamples**

Average of two analyses	Maximum permissible deviation	Average of two analyses	Maximum permissible deviation
3	5	152-160	35
4	6	161-169	36
5-6	7	170-178	37
7-8	8	179-188	38
9-10	9	189-198	39
11-13	10	199-209	40
14-15	11	210-219	41
16-18	12	220-230	42
19-22	13	231-241	43
23-25	14	242-252	44
26-29	15	253-264	45
30-33	16	265-276	46
34-37	17	277-288	47
38-42	18	289-300	48
43-47	19	301-313	49
48-52	20	314-326	50
53-57	21	327-339	51
58-63	22	340-353	52
64-69	23	354-366	53
70-75	24	367-380	54
76-81	25	381-394	55
82-88	26	395-409	56
89-95	27	410-424	57
96-102	28	425-439	58
103-110	29	440-454	59
111-117	30	455-469	60
118-125	31	470-485	61
126-133	32	486-501	62
134-142	33	502-518	63
143-151	34	519-534	64

III. Waste (impurity):

- remains of seeds (fruits) that have lost half or more of their size;
- seeds of legumes and cabbage plants without a seed coat;
- empty ears, spikelets and flower scales, films, fragments of stems, leaves, etc;
- rotten seed, sprouted seed (roots or sprout are half or more of the seed length, and in rounded seeds - half or more of the diameter);
- fungal formations (sooty sacs, lumps, spikelets, horns, sclerotia and their fragments), nematode galls;

- lumps of soil, pebbles, sand, excrement, insects, etc;
- of the seed that has passed through the sowing sieve (Table 1.17).

Table 1.17**Permissible deviations during seed purity analysis**

Arithmetic mean of the results of two replicates, percentage		Permissible deviations between samples, percentage	
		half	full
1		2	3
99,95-100,00	0,00-0,04	0,23	0,16
99,90-99,94	0,05-0,09	0,34	0,24
99,85-99,89	0,10-0,14	0,42	0,30
99,80-99,84	0,15-0,19	0,49	0,35
99,75-99,78	0,20-0,24	0,55	0,39
99,70-99,74	0,25-0,29	0,59	0,42
99,65-99,69	0,30-0,34	0,65	0,46
99,60-99,64	0,35-0,39	0,69	0,49
99,55-99,59	0,40-0,44	0,74	0,52
99,50-99,54	0,45-0,49	0,76	0,54
99,40-99,49	0,50-0,59	0,82	0,58
99,30-99,39	0,60-0,69	0,89	0,63
99,20-99,29	0,70-0,79	0,95	0,67
99,10-99,19	0,80-0,89	1,00	0,71
99,00-99,09	0,90-0,99	1,06	0,75
98,75-98,99	1,00-1,24	1,15	0,81
98,50-98,74	1,25-1,49	1,26	0,89
98,25-98,49	1,50-1,74	1,37	0,97
98,00-98,24	1,75-1,99	1,47	1,04
97,75-97,99	2,00-2,24	1,54	1,09
97,50-97,74	2,25-2,49	1,63	1,15
97,25-97,49	2,50-2,74	1,70	1,20
97,00-97,24	2,75-2,99	1,78	1,26
96,50-96,99	3,00-3,49	1,88	1,33
96,00-96,49	3,50-3,99	1,99	1,41
95,50-95,99	4,00-4,49	2,12	1,50
95,00-95,49	4,50-4,99	2,22	1,57
94,00-94,99	5,00-5,99	2,38	1,68
93,00-93,99	6,00-6,99	2,56	1,81
92,00-92,99	7,00-7,99	2,73	1,93
91,00-91,99	8,00-8,99	2,90	2,05
90,00-90,99	9,00-9,99	3,04	2,15
88,00-89,99	10,00-11,99	3,25	2,30
86,00-87,99	12,00-13,99	3,49	2,47
84,00-85,99	14,00-15,99	3,70	2,62

The end of the Table 1.17			
1		2	3
82,00-83,99	16,00-17,99	3,90	2,76
80,00-81,99	18,00-19,99	4,07	2,88
78,00-79,99	20,00-21,99	4,23	2,99
76,00-77,99	22,00-23,99	4,37	3,09
74,00-75,99	24,00-25,99	4,50	3,18
72,00-73,99	26,00-27,99	4,61	3,26
70,00-71,99	28,00-29,99	4,71	3,33
65,00-69,99	30,00-34,99	4,86	3,44
60,00-64,99	35,00-39,99	5,02	3,55
50,00-59,99	40,00-49,99	5,16	3,65

The masses of the components are added and the sum is compared with the initial mass of the working sample (sub-sample). If the difference between them does not exceed 5 per cent (by weight of the working sample or sub-sample), the analysis results are considered reliable, if it does, the analysis is carried out on a re-sampled sample. The content of each constituent is calculated (in percentage) to one decimal place, based on the sum of their masses. The sum should be 100 per cent. A deviation of 0.1 per cent from this is corrected by the content of the largest of the components. A deviation of more than 0.1 per cent indicates an error in analysis or calculation. When analysing sub-samples, calculations (in percent) are rounded to the second decimal place; in addition, the difference between them and the arithmetic mean for each component is assessed: it should not exceed the tolerances given in Table 4. Otherwise, a re-sampled sample is analysed.

It is permissible to analyse half of a re-sampled sample (sub-sample). In this case, the arithmetic mean is calculated from two close results that are within the permissible limits; if the results of all three half samples are within the permissible limits, the arithmetic mean is calculated from all of them. The results of the analysis for purity and waste are recorded to one decimal place (their sum should be 100 percent).

The results of the purity and waste analysis are recorded to one decimal place (the sum of the results must be 100 per cent). If a constituent is not detected, the number zero is recorded. If the content of a particular waste constituent does not meet the regulatory requirements, it is indicated in the document as a separate line.

Determination of the mass of 1000 seeds. The analysis consists of collecting, weighing and calculating the mass of 1000 seeds, according to their number in the sample. The sample of the main plant seed is used after analysing its purity. The counting is done manually or with the help of counters.

The whole sample or part of it is used for analysis. If the whole sample is taken, the number of seeds in the sample must be counted and weighed to the required accuracy. The weight of 1000 seeds is calculated by dividing the total weight of the sample by the number of seeds in it and multiplying the result by 1000. If a certain number of seeds are used from the sample, one of the methods is used:

I. Eight repetitions of 100 seeds (a more accurate method);

II. Two repetitions of 500 seeds each (a more common and affordable method).

Method I. Eight replicates of 100 seeds (without selection) are taken from the seed of the main plant and weighed with the accuracy required for the purity analysis. The weight of 1000 seeds is calculated by multiplying by 10 the arithmetic mean ($\bar{X}$) weight of 100 seeds:

$$\text{The arithmetic mean weight } (\bar{X}) \text{ of 100 seeds, } \bar{X} = \frac{\sum x}{n}, n \quad (1.15)$$

where x is the mass of 100 seeds of each repetition, g; n is the number of repetitions.

Next, to check the reliability of the result, the coefficient of variation is calculated using a number of formulas.

$$1. \text{ Variant } V = \frac{n (\sum x^2) - (\sum x)^2}{n (n-1)}; \quad (1.16)$$

2. The standard deviation (δ) is the square root of the variance, $\delta = \sqrt{V}$;

$$3. \text{ Coefficient of variation } (k), k = \frac{\delta}{\bar{X}} 100. \quad (1.17)$$

If the coefficient of variation (k) does not exceed 6.0 for seeds of filmy cereals and 4.0 for other seeds, the analysis is considered reliable; if it does, eight more replicates are treated and the standard deviation is calculated for sixteen replicates; in this case, replicates that differ from the mean by more than double the standard deviation (2δ) are excluded.

Method II. From the seed of the main plant, two replicates of 500 seeds are counted without selection and each is weighed to the required accuracy. The missing number of seeds is taken from the second replicate during the purity analysis or from the middle sample. Calculate the arithmetic mean of the weights of both replicates and the actual difference between the replicates, which should not exceed 3 per cent of the arithmetic mean. If the actual difference is within the permissible limits, the analysis is considered reliable.

The mass of 1000 seeds is calculated by summing the masses of two replicates, rounding the result to the first decimal place, and for small-seeded plants (mass of 1000 seeds less than 10 g) the result is rounded to the second decimal place. If the actual discrepancy exceeds the permissible one, a third repetition is taken. The final result is calculated from the two replicates whose actual differences are within the permissible limits. If the value of all replicates exceeds the permissible deviations, the arithmetic mean is calculated from all replicates (provided there are no errors).

Determination of germination, germination energy, seeding suitability, growth vigour and seed viability

Objective. To master the methods of determining laboratory germination, germination energy and seed growth force when germinating in different environments and to get acquainted with the methods of determining seed viability.

Objective. Determine the laboratory germination and germination energy of seeds of one of the agricultural plants when germinated in different ways: on sand, in sand, on paper, between paper, in rolls, on corrugated paper; determine the viability of

seeds using acid fuchsin, indigocarmine or tetrazol to determine the strength of seed growth when sown in sand.

Procedure. To determine germination energy and seed germination, take 8 samples of 100 seeds (or 8 samples of 50 seeds for large-seeded plants) from the seed of the main plant (after determining purity);

- use filter paper as a bed, germinate on paper;
- moisten the growing and filter paper, spread the seeds;
- Germinate 4 samples in a thermostat and 4 in a Jacobson apparatus;
- count the germinated seeds in two stages: on the 3-4th day to determine the germination energy, on the 7-10th day the germination rate;
- germination is defined as the arithmetic mean of the results of germination of four samples, if they do not exceed the permissible deviations.
- if such deviations are present in one sample, germination and germination energy should be determined using three samples.

Laboratory germination is the number of normally germinated seeds under standard conditions as a percentage of the sown sample. It is determined by germinating 4-2 samples of 100-50 seeds each under the conditions specified in DSTU 2240-93. Germination energy - the number of normally germinated seeds expressed as a percentage of the sown sample on a conventionally defined day, in most cases 3-5 days of germination (Addition 2).

Content of the work. Determination of seed germination and germination energy
The germination analysis is carried out on the seeds of the main plant isolated during the purity determination. For this purpose, 4 weights of 100 seeds (or 50 seeds for large-seeded plants) are randomly counted out. Spread the seeds evenly on a moistened substrate.

Seeds are germinated in thermostats or Jacobson apparatus. Thermostats and Jacobson apparatus and utensils are washed with hot water and detergent and disinfected with a 1 per cent potassium permanganate solution or alcohol before each test. A water tray is placed in the working chamber of the thermostat, and the Jacobson apparatus is rinsed and filled with water. Petri dishes and Koch dishes can be sterilised in an oven at $130 \pm 2^{\circ}\text{C}$ for an hour or boiled in water for 40 minutes. The conditions that are mandatory (substrate, temperature) for the analysis, as well as additional instructions for disturbing the dormancy of the seeds, are given in Table 1.18.

The modes that are most suitable for the laboratory's equipment should be selected, taking into account the condition of the seeds. It is recommended to give preference to the variable temperature mode, as it is biologically more natural. If the selected analysis mode does not allow for an objective evaluation of the seed (due to an inappropriate mode, but not errors), the analysis should be repeated under different conditions. If the last analysis result confirms the previous one, the document shall indicate the arithmetic mean between them, subject to permissible differences.

The sum should be 100 per cent. A deviation of 0.1 per cent from this is corrected by the content of the largest of the components. A deviation of more than 0.1 per cent indicates an error in analysis or calculation. When analysing sub-samples, calculations (in percent) are rounded to the second decimal place; in addition, the difference.

Table 1.18

Conditions for analysing seed germination

Plant.	Substrate (bed)	Temperatura C°, ±2 C°	Accounting period, days		Additional conditions and instructions
			The energies of germination	Similarities	
1	2	3	4	5	6
Seeded:					
Buckwheat	NF, VF	20,25,25-30	4	7	By.
Corn	VF,vP,nP	20,25,20-30	4	7	Pp,O
Sugarcane	Vf, vP, nP	25,20-30	4	7	Extended for 3 days
Oats	Vf,vp,np	20	5	10	Paragraphs (30-35),Po,GC
Millet	NF,vF	25,20-30	3	7	
Winter wheat	nF,vF,nP,vP	20	4	8	Po,Mn(30-35C),GC
Rye	NF,vF,vP,nP	20	4	7	Po, Pp, GC
Barley	VF,vP,nP	20	4	7	Po,Pp,(30-35C),GC
Sorghum plants	NF, vF, nP	25,20-30	4	10	By.
Triticale	NF,vF,nP,vP	20	4	8	Po,Pp,(30-35C),GC
Legumes:					
Peas	VF, vP, nP	20	5	8	By.
Vegetable peas	VP, nP	20	4	8	By.
Legume	NF, vF, nP	20	5	14	By.
Beans	VF, VP, nP	20,25,20-30	5	9	
Oilseeds and technical					
Sunflower	VF, VP, nP	20-30,25,20	4	10	Mon, (30C), 10 days, Po
Rapeseed and rape	NF	20,20-30	5	7	Po, O
Mustard	nF	20,20-30	5	7	Po, K#Oz
Soybeans	VF,vP,nP	25,20-30	5	8	
Sugar beet	Γ	20	4	10	Rinse in water
Vegetable:					
Pumpkin	VF,nP	25,20-30	3	7	
Watermelons	nF	30,20-30	4	10	At 6 p.m., Prop. (30C)
Melon	VF, nP	20-30	3	8	O,Pp
Zucchini	VF,nP	25,20-30	3	10	O
Squash and zucchini	VF, nP	25,20-30	3	10	O
Cucumbers	VF, nP	25,20-30	3	7	O,Pp
Aubergines	VF,nP	20-30	7	14	By (within 4 days, the first accounting on the 10th day)
Cabbage	nF	25,20-30	3	8	O

1	2	3	4	5	6
Watercress salad	nF	20,25	3	5	O,Po, Pr(15C) similar per day
Salad	nF	20,10-20	4	10	O, P, Po
Dill	nF	10-30	10	21	O, Pp, Pp
Carrots	nF	20-30	5	10	O.P. (30C) after warming up
Sweet and bitter peppers	NF,vF	20-30	7	15	O, K№Oz
Parsley	nF	20-30	7	14	O,Pp
Parsnips	VF,nP	20-30	10	21	O
Celery	NF	20-30	8	18	Po, K#Oz
Tomato	VF,nF	20-30	5	10	O
Onions	VF,nF	15,20	5	12	By.
Sorrel	nF	20	3	7	Po, Flushing
Poppy	nF	20	5	10	By,O,Post rinse.Pour(10- 30C)
Radish, radish	NF,vF	20,25,20-30	3	6	By.
Table and fodder beetroot	VF, VP	20-25	5	10	First rinse in running water (25°C) and dry for 1-2 hours
Spinach	vF	15,10	7	14	By.
Legumes:					
Sweet clover	NF,vF	20	4	10	By.
Red clover	NF,vF	20	4	10	Poe, Prop.(15C)
White clover	NF,vF	20	4	10	By,Placement. In package, Inlet (15C)
Alfalfa	VF,nF	20	4	10	By.
Phacelia	NF,vF	15,20,20-30	5	14	Soak the seeds in a 0.01 per cent succinic acid solution for 1 day at room temperature.
Sainfoin	NF,pF,nP,vP	20-30,20	5	14	Po, Prod (10C), 5 days, then 20-30C
Eastern galea (goat's milkweed)	vF	20	3	14	
Cereal grasses:					
Fenugreek	NF	20,20-30	5	14	Po,K#Oz,O,Pr or. (10-30C)

The end of the Table 1.18					
1	2	3	4	5	6
Tall ryegrass	nF	20-30	6	14	Po,O,Pror.(10-30C)
Fescue (meadow fescue)	nF	20-30,15-25	7	14	Po,K#Oz,O,Pr or. (10-30C)Prot. 20 days
Fescue (sheep's fescue)	nF	20-30,15-25	7	21	Po,K#Oz,O,Pr or. (10-30C)
Stokolos	nF	20-30,15-25	7	14	Po,K#Oz,O,Pr or. (10-30C)Prot.20 days
Timofeevka (meadow)	nF	20-30,15-25	7	10	Po,K#Oz,O,Pr or. (10-30C)Prot.20 days
Raggedy team	nF	20-30,15-25	7	21	Po,K#Oz,O,Pr or. (10-30C)

Filter paper (F) and sand (S) are used in the analysis. Filter paper as a substrate for the bed is used in two ways, "on paper" (nP) and "in paper" (inP). To moisten the paper, it is immersed in water, removed and allowed to drain (no water film forms around it when pressed with a finger). In Jacobsen-type machines, the paper is constantly moistened by a wick with the lower end of the wick dipped in water.

For the paper test, the seeds are spread on one or more layers of moistened paper in either a growth plate or a Petri dish. The upper growth plates are covered with glass plates or empty growth plates, and the Petri dishes are covered with lids.

During the "in-paper" assay, the seeds are placed between two layers of moistened paper (edges: place in rows to facilitate visual assessment of the seedlings). The paper can be used in the form of envelopes, rolls, corrugations of different profiles (W, M, etc.), placed horizontally or vertically; (seeds are placed with the germs down). For better ventilation, it is recommended to place plates or frames made of moisture-proof material between the layers of paper. The device with the seeds prepared in this way is placed in the growing room, vessels or directly on the shelves of the thermostat.

It is recommended to germinate legume seeds in corrugated filter paper. To do this, take a strip of filter paper 50 ± 2 cm long and 12 ± 0.5 cm wide, fold it in two layers and make 12 to 13 folds 1 to 1.5 cm high. This bed is placed in a water-soaked grower, and the edges of the paper are fixed to the shorter walls of the grower. 100 seeds, 8-9 seeds each, are placed in the paper folds. Cover the tray with a 12 cm $\times$ 21 cm sheet of filter paper moistened with water, and add another portion of water (40 cm³) to the top of each tray to moisten the entire substrate.

Sand as a substrate for seed germination (sifted through a sieve with 1 mm

diameter holes, washed, and calcined until a piece of paper embedded in it is charred) is used with the following options: "on sand" (nS) - the seeds are pressed into the surface of the sand to their thickness (diameter); or "in sand" (inS) - the seeds spread on the bed are covered with a layer of sand 1-2 cm thick, leaving them loose. Before analysis, the sand is moistened to 60 per cent of its total moisture content (up to 80 per cent for legumes, 100 per cent for rice). After the analysis, the sand is washed, dried, sieved, calcined and stored for reuse. When analysing the treated seeds, the relevant safety rules are followed and the sand is not reused.

The seeds are placed in prepared growing containers using a counter or manually using a marker, after which they are wrapped and smoothed with a tamper. When analysing freshly harvested seeds with an incomplete period of physiological ripening, measures are taken to overcome the dormant state, namely: pre-cooling, heating, washing, treating the bed with chemicals, etc. For hard-seeded plants (legumes), in the case of a large number of healthy ungerminated seeds at the end of the analysis, it is recommended to germinate them in a closed plastic bag. For seeds that are in a state of deep physiological dormancy, a sharp change in temperature is required, which is achieved by moving them from one thermostat to another.

The temperature regime must be maintained throughout the entire period with an accuracy of ± 2 °C. When using variable temperatures during the day, the low temperature is maintained for 16 hours and the high temperature for 6 hours. On weekends and public holidays, if the variable temperature regime is not controlled, it is allowed to maintain the lower level of the prescribed temperature.

During the first count, the seeds that have germinated normally, as well as those with pronounced signs of abnormality and rotten seeds, are separately assessed and counted. The latter two groups are removed, and the normally germinated ones are removed if necessary. The final recording period may be extended to 3 days, or even longer if necessary, to allow healthy ungerminated seeds to germinate, or shortened if the picture is clearer ahead of time.

The results of the analysis are recorded in the working forms (cards) of the established form. Normal seedlings include those in which the most important structures (roots, subcotyledon and supracotyledon knees, bud, cotyledons, coleoptile) are well and proportionally developed, intact, healthy, and with minor defects in those structures that do not affect the normal development of the seedling. This includes normally developed seedlings with signs of surface infection acquired from neighbouring diseased seeds.

In plants whose seeds germinate with several germinal roots (seed spikelets), normally germinated seeds are those with at least two normally developed roots larger than the length of the grain and a sprout at least half its length. In the seeds of barley plants and oat plants, the length of the sprout (ring) is determined by the part of it that has extended beyond the flower scales.

In the seeds of pea plants, corn plants, millet plants and other plants that germinate with one root, normally germinated seeds are those with a developed main germinal root not less than the length (diameter) of the grain and a formed sprout not less than half the length (diameter) of the seed. Normally germinated seeds of sunflower plants should have cotyledons that can be easily released from the fruit and

seed coat.

Abnormal seedlings are those that are unable to develop into full-grown plants even under favourable conditions. These include:

- seedlings that are missing or severely damaged in any structure, which makes further proportional development impossible;
- underdeveloped seedlings due to physiological disorders, as well as seedlings with deformed structures;
- rotten seedlings.

A hard seed is a seed that does not bubble due to the moisture-proofness of the skin. A healthy dormant seed is a seed that remains ungerminated and shows no signs of decay due to deep physiological dormancy.

The results obtained during the germination analysis are expressed as a percentage for each of the identified categories (normal and abnormal seedlings, germinated and ungerminated seeds, including hard, dead, and rotten seeds). The reliability of the analysis is established by comparing the extreme values of the repetitions with the arithmetic mean. The result is considered reliable if the difference between them and the arithmetic mean, which is calculated to the nearest whole number, does not exceed the maximum permissible deviations.

If the results of one of the replicates have deviations greater than the permissible limits, the germination rate is calculated using three replicates. In this case, the germination energy is determined using the same three replicates. If the results of two out of four replicates fall outside the permissible deviations, germination is determined again. If the results of the second analysis also exceed the permissible deviations, the average value is calculated from both analyses (Table 1.19).

Table 1.19

Permissible deviations in the determination of seed germination

Arithmetic mean value of the indicator, percentage										Permissible deviations of individual samples from the average
99		or		1						- 2
From.	97	to	96	"	from	2	to	3		± 3
"	95	to	96	"	"	4	to	5		± 4
"	92	to	94	"	"	6	to	8		± 5
"	88	to	91	"	"	9	to	12		± 6
"	83	to	87	"	"	13	to	17		± 7
"	75	to	82	"	"	18	to	25		± 8
"	62	to	74	"	"	26	to	38		± 9
						"	39	to	61	± 10

Calculation of seed germination capacity (SGC). Sowing suitability of seeds is determined by the formula: $\text{Seed availability} = \frac{4 \times C}{100}$, where C is seed purity, per

cent; S is seed germination, per cent. This indicator is used to make adjustments when determining the recommended (per unit) seeding rate (K).

To calculate the mass seeding rate in kilograms (N), use the following formula: $N = K \times A \times 100 : PP$, where K is the recommended seeding rate for similar seeds, million seeds per 1 ha; A is the weight of 1000 seeds, g; PP is the seed germination rate, percent. Thus, knowing the individual seeding rate, it is possible to determine the mass rate with adjustments for the sowing suitability of the seed and vice versa.

Determination of seed viability. Seed viability is the percentage of live seeds in the seed material. It is determined when it is necessary to have quick information about the quality of the seed, and it has low germination because it has not passed post-harvest maturation and is in a state of deep dormancy, when the seed needs to be germinated for longer.

For the analysis, prepare an aqueous solution of tetrazol at 0.1-1.0 per cent concentration (respectively, 1-10 g of tetrazol per 1 dm³ of distilled or freshly boiled water with a pH of 6.5-7.5). For example, to obtain a 1 per cent solution, 1 g of tetrazole per 100 cm³ of buffer solution, which is protected from direct sunlight.

Analyse two samples of 100 seeds each, taken from the seed of the main plant after the purity test; or analyse individual seeds (dormant) remaining at the end of the germination test. To facilitate the impregnation of the seeds with the tetrazol solution, the seeds are pre-soaked and the organ tissues are exposed. Seeds are spread on a moist substrate (for plants whose seeds crack in water, as well as for old and very dry seeds) or immersed in water at a temperature of $20 \pm 2^\circ\text{C}$ (for freshly harvested seeds - $10-15^\circ\text{C}$; soybean, flax and castor oil plants - $30 \pm 2^\circ\text{C}$) for a period of 2 to 22 hours, depending on the plant. If it is necessary to determine the content of hard seeds during the analysis of legumes, they are soaked at a temperature of $20 \pm 2^\circ\text{C}$ for 22 hours.

The duration of colouring is from 2 to 24 hours, depending on the plant. If necessary, the time can be extended to avoid excessive colouration. The seeds should be completely immersed in the solution. To make it easier to work with small seeds, they should be spread on filter paper after preliminary moistening, which is rolled up and immersed in the solution. After the colouring process is complete, the seeds are removed, rinsed with running water and then evaluated.

The seed is divided into viable and non-viable by examining each seed and assessing it according to the colouration of vital structures; it is advisable to use magnifying optics and lighting. Viable seeds are those whose organs are completely coloured or have small necrotic areas. Viability is expressed as a percentage, calculated as the arithmetic mean of the results of replicates, rounded to the nearest whole number. The reliability of the assay is assessed according to Table 1.20. If the analysis is unreliable, it is repeated on newly collected samples.

Determination of seed vigour. Seed vigour determines the ability of a seed to germinate quickly and amicably and to grow rapidly in the field; it is determined when the seed has low germination energy, contains many abnormal germinated and damaged seeds, is infected with diseases, and when it is necessary to make a comparative assessment of several batches of seeds of the same variety. When growing plants using intensive technologies, vigour is an essential indicator of seed quality.

Table 1.20**Permissible deviations between replicates in the seed viability analysis**

Arithmetic mean value of viability calculated from the results of two samples, percent						Permissible deviations between the results of analysis of two seed samples, percent
			99	or	1	2
			98	"	2	4
			97	"	3	5
From.	95	to	96	"	4-5	6
"	93	"	94	"	6-7	7
"	90	"	92	"	8-10	8
"	88	"	89	"	11-12	9
"	84	"	87	"	13-16	10
"	79	"	83	"	17-21	11
"	74	"	78	"	22-26	12
"	65	"	73	"	27-35	13
				"	36-64	14

Seed vigour or initial seed growth intensity is defined as the percentage of seedlings that have broken through a 4 cm thick layer of sand 10 days after sowing and the weight of 100 such seedlings in grams. Seed vigour is determined for cereals and flax.

For the analysis of growth vigour, 2 samples of 100 seeds each from the seed of the main plant are used after determining the purity. Seeds are sown in containers 20 cm high and 15 cm in diameter filled with millet sand through a 1 mm sieve. The sand is moistened to 60 per cent of its full moisture capacity and compacted with tampers before sowing. The sown seeds are covered with sand with a layer of 4 cm for cereals and 2 cm for flax. The surface of the sand should be 2-5 cm lower than the edges of the container. Cover the container with a glass plate. The seeds are germinated in the light for 10 days.

Growth vigour is expressed by two indicators: the percentage of healthy seedlings that appear on the surface and their weight per 100 seedlings in grams.

Determination of seed moisture content, pest infestation and disease infestation

Objective. To master the methods of determining and calculating seed moisture, overt and covert forms of seed infestation by pests, to get acquainted with the methods of determining seed infection by diseases.

Tasks. 1) Determine the moisture content of seeds of one of the agricultural plants after one and two times drying. 2. Determine the population of seeds of one of the cereal and legume plants with bugs and pests and justify the conclusion. 3. To analyse the infection of seeds with diseases by the luminescent method.

Content and progress of work. *Determination of seed moisture content.* Seed moisture content is the water content of seeds expressed as a percentage of the weight of undried seeds. Depending on the zone, plant and seed class, standards allow only a

certain maximum seed moisture content: for cereal grains - 14-16 per cent, for legumes - 14-17 per cent, for oilseeds - 9-13 per cent. High humidity is most harmful during long-term storage of seeds. Under such conditions, favourable conditions are created for the development of fungal diseases, self-heating and self-moistening of seeds, and their germination and germination energy are quickly lost.

Seed moisture content is determined by the air-thermal method, which is based on the accounting of water loss during drying in a drying oven. Before starting the mass analysis, the bolls are cleaned and roasted in a drying oven for 1 hour at a temperature of $130 \pm 2^{\circ}\text{C}$. Before the current analysis, the bolls are weighed together with the lid.

The analysis is carried out on the working sample separated from the second middle sample. The middle sample is thoroughly mixed with a spoon in the same plastic bag or by shaking the vessel before the working sample is taken out. The working sample is obtained by periodically crossing the seed flow with a scoop at the beginning, middle and end of the spillage from the vessel.

Sample size is as follows: 45-50 g - for large-seeded plants; 20-25 g - for small-seeded plants (except for those with an average sample weight of less than 50 g). If the weight of the average sample is 50 g or less, the samples are taken directly from it.

The working sample is divided into two approximately equal parts (half-samples):

- One of them is used for analysis;
- The other one is stored in a beaker with a lid on until the end of the analysis in case it is repeated (Addition 3).

For the 3 half-samples, two 4-5 g weights are weighed for drying when using bullion bungs with a diameter of up to 8 cm and 9-10 g for bungs with a diameter of 8 cm or more.

There are two drying methods: single-stage (Table 1.21) and two-stage (with preliminary drying), which is used for cereals and legumes with seed moisture content of more than 18 per cent (soybean plants over 16 per cent), annual lupine, shelled peanuts, and castor oil.

In the two-stage drying process, a half-sample of seeds (20 g) is dried in a mesh bag in the desiccator for a period of time:

- 15 min at $120 \pm 2^{\circ}\text{C}$ for wheat, rye, triticale, barley, buckwheat and vetch seeds;
- 30 min at $105 \pm 2^{\circ}\text{C}$ for seeds of other cereals and legumes, annual lupine and castor oil;
- 300 min at $105 \pm 2^{\circ}\text{C}$ for vegetable and melon seeds.
- The dried seeds are cooled (together with a mesh bin for 5 minutes on a cooler, or 10-15 minutes on a metal plate, or 15-20 minutes in an exciter), poured into a balance cup and weighed to the second decimal place, after which they are ground and weighed for further analysis.

Table 1.21**Conditions for analysing seed moisture content**

Plant.	Preliminary preparation of seeds for drying		Drying conditions	
			°C±2° C	min
Beans, peas, beans, corn, chickpeas, oats, chickpeas, barley	Grinded in a laboratory mill, s	60	130	40
Vetch, sainfoin, lupine (except annual), winter wheat, rice, lentils, triticale, rye		40		
Buckwheat, millet, sorghum plants		20		
Annual lupine, soya	Grind after preliminary drying, s	60	130	40
Castor oil		40		
Fodder grasses, root crops, hemp plants, flax, honey grasses, sunflower	Dried whole		130	60
Essential oil, other oilseeds, industrial plants	Dried whole		105	300
Terry cloth, tobacco	Dried whole		130	20
Pumpkin: pumpkin, melon, watermelon, zucchini, cucumbers, squash	Cut into 5-8 slices		130	120
Cabbage: rutabaga, mustard, cabbage (all types), radish, radish, turnip	Dried whole		120	120
Other	Dried whole		130	120

The buxas filled with the material are placed on the lids and placed in a single layer on the shelves of the drying oven heated to the desired temperature, and the time is recorded from the moment it is resumed. After drying, the bux are removed from the drying oven with crucible tongs, covered with lids and placed in an exciter to cool for 15-30 minutes. The bottom of the exciter should contain a water-absorbing material: phosphorus pentoxide or activated aluminium or dehydrated calcium chloride (the latter is calcined monthly); they are replaced with new ones if necessary. The cooled bungs are weighed together with the closed contents on an analytical balance.

Moisture content (W) is calculated as a percentage to one decimal place using the formula $W = \frac{m_2 - m_3}{m_2 - m_1} \times 100$, where: m_1 is the mass of an empty bin with a lid, g;
 $m_2 - m_1$ m_2 - weight of the bux with a weighting before drying, g ;
 m_3 - weight of the bux with a weight after drying, g. (1.18)

In the case of two-stage drying, the moisture loss (percentage) in each of the drying stages (W_1 and W_2) is calculated as described above. The original moisture content is then calculated using the following formulas

$$1) W = W_1 + W_2 \frac{W_1 \times W_2}{100m_3 \times m_4} \quad (1.19)$$

$$2) W = 100 \times (1 - \frac{m_1 \times m_2}{100m_3 \times m_4})$$

The result is the arithmetic mean of the analyses of both weights if the difference between them does not exceed 0.2 per cent for milled and 0.4 per cent for unmilled seeds. Otherwise, the analysis is repeated on the second half-sample.

Determination of seed infestation by boll weevils.

Seed is considered to be infested if live pests are found in it - eggs, larvae, pupae, adults (Addition 4). They are not allowed in seeds. Exceptions are: mites - for reproductive seeds (up to 20 pcs./kg); pea beetle - for pea plants (up to 10 pcs./kg); hemp leafminer - for reproductive hemp seeds (up to 4 pcs./kg). Seed infestation in the overt form is determined by the presence of live pests in the inter-seed space; in the latent form - inside individual seeds.

The mite infestation of seeds of all plants and pea plants with pea grains is calculated and expressed in specimens per kilogram. Mites infest seeds in an overt form, pea beetles in an overt and latent form. For more complete information on the infestation of pea seeds with pea weevils, it is recommended to indicate the overt and latent forms in the document.

The presence of these pests is explicitly determined during the seed purity test. As for all other plants and pests, the results of the analysis are used to conclude whether or not the seeds are infested with live pests.

The analysis of seed pest infestation should be carried out no later than 2 days after receiving the sample. In the cold season, the sample is kept at room temperature for 1.5-2 hours before analysis. To bring the mites into a mobile state, the sample is heated for 20-30 minutes at a temperature of 25-28 °C.

Determination of seed infestation by boll weevils in an obvious form. The seed sample is sieved through two sieves with round holes of 1.5 and 2.5 mm diameter. For small-seeded plants, the sieve with 1.5 mm holes is replaced by a sieve with 1 mm holes. Sieving is carried out for 3 minutes. The sifted material is poured onto a glass with black paper under it and inspected for mites. The number of live mites is counted and their content in specimens per 1 kg is determined. If this figure exceeds 20 specimens/kg, further analysis of this pest is discontinued.

In the seeds remaining on sieves with a hole diameter of 1.5 or 1.0 mm, the presence of borers, mealybugs, May beetles and their larvae is determined, and on a sieve with a hole diameter of 2.5 mm - large beetle, moths, moths, other insects and their larvae. When the first live pest is found, the analysis is stopped.

The apparent infestation of seeds of legumes with grain borers, millet plants with millet moths, maize plants with seed moths, clover, alfalfa, horned lambsquarters, rye, sainfoin with seed beetles is determined during the purity analysis by visual inspection of seed samples. If no live pests are found in the samples, the remainder of the average sample is analysed.

If live pests (eggs, larvae, pupae, adults) are found in the inter-seed space, the analysis is stopped. Hidden infestation is determined when no live pests are detected in an obvious form.

Determination of seed weevil infestation in latent form. If no live pests are found in the seed sample, but dead weevils or damaged seeds are found, then the latent form of seed infestation is determined.

To determine the latent form of weevil infestation of seeds of wheat plants, rye plants, triticale plants, rice plants and barley plants, working samples of 200 seeds are taken and analysed in one of two ways:

- 1) longitudinal cutting of the seed in half;
- 2) colouring the seeds with potassium permanganate and then cutting them.

Seeds of wheat and rye plants that have crust-like spots on the surface but are distinguished by the absence of convexity, blurred shape of the coloured spot, and brown colour are uninfested. When the first live pest is detected, the analysis is stopped.

Determination of the latent infestation of legume seeds with seeds. For the analysis, 500 seeds are counted from the remaining seed of the working sample, weighed and inspected. If the following characteristic features are present, the seeds are opened:

- peas, beans, vetch, lentils - beetle flight holes in the form of darkish round spots covered with seed coat, under which larvae, pupae or beetles are located; In addition, the seeds of bean plants may have subtle injections with a diameter of 0.1-0.3 mm, which are the entrance holes of the larvae of the bean beetle, as well as heavily eaten seeds, from which only the shells remain and which are easily destroyed when pressed;
- Fodder beans - the seeds have the same characteristics as peas, but with a greater number of entrance holes (2-3 or more per seed);
- Sainfoin - seeds with gnawed holes or whitish spots, covered with thin shells, under which beetles or pupae are contained.

If the visual inspection of the seeds does not reveal any characteristic signs of latent pest infestation, the seeds are treated with a 1 per cent solution of iodine in potassium iodide to check for the presence of invisible larval entry holes. After chemical treatment, larval entry holes or puncture sites turn black and become clearly visible as small round spots 1-2 mm in diameter on the surface. Seeds with black spots are dissected to detect live pests (larvae, pupae, beetles).

The seed infestation of pea plants with latent pea moths can also be determined by soaking a sample of seeds (500 pcs) in water at room temperature for 6-14 hours. Seeds with clearly visible "windows" up to 2-3 mm in diameter are isolated from the sample. Each such seed is opened and a live pest (larvae, pupae, beetles) is detected.

The method is suitable both immediately after harvest and during storage. When the first live pest is detected, the analysis is stopped.

Determination of hidden seed infestation of fodder grasses by seed beetles. To determine the infestation of clover, alfalfa, horned bentgrass, and sainfoin seeds, 500 seeds are counted from the remainder of the average sample and probed with a spatula. A liquid mass protrudes from the seed containing the live pest.

To determine the infestation of rye and fescue seeds, 200 seeds are counted from the remainder of the average sample and cut open with a dissecting needle. Infested rye seeds may contain lemon-yellow larvae, fescue seeds may contain yellow-green larvae, or white pupae in light yellow and yellow-brown cocoons. When the first live pest is found, the analysis is stopped.

Determination of hidden infestation of millet seeds by millet mosquito, hemp seeds by hemp leafminer, and maize seeds by seed moth. From the remainder of the average sample, 500 seeds are counted out, examined and isolated from the seed:

- of millet plants - oblong, flatter than undamaged, with greyish-matte flower scales;
- cannabis plants with gnawed holes or cobwebs;
- corn plants - with darkening in the germ zone in the form of a speck.

The isolated seed is opened until the first live pest (larvae, pupae, adults) is detected, after which the analysis is stopped.

Determination of seed disease infestation. Disease contamination of seeds is the presence of viable pathogens on the surface or inside or in the inter-seed space that have caused or are capable of causing damage to seeds, seedlings and vegetative plants with characteristic symptoms under favourable conditions of germination. There are four types of contamination: 1 - impurities; 2 - external, on the surface of the seed; 3 - internal, inside; 4 - combined.

The main indicator of seed disease infection is the ratio of the number of infected seeds to the number of seeds in the record, expressed as a percentage. For certain types of diseases, it is expressed as the amount of pathogen (its formations) in grams or pieces per unit weight or surface area of the seed or per seed.

There are various methods for determining the infection of seeds with pathogens. The choice of methods is determined by the analyst, depending on the plant, the presence and nature of the symptoms of seed diseases and the biological characteristics of their pathogens.

Macroscopic method (carried out simultaneously with the determination of seed purity) - visual detection of sooty formations, ergot and other fungi, as well as wheat nematode galls in seeds. Seed infestation with sooty lesions and cereal ergot is expressed as a percentage of the sample weight, and wheat nematode galls are expressed in pieces per 1 kg of seed.

The method of washing seeds and centrifuging the spore suspension is used to determine the infection of seeds with diseases whose pathogens are present on the seed surface in the form of spores or mycelium:

- hard and stem smut of wheat plants and rye plants;
- hard (stone) and black smut of barley plants;
- maize plant smut;
- common smut of the millet plant;
- *Helminthosporium*, *Fusarium* and rice blight.

For the analysis, four working samples of 100 seeds each are taken from the middle sample. Each of them is placed in a test tube, poured with 10 cm³ of water and shaken. Seeds with a smooth surface (winter wheat, rye) are shaken for 5 minutes, seeds with a rough surface (beetroot, etc.) for 10 minutes, flax seeds for 1 minute. The resulting suspensions are examined under a microscope.

At very low concentrations of spores in suspensions, centrifugation is performed. The wash water from each seed sample is poured into separate centrifuge tubes and centrifuged for 10-15 min at 2000-2500 rpm. After centrifugation, 9 cm³ of supernatant is carefully removed from the tubes. The remaining precipitate is pipetted off and 5 preparations (5 drops each) are prepared from each tube. To determine the

type of fungus, the preparations are viewed under a microscope. Quantitative counting of spores is carried out in a Goryaev chamber. Spore infestation of one seed (Sf) is calculated using the following formulas

$$\text{a) without centrifugation: } C_n = \frac{C_1 \times 10}{100}; \text{ b) with centrifugation } C_n = \frac{C_1}{100}, (1.20)$$

Where: C_1 - number of spores per 1 cm³ of suspension, pcs./cm³; 10 - volume of water taken for washing, cm³; 100 - number of seeds taken for analysis, pcs.

The value of C is calculated by multiplying the number of spores detected in the large squares of the Goryaev chamber by 250000, in the small squares by 400000, and in the entire area of the chamber by 1111.

Imprinting methods - used instead of the method of washing seeds and centrifuging a spore suspension to determine the surface contamination of cereal seeds with smut fungi.

The method of imprinting the entire surface of the seed. Twenty-five seeds are taken from the middle sample, each of which is wrapped with a 1 cm piece of transparent tape², pressing firmly over the entire surface of the seed. The tape is then peeled off with tweezers and placed on a glass slide to identify the pathogen and count the number of spores under a microscope. The spores are counted in 10 fields of view of the microscope in those places of the tape segment that touched the seed and the average number of spores in one field of view of the microscope is determined.

For wheat plants and barley plants, the length and width of the seed are determined with a single magnification under a microscope of the MBS-9 type to an accuracy of 0.1 mm. Based on these measurements, the seed area is determined (Annex I, DSTU 4138-2002). For other cereal plants, the surface area of the seed is measured by imposing prints on millimetre paper or using a microscope eyepiece. The number of spores in units, which falls on the entire area of the seed surface imprint (Ss), is calculated by the formula

$S_n = \frac{N_p \times P_n}{P_n}$ where N_p is the arithmetic mean number of spores in the field of view

N_p of microscope, pcs; F_f - area of the microscope field of view, mm²; S_s - seed surface area, mm².

The average number of spores in pieces per seed in the sample (C_n) is determined by the formula

$$S_p = \frac{\sum C_H}{N_n} \text{ where } \sum C_H \text{ is the total number of disputes on all accounts}$$

N_n seeds in the sample, pcs; N_n - number of accounting seeds
seeds per sample, pcs.

Seed germ surface imprinting method. It complements the previous method and is designed to determine the infection of wheat seeds with hard smut in the germ zone. From the average sample, 100 seeds are selected, from each of which an embryo print is obtained by pressing lightly against the adhesive surface of the tape. The embryo surface prints are viewed under a microscope at 150-600x magnification to detect, identify and count the number of spores per unit area. The average number of spores per unit area of the surface of wheat seed embryos, pcs./mm² (C_3) is determined by the formula

$$C_3 = \frac{\sum H_n}{N_n}, \text{ where } \sum N_p \text{ is the total average number of spores in one field of view}$$

$N_p \times H_n$ of the microscope on all sample seeds, pcs.

the area of the microscope's field of view at the appropriate magnification,

mm^2 ; N_n - number of accounting seeds in the sample, pcs.

Germ analysis method. It is used to detect the mycelium of the fungal pathogen *Ustilago* sp. in the seed embryos of wheat and barley plants separated from the endosperm. To separate the films before analysis, barley seeds were placed in a 50 per cent sulphuric acid solution for 40 minutes. Seed embryos of wheat and barley plants are separated from the endosperm in two ways:

1. The seeds are soaked in a glass or enamel vessel in 1 dm³ of hot freshly prepared alkali solution (KOH or NaOH - 100 g per 1 dm³ of water), in which aniline blue dye for cotton fabrics or trypan blue "for micro" in the amount of 1 g per 1 dm³ of alkali solution is dissolved, and left in a thermostat at 24 °C for 12-24 hours;
2. The seed is placed in an enamel or glass vessel, poured with a 3% alkaline solution and boiled for about 1 hour until the embryos are completely separated from the endosperm.

Four samples of 500 embryos are taken for analysis. Using a dissecting needle or scalpel, they are placed on slides or in Petri dishes in even rows, outlined with a wax pencil, and examined under a microscope from the side of the germinal bud, roots and coleoptile, where mycelium may be present, and from the side of the shield. At low magnification, the mycelium of the pathogen looks like tangles of tangled mycelial hyphae. The hyphae are blue-blue in colour and about 3 µm thick. In addition to smut fungi, other fungi are occasionally found in the tissue of the shield, but their mycelial structure is different and they can be clearly identified.

All infected embryos are counted, regardless of the location of the mycelium, and the percentage of smut infection in each sample and the average in the analysed seed batch is determined.

The luminescence method is used as a rapid method for preliminary analysis of seed infection with certain diseases. Four replicates of 100 seeds each are taken from an average sample, placed on black paper and viewed under an ultraviolet illuminator. The glow of the seed is used to determine the presence or absence of the pathogen:

- Healthy wheat seeds glow with a blue-blue or blue-violet light, while those infected with smut are dark and dull;
- pea seeds in areas of ascochyta or fusarium infection glow with a dull brownish-red light;
- The seed of a maize plant infected with *Fusarium* glows with a bright orange or crimson light;
- healthy soybean seeds glow light blue, while affected areas glow dull brown or dark;
- On beet seeds affected by phomosis, the pycnidia of the disease pathogen glow with a white dull light.

The biological method is the most common. It is used to detect external and internal infection of seeds with diseases. It is based on stimulating the growth and development of pathogenic microorganisms in infected seeds. To determine only

internal infection, the seeds are pre-disinfected with a 0.5 per cent solution of potassium permanganate, 96 per cent alcohol or other reagents.

Seeds are analysed within the timeframe provided for the analysis of their germination. From the average sample, four replicates of 50 or 100 seeds are isolated, depending on the plant species, which are germinated in Petri or Koch dishes in two ways: 1 - in a humid chamber, 2 - on nutrient media.

According to the first method, seeds are germinated without ventilation in sandy growing rooms, small-seeded plants - in bacteriological cups on gauze or filter paper with cotton wool; wheat and rye - in rolls. During seed germination in a humid chamber, bacterial Diseases are detected by softening and slimy seed tissue. Fungal Diseases appear on germinated and ungerminated seeds as spots of various shapes and colours, mycelium, pycnidia, deformity, deformation or death of parts of seedlings.

According to the second method, seeds are germinated on a nutrient medium made of potato agar, potato glucose agar, beer wort or other agar, which creates conditions for the formation of clearly visible conidia. The type of pathogen is determined by the colour, shape of spores and conidia. The number of diseased seeds is counted and their content in the sample is calculated as a percentage.

In order to control the correctness of the identification of seed diseases, a small part of the pathogen colony that has developed on the culture medium is examined under a microscope in a drop of water.

Particular attention should be paid to maintaining sterile analysis conditions. Before analysis, the thermostats are thoroughly cleaned with hot water and detergent and disinfected with a 1% potassium permanganate solution every 10 days.

Before each phytopathological analysis, they are disinfected with ethyl alcohol (96 per cent) or a germicidal lamp for 30 minutes. Monthly, the thermostats are disinfected with bactericidal lamps for 8 hours. The water in the thermostat sump is changed every 3-5 days.

Bacteriological cups with substrate are sterilised in a drying cabinet, water for analysis is sterilised in an autoclave or boiled, metal objects are sterilised over a burner flame, and other equipment is wiped with alcohol.

In each sample, the total number of seeds infected with certain diseases, including bacterial diseases, is counted. If two or more diseases are present on the seeds and seedlings at the same time, the infection of each seed is recorded according to the predominant signs of the Disease. If the Diseases appear in approximately the same amount, they are recorded according to the more harmful one.

Infestation of seeds with saprophytic fungi of the genera *Mucor*, *Trichothecium*, *Monillia*, etc. is recorded separately and is not included in the total infestation.

The amount of seed infection with the relevant diseases by each method is calculated by the formula $Sd = \frac{K + K_1 + K_2 + K_3 + K_4}{Co} \times 100$, (1.21)

where K_1 , K_2 , K_3 , K_4 are the number of infected seeds in each of the four samples,

pcs., Co - total number of accounting seeds in four samples, pcs.

The probability of the results of the analysis of seed disease infection by each method is calculated by the formula:

$$\lambda^2 = \frac{4K_o \times [(K + K + K_1^2 + K_2^2 + K_3^2 + K_4^2) - 4]}{K_x \times (Co - K)_x}, \quad (1.22)$$

where K_1, K_2, K_3, K_4 are the number of infected seeds in each of the four samples,

pcs., K_x - total number of infected seeds in four samples, pcs.

The analysis is considered complete if λ^2 does not exceed the reference value of 16.27. If K_x is equal to or less than 5, no probability check is performed.

Seed quality documents and arbitration rules

Documents for varietal and sowing qualities of seeds. According to the Law of Ukraine "On Seeds" and current national standards, a certain system of state and supporting documentation is established to ensure proper management of the seed production system and to eliminate depersonalisation of varietal material. Seed crops are subject to field testing, and the seeds obtained from them are subject to laboratory testing, which is the basis for the producer to receive state documents for varietal and sowing qualities.

A distinction is made between state and accompanying economic documents on the quality of agricultural seeds. State documents on seed quality are issued by seed inspections of Ukraine.

State documents include documents for:

- a) Seed crops;
 - "**Act of approval of varietal sowing**". It is issued by a commission for testing varietal crops;
- b) seeds prepared for sowing:
 - "**Certificate for Seeds of Ukraine**". It is issued to the producer by the district state seed inspection only for conditioned seeds intended for sale within Ukraine, based on the analysis data and the "Certificate of Approbation"; it is issued for each batch (control unit) separately. It also applies to seeds intended for on-farm use in seed farms included in the State Register of Seed Producers.
 - "**Seed Condition Certificate**". It applies only to conditioned seeds intended for on-farm use. It is issued to the seed producer on the basis of the analysis of the district state seed inspection and the "Certificate of Approbation".
 - "**Seed analysis result**". Issued by the regional state seed inspection in case of seed defects.

Supporting documents include those business documents issued to the consumer by the seed producer:

- "**Certificate for seeds**" - for original and elite seeds;
- "**Seed certificate**" - for reproductive seeds;
- "**Certificate for hybrid seed**" - for the first generation of hybrids. The documents are issued on the basis of the "Certificate" and the "Certificate of Approbation". In the case of resale, the intermediary (reseller) issues new supporting documents for the quality of the seeds (under his own responsibility).

The validity of the "Certificate" and "Certificate" is limited (Table 1.22). After this period, a new sample is taken for analysis by the State Seed Inspectorate, new documents are issued, and the previous ones are cancelled.

Table 1.22**Validity of seed quality documents**

Plant.	Expiration date
Winter seed plants	4 months
Winter crops tested for viability	Before the end of autumn sowing this year
Vegetables, melons, fodder:	
- to the second reproduction	8 months
- III and subsequent reproductions	6 months
Treated and packed maize	12 months
Seed infested with mites	2 months
Sugar beet with a moisture content of up to 14.5 per cent	4 months
- more than 14.5 per cent	2 months

It is prohibited to sell seeds whose producer has not passed the appropriate certification and is not listed in the Register of Seed Producers of Ukraine and does not have an agreement with the originator or author of the variety for its reproduction. For seeds harvested by a grain elevator from several farms, the indicators of varietal and sowing qualities in the "Certificate" are indicated according to the worst data. Batches sold outside Ukraine must receive an international quality certificate.

Rules for arbitration determination of seed quality. The purchased seeds shall be subject to arbitration upon availability of the "Certificate" or "Certificate" issued by the sender and the "Result" issued to the consumer by the district state seed inspection in case of a discrepancy in seed quality exceeding the permissible deviations.

The decision to submit to arbitration is made by the seed inspector at the request of the consumer. The arbitration analysis is carried out by regional state seed inspections (state seed inspection of the Autonomous Republic of Crimea) according to the following indicators:

- cleanliness (except for the content of fallen grains);
- content of impurities of seeds of other species (except for poisonous weeds, quarantine objects), other types of fodder grasses, diaper in peas, flat-seeded vetch in lentil plants;
- content of sclerotia of white and grey rot in sunflower seeds;
- similarity;
- single and multi-sprouted beet seeds;
- viability (only for seeds of winter plants to be sown in the year of harvest).

An arbitrage analysis is carried out if:

- the document being challenged has not expired;
- the application is submitted no later than 10 days from the date of publication of the "Result";
- arbitration samples are selected in accordance with the requirements of Section 4 of this Standard;

- the discrepancy between the quality indicators to be used for arbitration in the accompanying document and in the "Result" exceeds the permissible magnitude of the discrepancy specified in the annexes of DSTU 4138-2002.
- availability of properly executed necessary documents.

Discrepancies between the indicators specified in the accompanying document and those determined by the district state seed inspection serving the consumer are assessed on the basis of the arithmetic mean between them by comparing them with the permissible ones. For plants in which the impurity recorded by the piece is determined by a sample of 500 g or less, the differences are calculated after converting the amount of impurity to the weight of the working sample for purity analysis.

The following documents shall be attached to the application: arbitration trial; the act of taking the arbitration sample; a copy of the document that is being challenged; a copy of the "Result" at the place of service of the seed consumer.

Copies of the documents are certified by the regional state seed inspection. The regional state seed inspection that conducts the arbitration analysis issues a "Result" to the consumer with a mark in the upper right corner: "Arbitration".

After comparing the data from the arbitration analysis with the indicators specified in the documents of the seed producer and consumer, one of the following conclusions is recorded in the "Result" field:

- "The value of _____ in the seed sender's document is confirmed" if the value of the indicator specified in the accompanying document and the result of the arbitration analysis do not exceed the permissible deviation;

- "The value of _____ in the seed consumer's document is confirmed" if the values of the "Result" indicators obtained at the seed consumer's place of service and arbitration analysis are within the permissible deviation;

- "Valid result of the arbitration determination of the indicator _____", if the result of the arbitration analysis exceeds or does not exceed the permissible deviation from the indicator values in both documents or the seed quality was not uniform. The germination rate of barley seeds: according to the sender's documents - 95 per cent; during the inspection at the consumer's place of service - 87 per cent. The arithmetic mean between them is 91 per cent, which (according to the Annex to DSTU 4138-2002) corresponds to a permissible deviation of 6 per cent; the actual difference (95 per cent - 87 per cent = 8 per cent) exceeds the permissible deviation. This means that the seed is subject to arbitration.

The arbitration analysis established: similarity - 85 per cent, permissible deviation - 7 per cent; the difference between the similarity in the sender's document and the one established during the arbitration analysis is 95 per cent - 85 per cent = 10 per cent, which exceeds the permissible deviation; the difference between the similarity indicators determined at the consumer service point and the arbitration analysis is 87 per cent - 85 per cent = 2 per cent, which is within the permissible deviation (7 per cent). The arbitrator's conclusion: "The value of the germination index in the seed consumer's document is confirmed".

Conclusions to Section 1

1. Plant science is essential for human survival and global economies, as it provides food, animal feed, and raw materials for industries like textiles, fuels, and pharmaceuticals. It is the foundation of global food security, ensuring populations have access to sufficient and nutritious food, and it plays a crucial role in economic development by creating employment and generating export revenue. Crops provide the essential food that sustains human and animal populations, from staple grains like wheat and rice to vegetables, fruits, and oilseeds. Horticultural crops, in particular, add variety to diets and contribute to a healthier environment.

2. Plant science are vital for producing feed for livestock, ensuring a consistent supply of animal protein for consumers. Agriculture, and crop production in particular, is a fundamental part of any nation's economy. The sector provides a major source of employment for a significant portion of the population. Crops are used as raw materials for a wide range of industries, including food processing, textiles, and the production of biofuels and pharmaceuticals. Crop production is a major component of international trade, with countries exporting and importing crops to meet their needs. Maintaining crop diversity is crucial for the resilience of food systems, especially in the face of climate change and other threats. Efforts to increase crop yields through technology and improved practices are essential to meet the demands of a growing global population.

3. The yield of agricultural crops depends on the physical and chemical characteristics of the soil, its fertility, cultivation methods, the use of appropriate types and doses of fertilizers, bacterial preparations, plant protection products, agricultural machinery and mechanisms, etc. Therefore, crop production is based on such basic sciences as soil science, microbiology, plant physiology, agriculture, agrochemistry, botany, phytopathology, entomology, mechanization of crop production processes, selection, land reclamation.

Questions for discussion and self-assessment to Section 1

1. Establish how far apart the seeds should be sown in a row if they are sown using the conventional row method with row spacing of 15 cm, a seeding rate of 5 million germinating seeds per hectare, and a laboratory germination rate of 90 per cent?
2. The method of sowing is wide-row with row spacing of 45 cm. Determine the seeding density if 12 kg of beet seeds are sown per 1 ha and the weight of 1000 seeds is 20 g?
3. Determine the distance at which seeds should be sown in wide-row crops with row spacing of 45, 60 and 70 cm if 22 kg of seeds are sown and the weight of 1000 seeds is 100 g?
4. Determine how far apart the tubers of potato plants should be planted in a row if they are planted with row spacing of 70 cm and the planting rate is 60 thousand tubers per 1 ha?
5. Explain the essence of the concept of "seed lot".
6. Indicate the purpose of spot, pooled, average and working samples?
7. What tools are used for seed sampling?
8. What are the components of the sub-samples when determining seed purity?
9. In which cases do parts of the seeds (broken seeds) belong to the main plant and in which cases do they belong to waste?
10. Which weeds are not allowed to be sown?
11. What do the terms "laboratory germination" and "germination energy" mean?
12. Name the methods of germination.
13. What are the measures to overcome the dormant state when analysing freshly harvested seeds with an incomplete period of physiological ripening?
14. What are the seed groups that are evaluated separately during the first germination test?
15. Name the methods for determining seed viability.
16. Where is the 1000-seed weight used?
17. Name the methods for calculating the mass of 1000 seeds.
18. What method is used to determine seed moisture content?
19. When is the two-stage seed drying method used?
20. What diseases can be transmitted by seeds?
21. Name the methods for determining the infection of seeds with pathogens.
22. How many live pests are allowed in the seeds of pea plants and hemp plants?
23. When should we stop analysing seed weevil infestation in latent form?
24. Determine the sowing suitability of seeds of durum wheat plants with extremely low purity and germination of seeds of the first, second and third classes.
25. Determine the seeding rate set for the seeder, if a unit of one SZ-3.6 seeder, having driven 200 m in the working position, sowed 14.4 kg of grain.
26. Find out how many metres a two seeder unit with a 7.2 m working width must travel to sow 144 kg of seed at a seeding rate of 200 kg/ha.

2 CEREAL PLANTS

2.1 General characteristics of cereal plants

Seed plants are the main group of agricultural plants. Depending on their use, botanical and morphological characteristics, and biological features, they are divided into cereal seeds, legumes, and other seeds.

Cereal grain plants include winter wheat, rye, barley, oats, triticales plants, corn, millet, sorghum plants, and rice. Buckwheat is also included in this group due to its specific use. Grain from these plants is used to produce staple foods such as bread, bakery and confectionery products, pasta, noodles, cereals and other products, the average annual consumption of which in different countries ranges from 80 to 150 kg per capita. About half of the world's grain production is used for feed purposes. Straw and grain chaff are of great feed value. Seed plants are also used for green fodder and silage. Grain is used to produce dextrin, starch, alcohol, beer, oil, glucose, etc. Seeds are well transported and stored, which makes it possible to create food reserves for a long period of time.

The seeds and straw of many cereal plants are used as raw materials for technical processing. Grain is used to make starch, alcohol, beer, dextrin, oil, glucose and other products. Straw is used to make paper, cellulose, household goods, adobe, matting and livestock bedding.

The chemical composition of grains varies depending on the type and variety, soil fertility, meteorological conditions and cultivation techniques.

A seed consists of water, organic and mineral substances. Among the organic substances in grain, the largest amount of nitrogen-free extractives is represented by *carbohydrates*, among which starch predominates. Rye, wheat (60-70 per cent) and maize (75-78 per cent) contain the most starch in their grains.

The proteins in cereal breads contain essential amino acids (lysine, tryptophan and others), which determine the food and feed value of grain. Grain contains both simple proteins (proteins) and complex proteins (nucleoproteins, lipoproteins). The protein content of grain depends on the growing conditions. The protein content in the grain of plants grown in the south and east of the country increases. More protein is produced in dry weather, when nitrogen fertilisers are applied and wheat plants are grown after black fallow. Most protein is found in the grain of wheat plants, especially durum wheat (16 per cent), and the least in the grain of rice plants (7.6 per cent).

The quality of flour is characterised by the content and quality of gluten. *Gluten* is a clot of water-insoluble protein substances that remain after the dough has been washed from starch, fibre and other substances. In addition to proteins, gluten contains small amounts of fat, starch and ash elements. The highest quality gluten is found in soft wheat grain, with a gluten content of more than 30 per cent. Barley seeds contain from 2 to 19 per cent, and rye from 3 to 26 per cent gluten. Other cereal grains have a low gluten content, so their flour is not suitable for baking bread.

The fat content of grains is low (2-6 per cent) and is found mainly in the germ. Corn germs contain the most fat - up to 40 percent, oat germs - up to 26 percent, millet germs - up to 20 percent, and less fat in wheat germs, rye germs, and barley germs - up to 14 percent. *Fibre* is a high-molecular-weight carbohydrate substance that forms the

basis of cell walls, grain hulls and flower scales (in filmy breads). Unlike other organic substances, it is poorly digested.

Ash is found in the hulls of grains and in the flower scales of filmy breads. It consists of phosphorus, potassium, sulphur and other oxides. Grain contains many *vitamins* (B, B₁₂, B₃, A, PP, E, etc.) and enzymes (amylase, protease, lipase). Seeded breads are conventionally divided into two groups: *true breads*, or breads of the first group, and *proseeds*, or breads of the second group. Grains of the first group (winter wheat, rye, triticale plants, barley, oats) are cold-resistant plants represented by winter and spring forms, are plants of long daylight hours, less demanding on heat and light and more demanding on moisture than grains of the second group. Cereals of the second group (corn, millet, sorghum, rice) are spring heat-loving plants with short daylight hours and are demanding of heat and light.

Morphological and biological features of bread plants. Bread plants, with the exception of buckwheat, belong to the botanical family of grasses and have much in common in their structure.

The root system is fibrous, consisting of primary and secondary roots, which penetrate to a depth of 2-2.5 m in maize and sorghum plants, up to 2 m in winter wheat, rye, and triticale plants, and up to 1-1.5 m in other plants. Rice roots penetrate the soil to a depth of 60 cm. Germinal roots are formed from the tissues of the seed embryo, secondary roots from underground stem nodes, and most of all from the tillering node. The number of germinal roots varies between different types of bread. For example, wheat plants usually form 3-5 roots during germination, oat plants - 3, rye plants - 4, barley plants - 5-8, and breads of the second group - 1.

On sod-podzolic soils, the roots penetrate to a shallower depth than on black soil. The distribution of roots through the soil layers varies with the age of the plants, but always more than half of their mass is concentrated in the 0-25 cm layer. The 0-40 cm soil layer contains up to 70-85 per cent of the root system mass, and on sod-podzolic soils, up to 90 per cent of the root mass is located in the 0-30 cm layer. Optimal conditions for root growth are created when soil temperature is lower than air temperature, soil density is 1.1-1.3 g/cm³, soil moisture is 65-80 per cent of HB, and capillary porosity is 50 per cent of the total. The root system of corn, rye and winter wheat plants is the most developed. The root system of oat plants, rye plants and buckwheat plants is characterised by high physiological activity and is able to absorb nutrients from hardly soluble soil compounds. In spring wheat and barley plants, the root system is poorly developed and has a low absorption capacity, so it is necessary to apply easily soluble compounds with fertilisers to the soil. At the beginning of plant development, roots grow faster than shoots. In the two- to three-leaf stage, the roots of oat plants penetrate to a depth of 80 cm, wheat plants - 45 cm, and maize plants - 30 cm.

The stem of cereal grains is a cylindrical straw divided into internodes by stem nodes. It breaks the grain coat and appears at the top of the germ in hollow grain breads and at the top of the grain in filmy breads. In bread cereals, the stems are capable of tillering, i.e. forming lateral shoots from underground stem nodes. In maize and sorghum plants, the stem length can reach 2.5-5.0 m, in rye plants - up to 1.8 m, and in other plants - 0.6-1.3 m. The stem of maize and sorghum plants is

filled with a loose core, while the stem of other plants is hollow.

There are two types of cereal stem growth: *apical* and *intercalary*. Apical growth prevails at the beginning of the plant's life (before the tube emerges) as a result of the activity of the apical meristem. It forms the rudiments of nodes, internodes, leaves, and flowers.

From the time of inflorescence formation, the apical growth of the main and lateral shoots stops and the intercalary growth, which is characteristic of the stem, flower and leaves, increases.

Intercalary growth of the stem is caused by the activity of the insertion (intercalary) meristem, which is located above its nodes. It also forms nodal roots and vaginal buds - no more than one in the leaf sheath. In breads of the first group, sheath buds are formed only near the underground nodes of the stem, and in the second group - near the underground, surface and aboveground nodes. Stem growth occurs sequentially from the bottom up. First, the first (lower) internode, located above the upper tillering node, elongates. While it grows, the length of the internode above it remains almost unchanged. As the growth of the lower internode dies down, the growth of the next internode is activated, and so on. The growth of each subsequent internode is longer, longer, and smaller in diameter than the previous one. The longest internode is the one that bears flowers. Underground internodes of the stem, except for the first one in breads of the second group and oat plants, and the second one in breads of the first group, do not elongate under normal conditions and with shallow (3-5 cm) seeding.

Leaves are composed of a leaf blade (50-90 cm long and up to 12 cm wide in maize and sorghum plants, 15-40 cm and 0.5-3 cm in other cereals, respectively) and a leaf sheath and are formed at each stem node. The leaf sheath protects parts of the stem from damage and forms a ring-shaped thickening above the stem node - the leaf node, which helps to lift the stem during lodging.

In cereal breads, rosette and stem leaves are distinguished. Rosette leaves are connected to underground and above-ground nodes, while stem leaves are connected to the nodes of the above-ground part of the stem. The top stem leaf is called the flag leaf.

The rudiments of rosette leaves of the main and coleoptile shoots are formed during embryogenesis (leaves of embryonic buds), the stem leaves of the main shoot, as well as rosette and stem leaves of the lateral shoots are formed during the tillering phase.

The number of rosette leaves depends on the type of plant and the number of tillering shoots. Breads of the first group have 3-4 leaves on the main shoot and 2-3 leaves on the side shoots, so a plant with three shoots can have 7-10 rosette leaves. Breads of the first group mainly form 4-6 stem leaves, and those of the second group - 6-8 leaves or more.

The total number of leaves on the main shoot is a hereditary trait that changes little under the influence of growing conditions; the number and area of leaves of the entire plant largely depends on weather conditions, cultivation techniques, etc.

The rosette and lower stem leaves provide the vegetative organs of plants, the middle stem leaves provide the elements of flowers, and the upper leaves, especially

the flag leaves, determine the level and quality of the crop. Rosette leaves die earlier than stem leaves because their sheaths are injured by nodal roots and they are the oldest - their rudiments were formed last year during embryogenesis, and the age of individual organs, as well as the plant as a whole, is genetically limited.

Three types of inflorescences are distinguished: *spikelet* (winter wheat, rye, triticale plants, barley), *panicle* (oats, millet, sorghum plants, rice, male flowers of maize plants), and *ear* (female flowers of maize plants). A common feature of all inflorescences is the presence of spikelets. Spikelets have two spikelet scales between which flowers are placed.

The ear consists of an ear stalk, on the projections of which the ears are placed. The basis of the panicle is the axis, which ends the stem. The axis is capable of branching, forming lateral branches (1-4 orders), and spikelets are formed at the ends of the last order.

Each flower has two floral scales, an ovary, a column with a stigma, three stamens with anthers (rice plants have six), and two lodicules. In the corn plant, the flowers are unisexual; in the panicle, they are male with stamens, and in the beginning, female with a pistil. Other breads have bisexual flowers. The fruit is a dry, single-seeded grain, glabrous or membranous, covered with spikelet and flower scales. The grain consists of an embryo, endosperm and hulls (fruit and seed). The fruit and seed coats make up 5-8 per cent of the kernel weight (up to 15 per cent in membranous kernels), the embryo 2-3 per cent (14 per cent in maize plants), and the endosperm 76-82 per cent.

2.2 Growth and development of cereal breads

Ontogenesis (individual development) is a set of irreversible transformations that an organism undergoes in the course of its life from conception to natural death.

According to V. V. Skripchinsky (1977), ontogeny is characterised as life itself and the reproduction of a new individual. Life itself begins with the formation of a zygote and lasts until natural death; reproduction of a new individual begins with the same zygote and ends with the formation of gametes.

Stages of own life: *embryonic*, *juvenile* (youth), *generative* (maturity), and *senescent* (old age); stages of reproduction of a new individual: *proembryo*, *feeding*, *sporangia*, *spores*, *gametes*. The life itself and the reproduction of a new individual in the first half of ontogenesis are a single process. With the onset of the generative stage, monocarpic shoots are formed, in which reproduction processes occur that go beyond the limits of their own life. During the senescence stage (aging), the plant's own life continues, but the ability to reproduce is lost.

The full development cycle of cereal breads is completed within a year. In the ontogeny of these plants, we distinguish between the growth and development phases and the stages of organogenesis. The growth and development phases are characterised by external morphological changes that are repeated in each generation, while the stages of organogenesis are characterised by qualitative organogenic processes that result in the emergence of new organs in the embryonic state. Growth can be positive and negative. The main indicator of positive growth is an increase in dry matter weight, which is accompanied by the formation and increase in the size

of the plant's structural elements. A sign of negative growth is a decrease in the dry mass of the plant due to the consumption of photosynthetic products, for example, for respiration during winter dormancy of winter crops, when the seeds ripen after filling, etc. An example of negative growth is also seed germination: the size and wet weight of seedlings increase, but the dry weight decreases.

Thus, positive growth is characterised by the predominance of *anabolism* (synthesis) over *catabolism* (breakdown), and negative growth is characterised by the predominance of catabolism over anabolism. The main sign of growth is an increase or decrease in the weight of the plant's dry matter.

Growth is inextricably linked to development. Growth is a quantitative change in an organism, while development is a qualitative change. Qualitative changes occur at the points of plant growth, where hormones accumulate and cells differentiate, resulting in new structural elements. Growth is the process of forming the structure of organs, while development is the formation of their functions. A function can be performed only with a certain structure, and any structure has a functional purpose. An organ that is capable of fully performing its function is considered developed.

The following phases of growth and development of cereals are distinguished: seed germination, germination, tillering, tube formation (stemming), earing (ejection of the panicle), flowering, grain formation, grain ripening (milky, waxy, full grain ripeness). The beginning of any phase is noted at the time of its onset in at least 15 per cent of plants, and the full phase - in at least 75 per cent.

In most European countries, the so-called decimal code (Zadoks J.C., 1974) was proposed to characterise plant growth and development (Zadoks J.C., 1974), which describes the phenological stages of grain development, and on its basis the *BBSN scale* was developed for a unified coding of phenological stages of monocotyledonous and dicotyledonous plants (Table 2.1). Letters of the abbreviated name of the VVSN scale are the names of the agencies that developed the code (B - Biological Federal Agency for Agriculture and Forestry; V - Federal Agency for Variety Testing; CH - Chemical Industry).

Table 2.1

Developmental stages of grain plants according to the BBSN scale

Code.	Stages of grain development
1	2
<i>Macro stage 0: Germination</i>	
00	Dry seed
01	Start of water absorption
03	End of water absorption
05	Emergence of the rudimentary root tip
06	Embryonic root, extensible, root hairs and/or prominent lateral roots
01	Appearance of the tip of the germinal vagina (coleoptile)
09	Seedlings: coleoptile passes through the soil surface; leaf reaches the tip of the coleoptile
<i>Macro stage 1: Leaf development</i>	

1	2
10	The first leaf emerges from the coleoptile ^{1),2)}
11	The stage of the 1st leaf. The first leaf is unfolded. The top of the second leaf has appeared
12	The stage of the 2nd leaf. The second leaf is unfolded. The top of the third leaf has appeared
13	The stage of the 3rd leaf. The third leaf is unfolded. The top of the fourth leaf has appeared
1.....	Stages that last up to...
19	9 or more leaves unfolded
<i>Macro stage 2: tillering³⁾</i>	
20	No tillering
21	The first tillering shoot appears: the beginning of tillering
22	The second tillering shoot appears
23	The third tillering shoot appears
2.....	Stages that last up to...
29	End of tillering: maximum number of tillering shoots developed
<i>Macro stage 3: Entering the tube (main shoot)</i>	
30	The beginning of the tube: the main shoot and tillering shoots are directed upwards and begin to stretch. The distance of the ear from the tillering node is at least 1 cm
31	The stage of the 1st node: The first node appears on the soil surface, at least 1 cm from the tillering node
32	The stage of the 2nd knot: Second node appears, distance from the 1st node at least 2 cm
¹⁾ A leaf is considered to be unfolded when its ligule or the top of the next leaf is visible. ²⁾ The tillering can occur from the 13th stage. In this case, go to stage 21. ³⁾ The tube can begin to form by the end of tillering, in which case it is worth moving to stage 30.	
33	The stage of the 3rd node: Third node appears, distance from 2nd node at least 2 cm
34	The stage of the 4th node: Fourth node appears, distance from the 3rd node at least 2 cm
3....	Stages that last up to...
37	Appearance of the last (flag) sheet
39	Ligule (leaf tongue) stage: flag leaf ligule is visible, flag leaf is fully developed
<i>Macro stage 4: Swelling of inflorescences (ears or panicles)</i>	
41	The leaf sheath of the flag leaf is lengthened
43	The flowers (spike or panicle) inside the stem are shifted upwards, the leaf sheath of the flag leaf begins to swell
45	The leaf sheath of the flag leaf is swollen

The end of the Table 2.1	
1	2
47	The leaf sheath of the flag leaf opens
49	The awns appear above the ligule (leaf tongue) of the flag leaf.
<i>Macro stage 5: Emergence of inflorescences (ears or panicles)</i>	
51	The beginning of flower emergence (earring): The upper part of the panicle or spikelet is conspicuous
52	Appearance of 20 percent flowers
53	Appearance of 30 percent flowers
54	Appearance of 40 percent flowers
55	Emergence of half a flower. The lower part is still in the leaf sheath
56	Appearance of 60 percent flowers
57	Appearance of 70 percent flowers
58	Appearance of 80 percent of the flowers
59	The end of the ear: Spike or panicle has fully emerged
<i>Macro stage 6: Flowering</i>	
61	The beginning of flowering. The first stamens appear
65	The middle of flowering. 50 percent mature stamens
69	End of flowering
<i>Macrostage 7: Formation of grains (karyopses)</i>	
71	The first grains have reached half their final size. The kernel content is watery
73	Early milky ripeness
75	Medium milk ripeness. All grains have reached their final size. The kernel content is milky. The kernels are still green
77	Late milky ripeness
<i>Macro stage 8: Grain ripening</i>	
83	Early waxy ripeness
85	Soft waxy ripeness. The kernel content is still soft but dry
87	Hard wax maturity. The dent from the nail does not straighten out
89	Early full ripeness. The seed is hard, splits with a thumbnail with considerable force
<i>Macro stage 9: Dying off</i>	
92	Late full ripeness. The seed is hard, not broken by the thumbnail
93	Seed is poorly held in the ear during the day
97	The plant is completely dead. The straw breaks
99	Grain harvested

Germination begins when the seed is provided with sufficient moisture, heat and oxygen. The process begins with the seed absorbing water (swelling). Seeds of wheat plants, rye plants, triticale plants, barley plants absorb 48-60 per cent of their weight in water to fully swell, seeds of corn plants, rice plants - 30-40 per cent, millet plants, sorghum plants - 25-30 per cent. The amount of water required for complete seed swelling varies from plant to plant and depends on the biochemical composition

of the seed. Different substances that make up the grain absorb different amounts of water: proteins - 180 per cent, starch - up to 70 per cent, fibre - about 30 per cent, and fats do not absorb water at all. In the process of swelling, the activity of enzymes increases hundreds of times in the seeds, with the help of which proteins, fats, and carbohydrates are converted into water-soluble substances available to the embryo. At the third stage, the embryo absorbs these substances and the seed begins to germinate.

Breads of the first and second groups differ in the way they germinate. In breads of the first group, with the exception of oat plants, the internode between the shield and coleoptile nodes (epicotyl) does not elongate during grain germination, so the coleoptile node and germinal buds remain directly next to the grain. The embryonic stem with the growth point is ejected later, with the appearance of the second true leaf, due to the growth of the second internode - between the coleoptile and the first leaf nodes. Under natural conditions and at a normal sowing depth (6 cm), the growth point of the germinal stem of the first group of breads remains in the soil at a depth of 1.5-3.0 cm during germination. In breads of the second group and oat plants, the epicotyl elongates and carries the germinal bud together with the growth point and coleoptile to the soil surface, sometimes completely out of the soil. *Seedlings.* When a seed germinates, the first to grow are the germinal roots. Immediately after them, a stem with leaves grows, which, under the cover of the coleoptile (a single-celled white layer that performs a protective function, protecting the leaf from mechanical damage before it appears above the soil surface), breaks through the seed layer of the soil. In naked breads, the leaf stalk and coleoptile emerge from the germ directly above the germinal roots; in filmy breads, they first grow under the floral film and appear on the opposite side of the germ at the top of the grain.

After appearing on the surface, the coleoptile stops growing and, under the pressure of the leaves inside, breaks with a longitudinal crack. The first green leaf appears on the soil surface, indicating that the plants have entered the germination phase.

From a biological point of view, the germination phase lasts as long as the leaves of the germinal bud develop: two in oat plants, three to four in wheat and rye plants, and five to seven in maize plants. At this time, the seedling feeds mainly on organic substances in the seed (heterotrophic nutrition). The minimum temperature for germination of seeds of the first group of breads is $+1...3^{\circ}\text{C}$, the second group $+7...13^{\circ}\text{C}$ (the minimum temperature for germination is $+2...3^{\circ}\text{C}$ higher). The optimum temperature for germination of seeds of the first group is $+18...23^{\circ}\text{C}$, the second $+23...25^{\circ}\text{C}$, and the maximum temperature is $+30...33^{\circ}\text{C}$ and $+35...40^{\circ}\text{C}$, respectively.

The emergence of seedlings depends on the species (rye germinates earlier), germination energy, soil texture, depth of seed placement, soil moisture and temperature. Seeds germinate well only when there is free access to oxygen in the air. If it is restricted, for example, in waterlogged and very compacted soil, germination processes are inhibited.

The seedlings of cereal plants have a characteristic colour: wheat plants are green, rye plants are anthocyanin, barley plants are blue-smoky, and oats and pearl millet plants are pale green.

By the time 3-4 leaves are formed, the rudimentary roots branch out and penetrate the soil to a depth of 30-35 cm, stem and leaf growth is temporarily suspended, and the rudimentary stem differentiates into nodes and internodes. During this period, there is a risk of root rot damage, especially if the seedlings are exposed to waterlogging, low soil temperature, and deep seeding.

Bushing. For cereal plants, a characteristic biological process is the formation of lateral shoots and secondary roots at the underground stem node, which is formed closer to the soil surface. It is called the tillering *node*. The tillering node is a plant organ that is capable of forming and renewing shoots equivalent to the mother shoot. Wintering of winter crops depends entirely on the development of the tillering node and the accumulation of sufficient sugars in it. It is located in the soil at a depth of 1 to 4-5 cm, and most often 2-3 cm.

If the plant density is too high and they are shaded by each other, as well as if the soil temperature is too high, the underground internodes, especially the second one, grow rapidly and form a tillering node closer to the soil surface. The tillering node is an extremely important and complex organ with a large supply of plastic substances. When leaves and stems die, tillering nodes are able to reproduce new shoots with leaves and a new root system. In most breads, tillering begins when the plants have three leaves - 13-18 days after germination in breads of the first group, and 20-30 days in the second group. At this time, the above-ground growth of plants temporarily stops, and the plastic material is more actively directed to the tillering node for branching of the main stem with the formation of lateral shoots. When the first leaf of the main shoot emerges from the axil of the first leaf of the lateral shoot, the tillering phase begins. Under favourable conditions - with a sufficient feeding area for each plant, sufficient supply of nutrients and moisture, moderate temperature in the tillering node, especially for breads of the first group - 5-10, and on sparse crops - up to 15-20 lateral shoots and more (under particularly favourable conditions - up to 100-200 shoots) can be formed.

Simultaneously with the formation of lateral shoots at the tillering node, a nodal (secondary) root system is formed (initially, two roots are formed on each shoot).

Among the lateral shoots formed by the plant during tillering, there are fruiting shoots and those that do not form inflorescences or form inflorescences but without grain. In this regard, a distinction is made between *productive tillering*, which refers to the number of shoots on a plant with fruiting flowers, and *total tillering*, which refers to the number of all shoots on a plant. Shoots that form non-fruiting flowers are called a *pod*, and those without flowers are called a *sub-seed*.

Productive tillering in normally thickened crops of most breads averages 1.5-3. It is higher in winter plants, where tillering occurs over a longer period of time - in autumn and spring.

The tillering phase in cereal breads ends at the III stage of organogenesis - when plants move to the light stage of development. The total and productive tillering is determined by counting the number of plants, fruiting and non-fruiting shoots in plots of 1 or 0.5 m² in several places along the diagonals of the field. Based on the calculations, the average coefficient of total and productive tillering is derived. The intensity of tillering depends on the growing conditions, species and varietal characteristics of the cereal plants. At optimal temperatures (+10...15°C) and soil

moisture, the tillering period is extended and the number of shoots increases. Under normal conditions, winter plants form 3-6 shoots, while spring plants form 2-3. The number of shoots is also influenced by soil fertility, especially the application of nitrogen fertilisers before the start of the stemming phase.

The dynamics of the formation of tillering shoots and nodal roots in cereal plants is not the same. In rye and oat plants, tillering and rooting occur simultaneously with the appearance of 3-4 leaves. In barley plants and wheat plants, tillering shoots appear before rooting begins, tillering occurs when the 3rd leaf appears, and rooting occurs when the 4th-5th leaf appears. In millet plants, tillering shoots are formed when the 5-6th leaf appears, and in sorghum plants, when the 7-8th leaf appears. The nodal roots of these plants begin to develop when 3-4 leaves are formed. Simultaneously with the formation of lateral shoots, a secondary root system is formed, which is located mainly in the surface layer of the soil. During this period, the foundation for the future harvest is laid - the formation of spikelets.

The tillering stage is one of the reserves of ontogenetic strength, a mechanism for increasing the competitiveness of plants due to an increase in leaf surface area, number of roots, and reproduction rate. With the onset of the tillering phase, the probability of plant survival increases. Bushing is typical for all cereals, but in the second group of breads, unlike the first, lateral shoots are formed not only near the underground shoots but also near the nodes of the aboveground part of the stem, i.e. the stem bush and branch, which increases the reproduction rate. From an economic point of view, tillering plays both a positive (increased plant productivity and yield) and negative role: unproductive use of soil moisture and nutrients, uneven maturation of plants, increased costs of harvesting separately, seed heterogeneity, etc.

The tillering of plants can be controlled by adjusting the seeding rate, sowing time and methods, seeding depth, etc. For example, the tillering coefficient of winter wheat plants decreases with an increase in the seeding rate, seeding depth and late sowing, and vice versa: a decrease in the rate, normal depth and early sowing increase tillering. For normal plant development, the seeds should be sown at a depth such that the tillering nodes, especially the upper one above the growth point, are in the soil. This guarantees normal tillering, development of a powerful root system, and preservation of the growth point. Under favourable conditions, the optimum sowing depth for seeds of breads of the first group is 4-6 cm, with the upper tillering node at a depth of 1.5-3.0 cm.

The depth of the tillering nodes depends on the type of plant, the depth of seed placement, temperature, light level, etc. For example, in breads of the first group, the upper tillering node is deeper than in breads of the second group and is not taken out of the soil, while in breads of the second group, under insufficient light or delayed rooting, tillering nodes are taken out, sometimes to a considerable height. The tillering nodes of winter wheat plants lie deeper at late sowing dates and deep (more than 6 cm) seeding than at early sowing dates and optimal sowing depth. With deep sowing, the internodes between the tillering nodes are lengthened, bushiness and the number of nodal roots are reduced. At the optimum sowing depth, the tillering nodes are usually close together and look like a thickening in which individual nodes are difficult to distinguish.

The depth of the tillering nodes is regulated by the leaf sheath and tongue. The sheath grows until the tongue appears above the coleoptile or sheath of the previous leaf. Under the influence of light, the periscope cells of the tongue synthesise specific substances that enter the base of the sheath and inhibit its growth, causing the tillering node to which the sheath is attached to stop at a certain depth.

Tube growth. The transition of plants to the tube phase begins with the growth of the stem in length. In cereal plants, a stem with very short internodes, which look like densely spaced transverse rings, can be found in the tillering phase.

The growth of internodes begins with the lower one, which is directly above the tillering node. After that, the second one grows, then the third, and then the next. Each internode has its own growth zone at the base, which gave rise to the name of *insertion* or *intercalary* growth.

Another regularity was found in the growth of internodes: each subsequent internode grows more intensively than the previous one and, as a rule, exceeds it in length.

The phase of plant emergence into the tube in winter plants occurs in spring, after the appearance of 2-3 new leaves. The simple elongation of leaf sheaths, which is often observed in thickened crops of winter plants in rainy autumn, should not be mistaken for the stemming phase. In agronomic practice, the tube stage is often defined by the appearance of a stem node above the soil surface at a height of 4-5 cm. This phase continues until the VIII stage of organogenesis.

Drought, heat stress, frosts during the period of plant growth increase the number of dead shoots due to the limitation of plant resources. This period is a period of intensive growth and development in plants, and it is during this period that plants absorb the maximum amount of moisture and nutrients. Often, only the main shoot remains for reproduction in drought conditions. If the drought stops or additional nitrogen fertilisation is applied during this period, the synchronisation of plant development is disrupted and they form many ears that ripen late, which is also a problem during harvesting.

The yield also depends to a large extent on the size of the ear and its water content. The ear begins to form at the third stage of organogenesis, which coincides with the tillering and stemming phases. During the tillering period, plants must be sufficiently supplied with available nutrients, especially nitrogen, which dramatically increases growth processes and the formation of productive organs.

The fifth stage coincides with the middle of the phase of plant emergence into the tube and is characterised by the beginning of flower formation and differentiation, the laying of stamens, pistils and integumentary organs. Its phenological sign is the appearance of the second stem node. At this stage of organogenesis, the number of flowers per spikelet potentially possible for the variety is finally determined. Foliar feeding will be effective and ensure the establishment of a large ear, and the earlier it is carried out, the better the final result.

Heading, the end of cone differentiation, occurs during the sixth and seventh stages of organogenesis, which coincides with the second half of the heading to ear phase. During this period, the plants absorb the largest amount of nutrients, resulting in an increase in the number of productive stems, spikelets and grains in the ear. At this

time, the second dose of nitrogen fertiliser and foliar feeding (the appearance of a flag leaf before flowering) are applied. This feeding significantly increases the yield by increasing the viability of pollen and the formation of grains in the ear.

Thus, the earing stage is considered to be a critical period in the formation of plant productivity. The first critical period (the "*double ring*" period) begins when two bands form on the growth cone of the main shoot, indicating the beginning of ear formation. In winter cereals, the "double ring" appears even before the start of winter dormancy, in the sixth leaf stage. The second, so-called "*big critical period*" begins when the second above-ground node appears on the stem of the main shoot (the beginning of stemming) and lasts until the flag leaf appears. During this period, the stem and flowers are actively growing, and the sensitivity of plants to moisture, nutrient and light deficits increases dramatically. Under unfavourable conditions, wheat plants and rye plants at the bottom and barley plants at the top of the ear die off. The appearance of the flag leaf reduces the sensitivity of breads to growth regulators. *Spikelets*. During the growth of the last (upper) internode, flowers appear from the sheath of the upper leaf, which indicates the beginning of the earing phase or ejection of the panicle in plants with panicle flowers. The intensity of growth processes depends on the supply of moisture and nutrients. Heading (ejection of panicles) occurs at the VIII stage of organogenesis and lasts 5-7 days until the growth of the last internode stops. The duration of the phase is longer, the greater the tillering ratio. High temperatures accelerate earing, while low temperatures slow it down; under favourable conditions, the earing period is longer than under unfavourable conditions. *Flowering* in cereal plants occurs during or shortly after earing. For example, barley plants bloom before full earing, when the ear has not emerged from the leaf sheath, wheat plants bloom 2-3 days later, and rye plants bloom 8-10 days after earing. In terms of pollination, rye, corn, and sorghum plants are cross-pollinated, while winter wheat, triticale, barley, millet, and rice are self-pollinated.

Ripening. After fertilisation, a kernel forms from the ovary. The formation lasts 12-16 days, and at the end of the phase, 25-30 per cent of dry matter is accumulated in the grain. When the formation is complete and the growth of the kernel stops, the intensive supply of nutrients to the kernel begins, i.e. the kernel begins to *fill*.

Grain ripening actually begins when the grain reaches milky ripeness, which indicates the beginning of filling, i.e. the accumulation of photosynthetic products, primarily starch. The products of photosynthesis enter the grain in the form of a solution, which increases its wet and dry weight. During filling, organic compounds are polymerised, and soluble substances turn into insoluble substances and are stored for future use, displacing water from the endosperm cells, which leads to a decrease in grain moisture content. This is the so-called metabolic (physiological) evaporation of moisture, which occurs even at 100 per cent ambient humidity. At a moisture content of 65-60 per cent, the kernel content becomes a milky white liquid. This state is called milky *ripeness* and lasts for 10-12 days. At the end of milk ripeness, the moisture content of the kernel decreases to 45-40 per cent, and its contents turn first into a doughy and then waxy mass - the *waxy ripeness* phase begins. Depending on the conditions, it lasts 6-12 days. When the moisture content

of the grain decreases to 35-30 per cent, separate harvesting of bread plants can begin. Grains reach full ripeness when their moisture content drops to 13-15 per cent in the southern regions and 17-20 per cent in the northern regions. The grain becomes hard, its volume decreases, and it can fall off the flower.

The duration of the ripening period directly correlates with the yield: the longer the accumulation of plastic substances takes, the larger the grain and the higher the grain yield. High temps during this period lead to accelerated ripening and the formation of small grains. Temperatures that are too low also have a negative impact on yields, as they slow down the outflow of assimilants into the grain and delay harvesting. Heavy rains lead to lodging of crops, grain sprouting, reduced grain quality (gluten runoff), and complicated harvesting. Delayed harvesting in high temperatures leads to a significant reduction in grain moisture, increased cracking and grain shattering.

Each organ, like the plant as a whole, goes through several stages during its individual development (organogenesis). *Organogenesis is the* formation of plant organs in their embryonic germinal state. According to F.M. Kuperman, twelve stages of organogenesis are distinguished in the ontogeny of cereal breads.

Stages IV-X of organogenesis are the most crucial in plant life. At these stages, the main elements of plant productivity are formed: the number of spikelets per inflorescence, the number of grains per spikelet, and the number of productive inflorescences. In the first to third stages of organogenesis, living conditions play a leading role in the formation of plant productivity elements, while in the fourth to tenth stages, the influence of the environment is largely limited by the genetic characteristics of the plant. For example, under favourable conditions, during the IX-X stages of organogenesis, 3-5 grains can be formed in the ears of wheat plants, but there is no way to force the plant to form 20 grains in the ears, because this is not provided for in the genetic programme. At the XI-XII stages, no new organs are formed, and the morphogenesis of the embryo and the grain as a whole is completed.

The stages of organogenesis are taken into account when planning technological operations, which should provide favourable conditions for the formation of certain organ rudiments. A technological operation carried out at the wrong time not only fails to achieve the goal, but can also be harmful. For example, irrigation or fertilisation of plants during the IV stage of organogenesis will not increase the number of ears beyond the number of spikelet segments, but may cause excessive growth of vegetative organs and lodging of plants. Under unfavourable conditions, at the IV stage of organogenesis, some of the lower spikelets remain without spikelets or bear underdeveloped spikelets. At the V stage, it is impossible to increase the number of spikelets in the ear or the number of branches in the panicle, because their formation was completed at the IV and III stages, respectively.

In foreign countries, when grading cereal crops, not the stages of organogenesis are taken into account, but the detailed phases of plant growth and development. In this case, each phase and its individual periods (sub-phases) are designated by appropriate numbers (coded), a systematic series of which is called a *scale*. The most well-known are the *Feekes* scale and the international scale of the Association of Plant Breeders - *Eucarpia* or *ES*.

Seeded spiked plants are sensitive to *lodging*. Lodging of crops disrupts the normal growth and development of plants, reduces the size of the photosynthetic surface, slows down the absorption of nutrients and water, which causes significant yield losses. The faster the crops lie down, the greater the shortfall in grain yield. The level of losses also increases due to deteriorating harvesting conditions at harvest time. There are two types of lodging in cereal plants: stem lodging and root lodging. *Stem lodging* is observed on thickened crops. Insufficient lighting of plants in such crops leads to the fact that the lower internodes are stretched out, and little cellulose and hemicellulose are deposited in the cell walls. Such stems cannot support the weight of the plant and lodge during rains and winds. Rye and barley are most susceptible to lodging. Short-stemmed varieties are more resistant to lodging. *Root lodging* occurs when the soil is excessively moist. Frequent rains and strong winds cause lodging mainly in tall plant varieties with strong stems (corn, sorghum plants). To prevent lodging, apply high doses of nitrogen fertiliser in separate doses during the growing season. Varieties prone to lodging and those with high tillering energy are sown at lower seed rates.

To protect plants from lodging, biologically active substances that inhibit stem growth - retardants - are used. These are chlorocholine chloride (CCC, XXX), which is the basis for the formulations: TUR, Retacel, Chlormequat, Arotex and others, as well as Typhon (2-chloroethyl phosphonic acid), which is the active ingredient in Campozan, Erel, Flordimex, Dihydrel and other products. The effect of the drugs is manifested in the inhibition of subapical meristem cell stretching, which inhibits growth in length and slows down the differentiation of the growth cone. This leads to an increase in the duration of certain stages of organogenesis and an increase in the productivity of the ear due to an increase in its length, number of spikelets and grains in it. In plants sprayed with retardants, the height of the stems decreases by 15-30 percent, their thickness increases, and the plants become more resistant to lodging.

2.3 WINTER CEREALS CROPS

Winter cereals (winter wheat, rye, triticale plants, barley) are forms of bread plants that bear fruit only when sown in autumn and are harvested after overwintering. During spring sowing, winter crops only bush but do not sprout, because to complete their development, they must go through the vernalisation stage (stimulation of flowering by cold) at low temperatures of $0...+3^{\circ}\text{C}$ (in the tillering phase $+10...12^{\circ}\text{C}$) for 35-60 days and autumn lighting. By acting on the growth cone, low temperature conditions contribute to qualitative biochemical changes in plants - the passage of the vernalisation stage, which further ensures the onset of generative phases. That is why they are sown in autumn 50-60 days before the onset of stable frosts. Spring cereals (winter wheat, triticale plants, oats, barley and all millets - millet, sorghum, sorghum, corn, rice) are sown in spring and harvested in the same year. For vernalisation, they need higher temperatures ($+5...20^{\circ}\text{C}$) for 7-20 days under spring light.

In addition to winter and spring crops, there are also transitional forms - *two-handed crops* (winter wheat, triticale plants, barley) that go through the vernalisation stage at temperatures of $+3...15^{\circ}\text{C}$. They are able to sprout and produce grain during

spring sowing and, having higher frost resistance than spring forms, during autumn sowing. The biological feature of two-handed crops is that in autumn they end the growing season later than typical winter varieties, and in spring they resume it earlier. Winter crops, compared to spring crops, have a number of biological and organisational and economic advantages.

The biological advantages of winter crops are that they are able to accumulate more plant mass with timely sowing, as their assimilation period lasts 120-150 days, while spring crops have a 90-100-day assimilation period.

Using the warm autumn period, winter plants have time to form a developed root system and harden before winter. Hardened plants tolerate unfavourable overwintering conditions well, start growing earlier in spring, and therefore make better use of early spring moisture, nutrients, and light. With the onset of steady heat, they quickly increase their vegetative mass, outgrow weeds and smother them, and suffer less from spring droughts.

A better developed root system and earlier (by 10-15 days) maturation of winter crops help to reduce the negative impact of summer dry winds. An integrating indicator of the biological advantages of winter cereals is their higher yield, by 10-15 c/ha.

The organisational and economic advantages of winter crops are that sowing in autumn and harvesting them earlier in summer reduces the intensity of sowing and harvesting operations. Early harvesting makes it possible to better prepare the soil for subsequent plants, which is why winter crops are a valuable part of crop rotations for most agricultural plants. After winter crops are harvested, there is enough warm time left to grow an additional crop of post-harvest plants for seed (buckwheat, millet) or green fodder on the same area.

2.3.1 Winter hardiness of winter cereals

The biological characteristics of winter plants limit their distribution. In regions where winter conditions are very harsh, winter crops can be thinned out or die. The ability of plants to withstand a range of unfavourable conditions in winter and early spring is called *winter hardiness*, and their ability to withstand low temperatures is called *frost hardiness* (below 0° C) or *cold hardiness* (above 0° C). The resistance of winter crops to low temperatures is an important adaptive property that has evolved over time. The properties of protoplasm that determine its water-holding capacity play an important role in increasing the winter hardiness of plants. Excess or deficiency of water is one of the causes of winter crops death. With an excess of water, there is a significant formation of ice crystals in plant tissues, which has a detrimental effect on their condition. Lack of water leads to irreversible coagulation of protoplasmic biocolloids and plants die.

The resistance of winter crops to unfavourable conditions is influenced by the application of granular, especially manganese, superphosphate to the rows at the rate of 10-12 kg P₂ O₅ per hectare, simultaneously with sowing seeds. Fertilisation at the beginning of the growing season with phosphorus and manganese contributes to the accumulation of plastic substances in the tillering nodes and increases the winter hardiness of plants.

The application of phosphorus-potassium fertilisers helps to increase the

resistance of plants to unfavourable wintering conditions. Excessive nitrogen nutrition accelerates plant growth and negatively affects their hardening. Physiological transformations in plants that increase their frost resistance, according to I. I. Tumanov, are associated with the processes of transforming the cell contents from a relatively liquid state (ash) into a thickened, gelatinous state (gel) due to a decrease in free water, which freezes easily, and an increase in the content of bound water, which freezes hard, and in improving its structure and physical properties.

Plant winter hardiness is a complex physiological phenomenon. Winter hardiness and frost resistance are not permanent properties of winter plants, but are formed at certain stages of development, especially in the process of plant hardening. Tumanov found that hardening occurs in autumn in two phases. The *first phase of hardening takes place under* intense lighting conditions. For its completion, 10-12 sunny days are enough, when the temperature rises to +8...15° C during the day, at which photosynthesis processes are active, and at night it drops to 0° C, at which plants significantly reduce the consumption of assimilants.

The carbohydrates synthesised during the day are not fully used for building green mass and for respiration due to the inhibition of growth processes during cool nights, so they accumulate (up to 30 per cent or more of sugars in tillering nodes and leaf sheaths in terms of dry matter). Carbohydrates play a protective role (preventing coagulation and denaturation of proteins) and are also a reserve material that plants use in the spring when they resume vegetation.

Plants after the first hardening phase can withstand a decrease in temperature at the depth of the tillering node to -10...12° C. The *second hardening phase* (main) takes place in late autumn, at mild frosts (0...-5° C) both in light and in the dark. Some dehydration of tissues occurs. There is an outflow of water from the cytoplasm into the intercellular spaces and the transformation of water-insoluble organic compounds into solution in the cells. This increases the concentration of cell sap in the tillering nodes and leaf sheaths, and changes the properties of the cell cytoplasm: it increases viscosity and decreases permeability.

Sugar inhibits coagulation of colloids and lowers the freezing point of cell sap. Its osmotic pressure and water-holding capacity increase. Complex proteins are converted into simpler forms that are resistant to coagulation at low temperatures. Plants become resistant to frost and other adverse wintering conditions. Rye goes through the second hardening phase faster, winter wheat is slower, and winter barley is slower.

After this phase, resistance to unfavourable winter conditions increases sharply. In the process of hardening, a lot of soluble carbohydrates and free amino acids accumulate in the vegetative organs of winter crops. Among them, oligosaccharides, proline, asparagine and glutamic acid have the highest proportion. During hardening, the largest amount of soluble carbohydrates and free amino acids accumulates in the tillering nodes. Frost- and winter-hardy winter wheat varieties accumulate more oligosaccharides and free amino acids during hardening than weakly hardy ones. Oligosaccharides are gradually converted into soluble sugars (sucrose, etc.), resulting in an increase in the concentration of cell sap, which increases the resistance of plants to low temperatures.

Plant hardening depends on the meteorological conditions of autumn. Clear, sunny weather, with warm days and cool nights, promotes hardening, and vice versa, cloudy weather in autumn, with warm days and nights, delays plant hardening. Well-hardened winter wheat can withstand temperatures down to $-18...20^{\circ}\text{C}$, rye - down to $-22...23^{\circ}\text{C}$, triticale plants - down to $-20...22^{\circ}\text{C}$, winter barley - down to $-13...14^{\circ}\text{C}$. The ability to harden changes in the process of plant development. Successful hardening is possible only before winter crops complete the vernalisation stage. Hardening processes are reversible. If there are prolonged thaws in winter and early spring and the plants resume their growth processes, they will be hardened. After that, they are able to harden again, but the conditions for this are not right and the plants are damaged by subsequent frosts. Thus, winter hardiness of winter crops should be considered as a result of the interaction between plants and the environment, as an adaptation to unfavourable wintering conditions.

2.3.2 Growth and death of winter crops. Protecting plants from adverse wintering conditions

The benefits of winter cereals can be most fully realised when there are suitable conditions for their successful overwintering and spring and summer development. Therefore, weather conditions in winter and early spring play a crucial role in the life of winter plants.

The causes of damage and death of winter crops are different. In Ukraine, winter plants in the steppe regions are most often thinned out or killed by freezing, in the forest-steppe regions - by ice crusts, in the Polissya regions - by damping off, soaking, and freezing.

Freezing of plants is observed when the temperature at the depth of the tillering node is reduced to critical levels. Under the influence of prolonged frosts, ice forms in plant cells and intercellular spaces, which leads to mechanical damage to cell membranes, and the cytoplasm dehydrates to a level where irreversible processes of coagulation of its colloids occur, and protein denatures. Plants that are frozen and emerge from the snow are green at first, and after thawing turn yellow and die. The ability of plants to withstand low temperatures depends to a large extent on the variety, stage and autumn hardening. In frost-resistant varieties, the hydrolysis of starch and sucrose is vigorous, which increases the concentration of cell sap. The plant can also die from freezing as a result of insufficiently deep tillering. In winter-hardy varieties, the tillering node is much deeper than in less winter-hardy varieties. In addition, winter crops are at risk of freezing when a hanging ice crust forms on the soil surface. The most dangerous is the crust covering the tillering node. A reliable means of protecting plants from freezing is snow retention. Snow has low thermal conductivity and protects winter crops well from excessively low temperatures. It is proved that at a minimum temperature in the air of $-32...33^{\circ}\text{C}$, the temperature at the depth of the tillering node without snow is $-22...23^{\circ}\text{C}$, in fields with a snow cover of 15-17 cm it decreases to $-7...11^{\circ}\text{C}$, and at a snow thickness of 50 cm - only $-2...3^{\circ}\text{C}$.

Measures that increase the frost resistance of plants include the selection of frost-resistant varieties, sowing them at the optimum time and at a depth that ensures that the tillering node is at least 2.5-3.0 cm from the soil surface. The depth of the tillering

node is significantly increased when the seeds are treated with retardants before sowing. Phosphorus and potash fertilisers increase frost resistance.

Crops can be damaged in the following cases:

1. if the thickened, overgrown and poorly hardened plants are covered with a thick layer of snow that does not melt for a long time in spring.
2. when a hanging transparent ice crust forms on winter crops, under which the temperature rises and plants resume vegetation under the influence of light.
3. when snow falls on unfrozen soil, when winter crops are not prepared for winter. They continue to grow, breathe intensively and quickly use up their stored nutrients.

When winter crops are thawed out, they die of exhaustion due to insufficient light under the snow for assimilation. First, carbohydrates are consumed, then proteins are broken down and, as a result, the weakened plants are affected by snow mould and other fungal diseases and die.

To prevent thawing out when early snow falls on unfrozen soil, it is advisable to compact it with rollers. In this case, the soil cools down quickly and plant growth is halted. Avoid early and thickened sowing, as well as excessive nitrogen fertilisation. At the end of winter, to accelerate the melting of icy snow, it is advisable to loosen it and spread peat, ash or other neutral dark materials on the snow surface. In addition, hanging ice crusts should be destroyed, and varieties resistant to melting should be used. It should also be borne in mind that winter rye and barley are less resistant to damping off than winter wheat and triticale plants. *Soaking* is observed on low relief elements, on clayey soils with a heavy mechanical composition, where water lingers for a long time under the snow or after it melts in early spring. Underwater, plants die in 10-15 days due to excessive consumption of sugars to maintain life in anaerobic respiratory conditions. With increasing temperature, the process of soaking accelerates, and weakly hardened plants soak faster.

Protecting plants from getting wet involves installing drainage ditches in places where water stagnates, vertical drainage, soil slotting, sowing soaking-resistant varieties, and, if necessary, pumping out water.

Bulging out is the displacement of plant tillering nodes to the soil surface, accompanied by the breakage of the root system. It occurs in autumn, winter or spring on heavy, unstructured soils, as well as on soils that have not settled before emergence, due to their subsidence and alternate freezing and thawing. Bulging is also caused by the formation of loose ice under the soil surface, when it increases in volume and then settles during thawing, exposing the tillering nodes of plants. Bulging is particularly harmful when it is accompanied by severe frosts and dry windy weather in spring and during dust storms.

Strong winds blow out and cover the plants with soil particles. To protect plants from bulging, we need to cultivate the soil in a timely manner, compact it before sowing, sow seeds to the optimum depth, and treat the seeds with retardants before sowing, which helps to deepen the tillering node and improve root development. On crops where plants have bulged out, we roll them with ring rollers in the spring to ensure better contact of the tillering nodes with the still moist soil, which results in faster formation of new stem roots and resumption of plant growth.

The main means of protection against blowing, cutting and covering of plants with soil observed in areas of wind erosion are no-dump flat-cut tillage, stubble seeding, coulters and strip sowing. *Ice crusts*. They can be transparent and muddy, rubbed and hanging.

The greatest damage is caused by *ground transparent ice crusts*. They are formed when all the snow melts during thaws and the resulting water freezes with the onset of frost. Depending on the depth of soil thawing, the ice either adheres tightly to the soil surface or binds it to the depth of thawing, and winter crops are frozen in ice. Since the thermal conductivity of ice is 5 times higher than that of snow, winter crops freeze, gas exchange is also impaired, the supply of oxygen to plant tissues is reduced, and anaerobic processes increase.

Crusts on the surface of the frozen soil are much less damaging and do not capture the tillering nodes of plants.

Hanging ice crusts appear when water from thaws freezes on the soil surface. If the soil is thawed, the water is absorbed and there is a free space between the soil and the ice crust. The hanging crust (especially a muddy one) that forms on frozen soil is mostly harmless to plants, and sometimes even plays a protective role against severe frosts. For example, when the air temperature is -25°C , the temperature under a 4 cm thick ice crust rises to -14°C .

However, if the hanging crust is stored for a long time and solar insolation increases, the so-called "greenhouse effect" is created, which allows plants to come out of dormancy and resume vegetation. In the case of hanging ice crusts, plants die from damping off or soaking when the soil is waterlogged.

Destroy the crusted ice by sprinkling it with dark materials (peat, ash, humus, etc.). Snow retention significantly reduces the formation of crusts. Hanging ice crusts are destroyed by rolling. Ice crusts formed after the thaw on the snow surface usually do not cause damage to winter crops.

Snow mould is caused by the parasitic fungus *Fusarium nivale* and manifests itself in the form of whitish or pinkish patches on winter crops (most commonly winter rye) that have emerged from the snow. Snow mould is often accompanied by damping-off and develops on plants that are dead or dying as a result of damping-off or adverse events. However, the mould also affects plants that are alive but weakened during the winter. In addition to snow mould, winter crops often develop a disease caused by the fungus *Sclerotinia graminearum* after overwintering.

In this case, first white and then dark brown dense lumps - sclerotia - appear on the plants. In the fight against snow mould, the introduction of varieties resistant to *Fusarium* is crucial. Good results are obtained by disinfecting seeds before sowing with Granozan. Given the ability of winter wheat plants to continue tillering in spring, it is possible to correctly identify areas of dead crops only 2 weeks after the start of the spring vegetation.

2.3.3 Winter wheat (*Triticum*)



Winter wheat is one of the oldest and most widespread plants. It was known 6.5 thousand years before Christ in the territory of modern Iraq, 6 thousand years before Christ it was grown in Egypt and 3 thousand years before Christ in China. Since ancient times, wheat has also been grown in Ukraine.

Archaeological research has shown that wheat was grown in what is now the Khmelnytsky region as early as the fourth millennium BC.

Winter wheat is the most important seed crop in Ukraine. It ranks first in terms of sown area and is the main food crop. Winter wheat

is grown mainly in countries with mild climates. In countries with harsh climates, spring forms are common. In Ukraine, winter wheat is sown on an area of 6.5-7.5 million hectares (240 million hectares globally), while spring wheat is grown on 400-450 thousand hectares.

Wheat bread is characterised by high nutritional value and flavour, and is superior in terms of digestibility to bread made from flour of other cereal plants. 100 g of wheat bread contains 245-255 kcal, which indicates its high nutritional value and energy content. The value of wheat bread is determined by the chemical composition of the grain. The grain of wheat plants contains 11 to 20 per cent protein, 63 to 74 per cent starch, about 2 per cent fat, up to 2 per cent ash minerals and many vitamins (B, B₁₂, PP, E, provitamins A and D). In addition to bread baking, wheat flour is used for the production of pasta and confectionery. The seed is processed into alcohol, starch, dextrin, etc. However, high-quality bread and bakery products are made only from durum wheat flour, which is a type of soft wheat plant. According to the state standard, durum wheat seeds belong to the first and second classes, which contain 36, 32 and at least 28 per cent of crude gluten of the first group, respectively, and have a natural weight of at least 755 g/l, a glassiness of at least 60 per cent and a baking power of 280 or more alveograph units. Winter wheat is an important fodder plant. Wheat bran is a valuable concentrated feed for all types of farm animals. Straw and chaff have significant feed value. Straw in chopped and steamed form or supplemented with fodder molasses is used as roughage for cattle. 100 kg of straw contains 20-22 feed units and 0.5-1 kg of digestible protein. Winter wheat, either pure or mixed with vetch, is grown for green fodder, which is used in early spring, after rye. The agronomic importance of winter wheat plants is that it is a good place in the crop rotation for other crops in the rotation.

Biological characteristics, varieties. In its ontogeny, winter wheat goes through 12 stages of organogenesis and the following phases of growth and development: seed germination, germination, tillering, tube formation, earing, flowering, grain formation and filling, milking, waxing, and full ripeness. Seed germination, germination and partial tillering occur in autumn, during the first and second stages of organogenesis,

and the last phenophases and stages of organogenesis occur in spring and summer of the following year. The vegetation period in autumn is 40-50 days, in spring and summer - 90-110 days. The weight of 1000 grains is 35-50 g.

Under favourable conditions, seedlings appear 7-9 days after sowing. After 13-15 days, when 3-4 leaves are formed on the plant and a tillering node is formed at a depth of 2-3 cm, the tillering phase (underground branching of the stem - shoot formation) begins. By winter, the plant should form 2-4 shoots. This requires 40-50 days of autumn vegetation. The root system by this time is deepened by 50-70 cm.

With the onset of average daily temperatures of +4...5°C in spring, winter wheat resumes vegetation and continues to bush for another 25-30 days. After that, it begins to grow into a tube (stemming). It lasts for 25-30 days and is followed by the earing phase, and after another 4-5 days flowering and stem growth stop. Winter wheat is a self-pollinating plant, so pollination can also occur in fallen crops, but the number of grains per ear, weight of 1000 grains and yield are reduced by 20-40 per cent or more. After fertilisation, a grain is formed, which reaches its final length in 12-17 days and enters the phase of early milky, then milky, doughy, waxy and full ripeness. The milky ripeness phase lasts 7-14 days, and the waxy phase 7-9 days. In the middle of waxy ripeness, when the grain moisture content reaches 33-35 per cent, the flow of plastic substances into the kernels stops and separate harvesting can begin.

Winter wheat is a cold-resistant plant. Its seeds begin to germinate at temperatures of +1...2°C. To get good germination, the temperature during sowing should be +14...16°C. To obtain seedlings, the sum of active temperatures of 130-140° C is required. At temperatures of +25°C and above, weakened seedlings with thin roots are formed, which are severely affected by diseases. Well-hardened plants can withstand a decrease in temperature in the tillering zone to -17...18° C in winter, and highly frost-resistant varieties - to -19...20°. Sufficient snow cover protects plants even when the temperature drops to -35...40°C. A snow layer of 10 cm or more completely protects plants from freezing even when temperatures drop to -30°C. With a snow cover of 2 cm, winter wheat can withstand temperatures down to -22...25°C. *Winter wheat is demanding of moisture.* During germination, the seed absorbs 50-55 per cent of its own weight in water. It consumes 300-450 units of water per unit of dry matter. The transpiration coefficient (TC) decreases with sufficient use of phosphorus-potassium fertilisers, which promote the development of the root system, and retail application of nitrogen fertilisers. During the growing season, soil moisture should be between 65-75 per cent of the HB and not fall to the level of capillary rupture moisture, and even more so to the moisture content of stable plant wilting. If the moisture available to plants in the top 10 cm of soil is less than 10 mm, seedlings emerge late and are sparse. High grain yields are obtained with spring moisture reserves in the 0-100 cm soil layer of about 200 mm, and at least 80-120 mm in the earing phase.

Crops are severely damaged by a lack of soil moisture during seed germination and emergence. In this case, seedlings are usually sparse and appear singly. Moisture deficit during tillering (stages II-III) reduces bushiness, and during earing and flowering (stages VIII, IX) reduces the graininess of the ear, and during grain filling (stage X) reduces the weight of 1000 grains. *Winter wheat is light-demanding.* With insufficient light, the tillering node is formed close to the soil surface, the plants are

poorly hardened and therefore have low winter hardiness. Insufficient light in spring causes the lower internodes to stretch and the plants to lodge. Insufficient light during grain filling and ripening can lead to poor grain quality, in particular a decrease in protein and gluten content.

Nutrient requirements. Depending on the variety and growing conditions, 30-40 kg of nitrogen, 9-13 kg of phosphorus and 20-30 kg of potassium are required to produce 1 tonne of grain with the appropriate amount of straw. Phosphorus and potassium applied before sowing wheat plants contribute to better root development and accumulation of sugars in the plants, which increases their winter hardiness. Nitrogen is more valuable for plants in spring and summer. It enhances plant growth and contributes to the formation of grain with a higher protein content. The intensity of nutrient uptake from the soil varies throughout the growing season. Most nitrogen is absorbed during tillering, and potassium and phosphorus are absorbed during the earing and earing phases. Winter wheat grows well on fertile soils with a high humus content (at least 2 per cent) and nutrients readily available to plants. The soil's rating should exceed 55 points. The best soils are chernozem, chestnut, grey and dark grey podzolic soils, medium loamy in texture, with a neutral reaction (pH 6.5-7.5) and a bulk density of 1.1-1.25 g/cm³. When the bulk density of the soil increases to 1.35-1.4 g/cm³, root growth is inhibited, and when it exceeds 1.6 g/cm³, the roots do not penetrate deeper horizons.

Winter wheat grows poorly on saline and acidic soils with heavy texture, prone to flooding and in areas where water stagnates.

Wheat plant varieties are divided: by the type of development - winter, spring, two-handed; by baking qualities (soft winter wheat) - strong, valuable, good fillers, satisfactory fillers, weak; by the level of yield - intensive, ordinary; by the length of the growing season - early, medium early, mid-season, mid-late, late; by resistance to high and low temperatures, moisture deficit, lodging, diseases, etc. - resistant, unstable.

Strong, or improving, varieties are those whose seeds contain at least 14 per cent protein. The flour, thanks to its high quality gluten, forms a dough that can withstand intensive kneading and prolonged fermentation and provides a large volume of bread. Flour from strong varieties has the ability to improve the baking qualities of weak wheat flour. For example, to obtain bread with good volume and porosity, 20-50 per cent of strong wheat flour should be added to the flour of weak wheat plants. *Valuable varieties* have high baking qualities, but they are not able to improve the quality of weak wheat flour.

Fillers (fillers) are varieties with medium baking qualities. Their flour is used alone for baking bread and is also added (30-35 per cent) to stronger flour to dilute it, as the very high gluten content of stronger flour has a negative impact on bread quality. It is not advisable to bake bread from pure flour of the improvers' varieties.

Different varieties are offered for different soil and climatic zones of Ukraine, taking into account their biological and economic characteristics: drought resistance, winter hardiness, baking qualities of grain, etc. Almost 64 per cent of strong varieties are intended for cultivation in the Steppe and Forest-Steppe, and 55 per cent of valuable varieties are intended for cultivation in the Forest-Steppe and

Polissya. Breeders have created many varieties of intensive wheat plants with high baking and pasta qualities. The yield potential of current varieties reaches 12.0 tonnes per hectare and more. In recent years, the Register of Plant Varieties of Ukraine for the steppe zone has included high-yielding varieties of strong and valuable wheat: Columbia, Podolyanka, Kuyalnyk, Respect, Smuglyanka, Pereyaslavka, Remeslivna, Poshana, Driada 1, Kiriya, Vesnianka, Dobirna, Dar Luhanskchyny, Nasinyagradka 11, Luhanchanka, Stanychna, Spivanka, Tronka, Lyona, Pobeda 50, Zira and Khersonska 99.

For the Forest-Steppe, varieties of vigorous wheat are recommended: Columbia, Podolyanka, Kuyalnik, Povaga, Smuglyanka, Pereyaslavka, Remeslivna, Vesnianka, Dobirna, Vasilina, Dimetra, Dikanka, Yermak, Levada, Tronka, Lyona, Pobeda 50. Varieties of valuable wheat plants: Vesta, Elegy, Kopylivchanka, Zira, National, Stolichna, Favoritka, Volodarka.

New varieties of vigorous wheat are recommended for the Polissya zone: Podolyanka, Columbia, Respect, Smuglyanka, Remeslivna, Vesnianka, Dobirna, Vasilina, Dimetra, Yermak; varieties of valuable wheat plants: Vesta, Lars, Elegy, Kopylivchanka, Pereyaslavka, National, Stolychna, Favoritka, Volodarka. In order to rationally use yield factors, it is advisable to grow 2-3 zoned varieties in each farm that differ in biological characteristics and economic traits.

Agricultural technology. *Place in the crop rotation.* In different zones, the best place in the crop rotation for wheat plants, as well as for other winter plants, is for plants that leave the field early, do not deplete the soil of nutrients and moisture, leave fields free of weeds, and do not share pests and diseases. These requirements are best met by pure fallow, which is economically viable only in the arid steppe regions of Ukraine. In all zones, wheat is sown after fallow land, perennial legumes (clover, alfalfa), early harvest seed legumes (pea plants and ultra-early soybean plants), and corn for green fodder and early silage. In the Forest-Steppe and Polissya, it is also grown after perennial legumes and early potato plants, buckwheat plants, in Polissya - after lupine for green fodder and silage, long flax, and on sandy soils - after green manure lupine pairs.

It can be sown after oat plants, as it is not affected by root rot and leaves better quality crop residues than other seed plants. The yield of winter wheat plants in repeated sowings, when placed after barley plants and late harvested maize plants, is significantly reduced.

Winter wheat is picky about crop rotation and reduces yields when grown again by 15-20 per cent, and when sown for the third year in a row - by 30-35 per cent or more. With permanent cultivation, yields decrease even when additional fertiliser is applied. The main reason for the decline in yields is the progressive spread of diseases, pests and weeds.

Do not grow wheat and other winter seed crops after Sudan grass, sorghum plants, corn for seed, sunflower plants, which are harvested late and dry the soil to a considerable depth.

Soil preparation. When preparing the soil for winter wheat, as well as for other winter seed plants, the seed layer should be brought to a fine lumpy state to ensure maximum accumulation and preservation of soil moisture, to create favourable

conditions for high-quality sowing, seed germination and plant development at the beginning of the growing season. The seed layer should consist mainly of aggregates up to 10 mm in size, and the number of lumps 3-10 cm in size should not exceed 10 per cent of the weight of the seed layer.

The main task of soil cultivation is to preserve moisture, protect against weeds and increase effective soil fertility.

After harvesting, the areas allocated for black fallow are peeled to a depth of 6-8 cm with disc harrows (LDG-20, LDG-15A, LDG-10A, LDG-5A), and after weeds germinate, a second peeling is carried out with ploughshare peelers (PPL-10-25, PPL-5-25) to a depth of 10-12 cm. This is an effective measure to protect crops from perennial weeds and improve the quality of ploughing.

When weeds begin to germinate after the second peeling, ploughing is carried out with ploughs with skimmers (PTC-9-35, PNL-8-40, PLP-6-30, PLN-5-35, PLN-5-35, PLN-4-35, PLN-3-35) or loosen the soil with a flat cutter (PG-3-100) to a depth of 27-30 cm. Deep cultivation under black steam improves the structure of the topsoil, enhances the activity of beneficial microorganisms, helps to destroy weeds, pests and diseases, penetrate precipitation moisture into deeper layers, and develop the root system. After the plants that leave the field late, we peel the soil with disc harrows in two directions to a depth of 6-8 cm, and then deep plough it.

In the spring, black fallow tillage begins with closing the moisture with heavy harrows (BZSS-1.0, BZTS-1.0) in 1-2 traces. During the spring and summer, the soil is cultivated at different depths to ensure maximum moisture retention and weed control. 5-7 days after the moisture is closed, cultivation is carried out with cultivators (KShP-8, KZB-21, KPZ-9.7) to a depth of 10-12 cm with simultaneous harrowing. Subsequent cultivations are carried out as weeds emerge with a gradual decrease in depth by 1-2 cm. On fields infested with root and sprout weeds, the first cultivation is carried out to a depth of 12-14 cm.

To prevent moisture evaporation, it is advisable to reduce the number of cultivations and harrowing by treating black pairs with herbicides. In dry weather and on fields free of weeds, cultivation is not advisable. Pre-sowing cultivation is carried out to the depth of seed placement.

Under conditions of sufficient moisture, stubble is peeled and ploughed with ploughs with pre-ploughs in combination with ring rollers after the plants are harvested early, and no-till tillage is used on unweeded fields. The ploughing depth is 20-22 cm, after perennial grasses and maize plants - 25-27 cm, and on sod-podzolic soils - 16-18 cm. If corn is harvested no earlier than 20 days before wheat is sown, surface tillage is carried out.

Surface tillage to a depth of 12-14 cm with disc or flat-cutting tools after all the rotations is effective in years with dry weather, during soil preparation and sowing on fields free of perennial weeds and late harvesting of the crop. After peas are planted, such tillage is always effective.

Considerable attention should be paid to pre-sowing tillage. It should be carried out with cultivators such as KPS-4, USMK-5.4 with harrows or combined units RVK-7.2, RVK-5.4, VIP-5.6 carefully adjusted to the depth of cultivation. Uneven tillage of the seed layer causes uneven seeding depth, which in turn leads to a decrease in

field germination, uneven emergence of seedlings, and uneven plant development. Pre-sowing tillage is carried out to the depth of seed placement.

Fertilisation. When growing winter wheat plants using intensive technology, it is necessary to apply increased doses of organic and mineral fertilisers, which, if used incorrectly, can cause lodging and burns. In this case, the uniformity of their distribution over the area by spreading, row (local) or tape method is of exceptional importance.

If the humus content in the topsoil is less than 2 per cent, organic fertilisation is mandatory. Organic fertilisers are applied at the rate of 20-25 t/ha in the Steppe, 25-30 t/ha in the Forest-Steppe and 30-35 t/ha in Polissya under the main tillage or the previous crop.

Mineral and organic fertilisers should be used for wheat. It is mandatory to apply the latter on soils with a humus content of less than 2.2 per cent. In this case, more water-resistant aggregates are formed and the efficiency of mineral fertilisers increases.

Organic fertilisers are also required when growing wheat plants after stubble in crop rotations, as this improves the phytosanitary condition of the soil and enhances the activity of beneficial microflora.

The mineral fertiliser system involves basic and line fertilisation and top dressing. Potash fertilisers are used as the main fertiliser and 80-90 per cent of phosphate fertilisers are used for the entire growing season. Fertilisers are applied for the deepest soil cultivation. The remaining phosphate fertiliser (P_{10-15}) is applied to the rows during sowing, using granulated superphosphate or complex granular fertiliser.

Nitrogen fertilisers are applied at several times. On poor soils, part of the ammonium nitrogen fertiliser (up to 30 kg a.i.) should be applied for pre-sowing cultivation or as part of the main fertilisation along with phosphorus and potash fertilisers. This accelerates the development and increases the winter hardiness of plants on poor soils. Excessive amounts of nitrogen in the autumn period reduce the winter hardiness of plants, so the bulk of nitrogen fertilisers are applied as fertilisers in the spring and summer growing season. It is recommended to apply nitrogen fertilisers in three stages: at the II-III, IV and VII-IX stages of organogenesis. When carrying out early spring (*regenerative*) fertilisation, the main condition should be to maximise the use of extremely scarce moisture in the topsoil. For this purpose, it is extremely important to take advantage of the frozen ground condition, which can be very limited in time. Where this is not possible, urea nitrogen should be applied over a low layer of snow, as it is unlikely that the dissolved fertiliser will be washed away due to the high hygroscopicity of the topsoil. If possible, use night time. In the absence of snow, it is advisable to apply ammonium nitrate without waiting for the soil to become frozen. First of all, *early spring fertilisation* should be carried out on sparse and underdeveloped crops, where the dose of nitrogen fertiliser should be approximately 70-90 kg/ha, on crops in satisfactory condition - 50-60 kg/ha, and in good condition - 20-30 kg/ha. Fertilisation should be carried out before the start of the vegetation of winter plants. For early spring fertilisation, it is recommended to use ammonium nitrate, which is 15-20 per cent more effective than urea.

The main dose of nitrogen in fertilisation (*productive*) should be used at the

beginning of the plant's emergence into the tube (stage IV of organogenesis). The application of nitrogen during this period of plant development contributes to better survival of the productive stem, an increase in the number of ears per ear, and increased drought tolerance of winter wheat plants. This fertilisation is the main one on all areas under winter crops in the forest-steppe and Polissya zones of Ukraine. The doses of nitrogen are adjusted based on the previous application. For example, if 50-60 kg/ha of nitrogen was applied during the vegetation recovery, then 40-50 kg/ha should be added at the fourth stage, and if 20-30 kg/ha was applied in the first period, 60-70 kg/ha should be added at the fourth stage. In order to form a full-fledged protein-gluten complex of grain, it is necessary that plants are provided with nitrogen not only at the beginning of the growing season, but also during the filling and ripening period, for which purpose late fertilisation of plants is used in the earing - grain filling phase with the introduction of at least 30-60 kg/ha of nitrogen. Foliar application of urea solution (30-45 kg/ha) by spraying crops significantly improves grain quality. The concentration of the solution (by active ingredient) during the earing phase should not exceed 15 per cent, and at the beginning of the milk ripeness of the grain - 20 per cent. In hot, dry weather, lower doses of nitrogen are used in crops with moderate vegetative mass and in the later stages of plant development, and higher doses in wet weather, with developed aboveground plant mass and in the early stages of their development. In areas where strong wheat is grown, it is sometimes necessary to carry out additional, so-called qualitative, fertilisation with a solution of urea or UAN to improve grain quality. Spraying is carried out during grain filling at the rate of 30-45 kg of nitrogen per 1 ha.

Another effective measure for producing quality products is the use of *microfertilisers*. The use of micronutrient fertilisers in chelated form in foliar feeding increases the protein content in grain by 0.9-1.4 per cent and gluten in flour by 2.5-4.8 per cent. It has been established that trace elements are most effective for plants in the form of metal complexates (chelates) (nutrient, ecolist, rekom, crystallon, omex, puccioni, nanomix, quantum, etc.). They contain both macro- (NPK) and microelements (boron, zinc, manganese, molybdenum, copper, etc.). Trace elements directly increase the activity of enzymatic systems in the plant organism, stimulate biochemical processes, improve photosynthetic activity of plants, which contributes to the fuller realisation of their productivity potential.

For the formation of high grain productivity of winter wheat plants at high fertiliser application rates, a predominance of nitrogen is required. The need for higher nitrogen rates is due to high nitrogen removal from the soil (3-4 kg/ha), which is 3-4 times higher than phosphorus removal and 2-3 times higher than potassium removal. The recommended ratio of N:P:K nutrients is 1.5:1:1. The basis for the high efficiency of intensive technology is sowing high-quality seeds. They must be conditioned, meet the requirements of DSTU 2240-93 and have a purity of at least 98 per cent, germination rate of at least 92 per cent, growth force of at least 80 per cent, and a weight of 1000 seeds of more than 40 g. Seeds are disinfected from diseases or inlaid with film forming agents such as PVA (polyvinyl alcohol), NaCMC (sodium salt of carboxymethyl cellulose), LFC (liquid complex fertilisers), PVA with one of the systemic drugs.

Today, more than 20 pesticides are approved for use in Ukraine. Each of them has its own spectrum of action on pests, different mechanism and nature. Therefore, when choosing a disinfectant, it is worth paying attention to which pathogens they are used against: systemic preparations are effective against smut species: Baytan Universal, 19.5 per cent w.p. (2 kg/t); Vincit, 5 per cent c.s. (2 l/t); Vitavax 200 FF, 34 per cent c.s. (2.5-3.0 l/t); Derosal 50 per cent c.s. (1.5 l/t); Dividend Star, 036 hp (1 l/t); Premium 25, 2.5 percent hp (1.5 l/t); Raxil 6 percent hp (0.4 l/t); Real 200 hp (0.2 l/t), etc;

- The following preparations are widely used against fungi of the *Rhizaginthus* genus: Baytan Universal (2 kg/t), Maxim 025 (2 litres/t), Vincit (2 litres/t), Vitavax 200 FF (2.5-3 litres/t), etc;

- against root rot - Baytan Universal, 19.5 percent w.p. (2 kg/t); Vitavax 200 FF, 34 percent w.c. (2.5-3 l/t); Maxim 025, 2.5 percent w.c. (2 l/t), etc.

Sowing. Optimal sowing dates are those when plant seedlings do not move to the III-IV stages of organogenesis and at the same time manage to reach a state before the end of the autumn growing season to quickly start the process of differentiation of the growth cone and move to enhanced, synchronous formation of the ear, using the reserves of winter-spring moisture in the soil at these stages of organogenesis.

Wheat is sown in such a way that the plants have 3-5 shoots by winter. The optimal sowing dates in Polissya are 5-15 September, in the Forest-Steppe - 10-20 September, in the Steppe - 15-20 September, and in the Autonomous Republic of Crimea - 20 September - 10 October.

Sowing dates depend on soil fertility. On poor soils, it is necessary to sow earlier, and on fertile soils - later, so that the plants do not overgrow by winter. Optimal sowing dates on fertilised fields are shifted 10-15 days later compared to sowing on less fertilised fields. Sowing starts with late-ripening, mid-ripening varieties and ends with early-ripening varieties. When sowing winter wheat plants after different places in the crop rotation, the rule of thumb is to start sowing after the worst places in the crop rotation (silage corn, grasses) and finish after the best (legumes, busy pairs). Varieties with high tillering energy, such as Myronivska 65, Poliska 90, Poliska 97, should be sown later than varieties with lower tillering energy. It is not recommended to sow winter wheat after the optimal sowing dates; in spring, these areas should be planted with spring wheat, spring barley, peas, corn, soybeans, buckwheat, millet and other seed crops, depending on market conditions, spring vegetation and actual weather conditions. The main method of sowing wheat plants is conventional row planting with row spacing of 12.5 to 19 cm using seed drills, and in arid areas where wind erosion is possible, stubble cultivation after surface or flat-cut tillage.

Particular attention should be paid to adjusting seeding rates and seeding depth. Excessive thickening in some rows and thinning in others reduces crop yields. The optimal sowing rate in Polissya is 5.0-5.5 million, in Forest-Steppe - 4.5 million, in Steppe - 4.0-4.5 million germinating seeds per 1 ha. Seeding rates are increased when growing short, early maturing, weakly bushy, lodging-resistant varieties with an erectoid leaf type, after the worst place in crop rotations, on poor soils with good moisture supply, and with a delay in sowing. In other cases, seeding rates are reduced by 0.3-0.5 million, or 10-12 per cent.

The seed rate is directly related to the sowing date. When sowing in the early stages, the plants bush well at lower seeding rates. At later dates, the seed rate should be increased by 10-15 percent.

The basis for calculating seeding rates should be the need to obtain a seedling density of 400 pcs/m² for varieties with a low tillering coefficient, and 350-380 pcs/m² for varieties with an intensive tillering coefficient². If the gap between laboratory and field germination and germination energy is 10 per cent or more, the seeding rate should be increased by 8-10 per cent. The depth of seed placement on structural soils of medium mechanical composition with sufficient moisture should be equal to the depth of the tillering node (about 3 cm, taking into account soil subsidence). When the topsoil dries out, the depth is increased to 5-6 cm, and in arid regions - up to 8 cm. On heavy soils and in waterlogged conditions, the depth of planting is reduced to 2-3 cm. Properly organised care is a significant reserve for increasing yields. The main task of care is to preserve at least 500-600 pcs./m² of productive stems at the time of harvesting, which will guarantee the highest possible yield. To this end, crops are protected from pests, diseases and weeds, plants are fertilised, and retardants are applied. In order to properly anticipate and develop these measures, it is necessary to examine the soil for pathogens and pests, weeds and its moisture content before sowing. If there are more pests in the soil than the economic threshold of harmfulness, sowing should be carried out with the introduction of insecticides into the soil: 5 per cent Basudin (50 kg/ha), 5 per cent Volaton (50-75 kg/ha), Phosphamide (100 kg/ha).

If there is less than 10 mm of productive moisture in the 0-10 cm soil layer, the crops are rolled with ring spur rollers after sowing, which promotes friendly emergence. The soil crust is destroyed by harrowing with tooth or rotary harrows before or after emergence. Harrowing also kills weeds that are in the "white thread" phase during the cultivation period.

During the period of germination and tillering on early winter crops, under certain weather conditions, there may be a threat of damage to crops by cicadas, cereal aphids and flies, gnawing scoops, and bread beetles. During this period, it is necessary to spray winter crops with one of the following insecticides at the margins or selectively: Bi-58 new, 40 percent c.e. (1.5 l/ha); Volaton 500, 50 percent c.e. (0.8-2.0 l/ha); Decis, 2.5 percent c.e. (0.2-0.25 l/ha); Karate, 5 per cent of the fuel efficiency (0.15-0.2 l/ha); Sumi-Alpha, 5 per cent of the fuel efficiency (0.3 l/ha); Kinmix, 5 per cent of the fuel efficiency (0.2-0.3 l/ha). In the same phase, during warm, long autumn, crops are affected by powdery mildew. To protect winter crops from this disease, they are sprayed with one of the fungicides: Derosal, 50 per cent w.c. (0.5 litres/ha); Fundazole, 50 per cent w.p. (0.5-0.6 kg/ha); Impact, 25 per cent w.c. (0.5 kg/ha); Tilt, 25 per cent e.e. (0.5 litres/ha).

The autumn use of herbicides on winter wheat crops is economically and biologically justified. During this period, it is recommended to apply herbicides Pik 75 WG, v.d.g. and Derby 175 SC, h.p. The products can be applied from the beginning of tillering at a minimum temperature of +5...8⁰ C. In autumn, it is not recommended to use herbicides containing phenoxyacetic acid or its salts due to their negative effect on the reproductive organs of plants - deformation of the ear, partial or complete white

spikelet and hollow spikelet. In autumn, you should also take care of protecting crops from mouse-like rodents. Seed baits infected with a bactericide at a dose of 2 g per burrow or wax briquettes of Storm 0.005 per cent at a rate of 0.7-1.5 kg/ha are used. This makes it possible to plan preventive measures in advance to eliminate the causes of plant death, and to predict reseeding and reseeding. We reseed crops that have been completely killed and thinned out by 50 per cent or more, when there are no more than 700 live shoots of all orders per 1 m² at the time of plant regrowth. Crops where no more than 25 per cent of the plants have died are not reseeded or reseeded, and the density of the future productive stem is adjusted by increasing nitrogen nutrition depending on the sparseness of the sowing and the looseness of the plants. In order not to reduce grain production, it is advisable to sow sparse crops with barley varieties of the same early maturity as wheat. Seeding rates of barley plants vary depending on the degree of sparseness of wheat plants.

Under unfavourable wintering conditions with frequent thaws, the leaf apparatus of well-budded crops is sometimes damaged and such crops are mistakenly considered dead. In this case, it is imperative to determine the degree of viability of the tillering node by staining. If there is a viable tillering node in the spring, under conditions of a probable early resumption of vegetation, fertilisation with nitrogen fertilisers at a dose of 30-45 kg/ha per year should be carried out as early as possible in order to enhance growth processes, tillering and prevent significant plant loss.

The application of nitrogen during the first fertilisation in conditions of early vegetation recovery on well-cultivated crops causes additional tillering and the formation of pods, which ultimately becomes the main reason for the irrational use of fertilisers by pods and a decrease in yield by 3-4 c/ha, and in conditions of lodging crops, due to their excessive density, it leads to grain flowing onto stumps and a decrease in yield by up to 7-10 c/ha.

The critical period in the development of winter wheat plants in terms of moisture and nutrients, especially nitrogen, is the fourth stage of organogenesis. It is at this stage that the segments of the growth cone are differentiated into spikelet tubercles. Timely application of nitrogen fertilisers at moderate temperatures creates the conditions for their most efficient differentiation, which ensures higher grain size of the spike. In addition, nitrogen nutrition ensures the survival and, accordingly, reduces the loss of synchronous shoots of the second to fourth order in the further development of the ear.

The dose of nitrogen at this stage is at least 40-50 per cent of the total amount. In order to prevent additional tillering and the formation of unproductive stems, which usually leads to a decrease in crop productivity, the timing of the second feeding is regulated depending on the agrophysical background and fertilisers applied during the first feeding. On *low agro* backgrounds, such fertilisation is started in the first days of the diagnosed period, on *medium agro* backgrounds - on day 4-6, and on *high agro* backgrounds - on day 8-10 of the fourth stage of organogenesis. When determining the timing of fertilisation, it should also be borne in mind that the ammonium form of mineral nitrogen interacts with the plant's carbohydrate complex on the third day of foliar feeding under positive temperatures (+5°C).

The improvement in grain quality with a decrease in moisture reserves lasts

approximately until the moisture reserves in the one-metre layer (in spring and during the tube phase) are 70-80 mm. With a further decrease in moisture reserves, the protein content remains unchanged, and there is even a tendency for it to decrease. Therefore, in the conditions of a likely sharp increase in temperature after the resumption of winter crops, harrowing should be an important measure for crop care, which is carried out when the soil is physically ripe. The period of harrowing winter crops is limited in time, so this agricultural measure should be carried out in 1.5-2 days, avoiding drying out of the soil. It should be carried out using different types of harrows, taking into account the degree of plant development and field condition. For example, medium harrows can be used on well-developed crops, and light harrows with passive installation of working bodies can be used on underdeveloped crops. Harrowing can not only destroy the soil crust, loosen the upper soil layers, increase air access to plant roots and thereby intensify microbiological processes in the soil, but also kill weeds, free plants from shoots and leaves that have died during the winter period; improve the illumination of the growth cones and promote the formation of a normally developed ear. Spring harrowing is especially important for overgrown crops. A delay in spring harrowing in this case can lead to the elongation of the growth cone without its differentiation into spikelets. Such shoots then die off, dramatically reducing the yield.

Do not harrow crops that are weakly tilled, especially on light soils, and crops with bulging plants. It is advisable to harrow very thickened crops in two passes. Thinning such crops prevents early lodging. If the crops are fertilised with disc seeders, no additional loosening is required. In spring, under favourable conditions (humidity of 95-100 per cent and average daily air temperature above +15⁰ C), powdery mildew, Septoria and root rot develop on winter wheat crops.

To limit the development of these diseases, it is effective to spray vegetative plants in the tillering phase - the beginning of the tube with one of the fungicides: Alto Super 330 ES, c.e. (0.4-0.5 l/ha), Falcon c.e. (0.6 l/ha), Derosal, 50 percent c.e. (0.5 l/ha); Impact, 25 percent c.e. (0.5 kg/ha); Fundazole, 50 percent c.e. (0.3-0.6 kg/ha); Topsin M, 70 percent c.e. (1.0 kg/ha). The application of relatively high doses of nitrogen fertilizers in the early spring period on liquefied and weakened winter wheat crops with significant reserves of weed seeds in the soil can provoke intensive germination of the latter in the early spring period and they will be the main competitors of plants for moisture, nutrients and light, which will require intensive protection from segetal vegetation. The main weed infestation of winter cereal crops was formed in the autumn period - up to 75 percent of the total.

Herbicides are used to protect crops from weeds during the tillering phase. The choice of herbicide depends primarily on the types of weeds in each particular field, but preference should be given to products with a relatively broad spectrum of action and those that work effectively at relatively low air temperatures. These are, first of all, Agritox, 50 per cent by weight (1.0-1.5 l/ha); Granstar, 75 per cent by weight (20-25 g/ha); Grodil, 75 per cent by weight (20 g/ha); Grodil Ultra, v.a. (0.15-0.2 kg/ha); 2,4-D, 50 per cent v.a. (0.5-1.7 l/ha); Diallyn Super, 46.4 per cent v.a. (0.8-1.4 l/ha); Cowboy, 40 per cent v.a. (120-190 ml/ha); Cross, 16.4 per cent a.i. (100-150 ml/ha); Satis, 18 per cent a.i. (100-150 g/ha), etc. Against cereal weeds on winter wheat crops, Puma Super herbicide, 7.5 per cent a.i. (1.0 kg/ha), and Grodil Ultra, v.g. (0.15-0.2

kg/ha), are used against pink thistle and clinging crabgrass. A fairly effective mixture of herbicides: Grodil Super + Puma Super. It is advisable to treat well-developed crops with sufficient density of tillering shoots (more than 1000 pcs/m²) sown after fallow and leguminous crops in crop rotations at the III-IV stages of organogenesis with *retardants*.

This will not only protect the crops from lodging, but also improve the efficiency of moisture and nutrient use by the plants. As a result of treatment with retardants, which redistribute nutrients in plants to a greater extent for the growth of the ear and its elements, the grain size and grain filling improve, and the seed-to-straw ratio shifts towards the formation of more grain. The following products are approved for crop treatment: chlormequat chloride 460 at a dose of 1.5-2.0 l/ha, stabilan at 1.0-2.0 l/ha, terpal at 1.0-2.5 l/ha. During the earing phase, wheat crops are damaged by cereal leaf beetle caterpillars, larvae of the leech, and the harmful turtle bug. To protect crops from these pests, spraying with one of the insecticides is necessary: Bi-58 new, 40 per cent of the chemical (1.5 l/ha); Volaton 500, 50 per cent of the chemical (1 l/ha); Decis, 25 per cent of the chemical (0.25 l/ha); Karate, 5 per cent of the chemical (0.15 l/ha); Sumiton, 50 per cent of the chemical (0.6-1.0 l/ha) and others.

During the earing phase - the beginning of flowering in wet and warm weather, powdery mildew, brown rust, leaf and ear septoria, and ear fusarium develop. To protect winter wheat crops from these diseases, it is necessary to spray one of the fungicides during the earing phase: Alto Super 330 EC c.e. (0.4-0.5 l/ha); Bumper, 25 percent c.e. (0.5 l/ha); Impact, 25 percent c.e. (0.5 l/ha); Tilt, 25 percent c.e.e. (0.5 l/ha); Falcon, k.e. (0.6 l/ha); Folicur BT, 22.5 per cent k.e. (1.0 l/ha); Topsin M, 70 per cent w.p. (1.0 kg/ha).

During grain formation and filling, significant yield losses can occur due to damage by cereal aphids, cereal thrips and bread beetles. Crops are also significantly damaged by the harmful turtle bug. Therefore, at this time, it is necessary to spray the crops with one of the insecticides: Actellik, 50 percent c.e. (4.0 l/ha), Bi-58 new, 40 percent c.e. (1.5 l/ha), Volaton 500, 50 percent c.e. (1.6-2.0 l/ha); Decis, 25 percent c.e.e. (0.25 l/ha); Zolan, 35 per cent q.e. (1.5-2.0 l/ha); Karate, 5 per cent q.e. (0.15-0.2 l/ha); Sumi-Alpha, 50 per cent q.e.e. (0.2-0.25 l/ha); Sumiton, 50 percent of k.e. (0.6-1.0 l/ha) and others. *Harvesting*, depending on the condition of crops, weather conditions, weediness and other factors, is carried out by direct combining or by separate harvesting. Low-growing varieties, as well as crops that are not lodged and free of weeds, in rainy weather and with a moisture content of 17-18 per cent of the bulk of the grain, are harvested by direct combining; lodged, weedy, with multiple ripening and prone to shedding are harvested by separate methods.

Wheat is cut into swaths at the onset of the waxy ripeness phase, when the grain moisture content in the ear drops to 30-32 per cent. The cutting height for separate harvesting should be at least 20-22 cm. Threshing of wheat plants in swaths is started when the grain moisture content is within 14-16 per cent. Seed crops are harvested at a grain moisture content of no more than 16-18 percent.

2.3.4 Winter rye (*Sesame*)

The first mention of rye was made by the Roman writer Pliny (first century BC). In the third and fourth centuries, rye was already sown in the Kerch Peninsula, from where it spread to other areas. Brief information about the cultivation of rye plants is available in the chronicles of Nestor (1056-1115).

In Ukraine, there are 2 types of rye plants: crop or sowing rye (*S. cerulea*) and wild rye (*S. silvestre*). It is believed that oats and rye were weeds in wheat crops before they were introduced into the plant.



Rye has been known in Europe since the Bronze Age. It was grown in the Dniro and Dniester river basins as early as the first half of the first millennium AD. From there, rye spread to the north, east and west of the continent. Today, it is cultivated in temperate climates almost to the limits of agriculture. It grows better on poor soils than most cereals. In Ukraine, rye is mainly grown on sod-podzolic soils in the non-chernozem zone and in the Carpathians, less in the Forest-Steppe and Steppe, and in the Carpathians on small areas, as well as spring rye. Rye seeds contain 8-19 per cent of complete proteins, 67-80 per cent of easily digestible carbohydrates, and 2 per cent of fat. It contains vitamins B, D, E, fibre, carotene, and mineral salts. The grain contains unsaturated fatty acids that can dissolve cholesterol. Rye flour is used to bake bread that has good taste and is in many ways as good as, and sometimes better than, wheat bread. However, the gluten has a looser texture, lower viscosity, elasticity and extensibility, which makes rye bread less fluffy and porous than wheat bread. Eating rye bread prevents heart disease: rye flour contains linoleic and other fatty acids that are essential for heart function.

The value of rye as a fodder plant is determined by the fact that it forms early highly digestible green fodder, and rye bran contains up to 16 per cent protein, 3.5-4.0 per cent fat and up to 60 per cent carbohydrates. Winter rye is sown for green fodder and used to make early silage and hay. A perennial fodder rye has been developed that produces green mass for several years.

Winter rye has increased cold tolerance, grows vigorously in spring and produces better crops in regions where winter wheat freezes in some years.

In veterinary practice, rye flour in the form of gruel or slurry is prescribed as a mild laxative for constipation. A decoction of rye bran can be used internally for respiratory tract diseases (bronchitis, tracheitis, bronchopneumonia) as an expectorant, and externally as a poultice for the maturation of abscesses.

The main areas under rye are concentrated in Europe and partly in Asia, North and South America. The global area under rye crops is 12 million hectares. About 75 per cent of the world's rye production is concentrated in , Poland, Belarus, Germany and Ukraine.

In Ukraine, winter rye has long been considered a valuable food and fodder crop.

Over the past 80 years, its acreage has decreased from 4,517 thousand hectares to 300 thousand hectares, yields have increased from 10.1 to 22.7 centners per hectare, and production has decreased from 4.5 million tonnes to 0.68 million tonnes. In recent years, both Germany and Ukraine have seen an upward trend in rye acreage. Most rye plants are grown in Polissya and in the northern part of the Forest-Steppe. The average yield of rye plants is lower than that of wheat (about 2.4 t/ha). Advanced farms harvest 4.5-6.0 t/ha.

Biological characteristics, varieties. Of the 13 species of rye plants, only one is a vegetable. It is an annual herbaceous plant of long daylight hours. Rye has a lot in common with other breads of the first group in its structure. Its root system is well developed and absorbs nutrients from hardly soluble soil compounds better than other breads. The tillering node in rye plants is formed closer to the soil surface than in wheat plants (1.7-2 cm), and more often forms 2-3 tillering nodes. The depth of the upper tillering node is less dependent on the sowing depth. The height of rye plants is 90-200 cm, and they are prone to lodging. Rye ripens worse than winter wheat in windrows and shatters more heavily when it is left to stand. Therefore, it is better to harvest it at the end of the waxing stage - at the beginning of full ripeness in a short time. Rye seeds germinate at a temperature of $+1...2^{\circ}\text{C}$, and seedlings appear at a temperature of $+4...5^{\circ}\text{C}$. With an increase in temperature up to $+25^{\circ}\text{C}$, seedlings appear the fastest. At temperatures above $+30^{\circ}\text{C}$, germination stops. Winter rye is the fastest among cereal plants to start spring regrowth, already at temperatures of $+2...3^{\circ}\text{C}$. During the growing season, the optimum temperature is $+18...20^{\circ}\text{C}$. Frost resistance of rye plants is higher than that of winter wheat plants. At the depth of the tillering node, rye can withstand temperatures down to $-20...22^{\circ}\text{C}$.

In spring, plants develop better in moderately warm weather. High temperatures, intense light and dry air during this period reduce tillering and accelerate the plants' entry into the tube. Rye is sensitive to high temperatures during flowering. Dry, hot, rainy and windy weather during flowering causes incomplete pollination of flowers and shattering of the grain. In conditions of high temperatures (above $+30^{\circ}\text{C}$), a small seed is formed during the filling period.

The sum of effective temperatures required for full grain ripening is 1700-2100 $^{\circ}\text{C}$.

Rye is less demanding on *moisture* than winter wheat. The transpiration coefficient is 340-420. It can easily withstand spring droughts. The greatest damage is caused by soil drought in the phase of plant growth, when generative organs are formed. After flowering, rye is not very demanding on soil moisture, but on light sandy soils, even a slight drought can have a negative impact on grain filling. *Soil requirements.* Rye is less demanding on growing conditions than winter wheat. For the production of 1 tonne of grain, about 30 kg of nitrogen, 12-15 kg of phosphorus, and 20-25 kg of potassium are taken out of the soil. Rye is better than other plants at absorbing phosphorus from hardly soluble soil compounds. In terms of potassium absorption from the soil, it is slightly inferior only to oats. Rye has a well-developed root system with a high absorption capacity. Therefore, it grows well on podzolic sandy and sandy **loamy** soils that are unsuitable for wheat plants, but fertile structural chernozems, dark grey podzolic soils of light and medium texture are preferred. Rye

grows poorly on heavy clayey marshy soils. Rye can withstand high acidity ($\text{pH} < 5.5$) and slight salinity. The optimum soil acidity is $\text{pH} 5.5\text{-}6.5$.

The following winter rye varieties are zoned in Ukraine: Hasto, Kharkivske 98, Verkhnyausne 94, Velyten, Dozor, Intensive 99, Klych, Matador, Polycrosse, Pervistok F1, Matador, Picasso; hybrids - Askari, Festus, Fugato, Amato, Agronom.

Features of intensive agricultural techniques for growing rye plants. Rye is sown earlier than wheat, so it is important to place it after plants that clear the field early and allow for timely tillage. The best *places for rye plants* are the same *in the crop rotation as* for wheat plants. However, rye is less responsive to crop rotation than winter wheat. Among the cereal spiked plants, rye is considered the most resistant to growing as a mono-plant. In Polissya, it is grown after vetch-oat mixtures, pea plants, early potato plants, flax, lupine, perennial grasses, and corn plants. In the forest-steppe regions, rye is best sown after annual and perennial grasses, peas, silage corn, early potatoes, and in the steppe regions after silage corn, legumes, and vetch mixtures. Throughout Ukraine, rye is grown following the rotation of the perennial grass layer, after buckwheat and barley. On poor sandy soils, where other plants grow poorly, lupine and rye are often grown alternately. The *main tillage* for rye is not much different from that for wheat and is aimed at storing moisture, protecting against weeds, and accumulating nutrients. In Polissya regions, where soils have a shallow humus layer, ploughing is carried out to a depth of 16-22 cm. On the least fertile sandy soils, where in some years the wind blows sand away (pozemka), surface or flat-cut tillage should be used, leaving the stubble of the previous plant on the soil surface. Winter rye is more sensitive than other seed plants to the timing of tillage. The period between ploughing and sowing should be at least 20-25 days. Winter rye reacts particularly negatively to sowing in late ploughed soil. After a place in the crop rotation, which releases the field early, the main tillage for rye is carried out as a semi-steam type. In dry summer and autumn, it is advisable to use surface tillage instead of ploughing when sowing rye plants after peas, flax, and potato plants on fields that are free of weeds.

In regions with sufficient moisture reserves, where the gap between harvesting the crop rotation and sowing rye plants is more than 5-6 weeks, it is advisable to sow intermediate plants (cabbage) after harvesting. Lupine for green fertilisation is ploughed in the phase of grey beans to a depth of 23-25 cm in a machine with heavy rollers no later than 3-4 weeks before the optimal time for sowing winter rye plants.

Rye responds well to *fertilisation*. According to generalised data, with a yield of 6.0 t/ha, winter rye removes 120-180 kg/ha of nitrogen, 40-90 kg/ha of phosphorus and 120-180 kg/ha of potassium from the soil. On podzolic soils, up to 30-40 t/ha of manure should be applied, and on grey forest soils - up to 20-25 t/ha. This amount of organic fertiliser on podzolic soils provides an increase in grain yield by 6-8 c/ha, on black soil - 4-6 c/ha, and in arid areas - 2-3 c/ha. In areas of sufficient moisture, it is advisable to sow lupine for green manure after harvest. Rye is less resistant to lodging than winter wheat and is characterised by increased root system activity.

These features are taken into account when calculating fertiliser doses. Phosphorus and potassium fertilisers (40-90 kg/ha d.m.), and nitrogen fertilisers (30-40 kg/ha d.m.) on podzolic soils, are applied under the main tillage, as in wheat

cultivation. This contributes to better root development, especially in autumn. Phosphorus and potash fertilisers are inactive, moving slowly in the soil, and when applied under pre-sowing cultivation, will be concentrated in the topsoil. The root system is also formed and grows closer to the soil surface. During sowing, 50 kg/ha of granulated superphosphate (P_{10}) or nitrophosphate is applied to the rows. Prevention of lodging is an important task of modern intensive agricultural technology for winter rye. Lodging results in a 20-50 per cent yield loss, complicates or makes mechanical harvesting impossible, and drastically reduces grain quality. Therefore, nitrogen fertilisers should be applied 2-3 times to prevent high nitrogen concentrations in the soil that cause lodging and to best ensure that plants are nourished at the appropriate stages of development. On poor sandy soils, it is advisable to apply part of the N_{30} under the main cultivation, and the rest - in the spring fertilisation. At the beginning of the spring growing season, depending on the density of plants, their development, moisture and nitrogen reserves in the soil, N_{30-50} is applied during the first feeding. In the phase of plant emergence into the tube, the second feeding is carried out at the rate of N_{30-60} , and in the earing phase - for the third time N_{20-40} . The later the sowing is carried out, the higher the rate is set for the first feeding. It can be N_{60-80} . In this case, the dose of the second feeding is reduced to N_{30-40} , and in the earing phase - N_{40} .

Nitrogen in the tillering phase increases the density of productive stems, in the earing phase - increases the grain size of the ear, and in the earing phase - the weight of 1000 grains and protein content in the grain.

To prevent lodging, the recommended nutrient ratios must be observed. A one-sided preference for nitrogen, which is often observed in practice, leads to lodging, severe disease damage and reduced grain yields.

Winter rye is more demanding than wheat in terms of micronutrients. To get 3-4 t/ha of grain, their application is mandatory. Rye responds particularly well to micronutrient applications on soils with low nutrient content. Boron fertilisers are applied to sod-podzolic, sod-gley, peat and grey forest soils. Copper micronutrient fertilisers should be used on the same soils that are light in texture. Zinc is applied on soddy-carbonate, chernozem and sod-podzolic soils with a high phosphorus content and well-lime. The dose of boron is 0.4-0.5 kg/ha, copper - 0.2-0.2 kg/ha; zinc - 0.15-0.20 kg/ha.

Sowing. Conditioned seeds with a purity of at least 97 per cent, germination rate of 87 per cent or more and vigour of more than 80 per cent are used for sowing. Seed preparation for sowing is the same as for wheat plants.

The optimal sowing time for rye plants is more extended. It is less bushy in spring, so it is worth promoting bolting in autumn. To ensure a high yield of winter rye plants, the plants must be well established and accumulate sufficient sugars and nutrients before the end of the autumn growing season to ensure a good overwintering. To ensure such development, the sum of average daily temperatures (above $+5^{\circ}\text{C}$) of 500-550 $^{\circ}\text{C}$ is required before the autumn growing season ends, and the duration of the autumn growing season is 60-70 days. In Polissya, the optimal sowing dates are 25 August-15 September.

Rye is sown first on poor soils and then on poorer soils in the crop rotation, and

on fertile soils and then on good soils in the second half of the optimal timeframe. While wheat plants can be sown in October, winter rye must be sown by the end of September. Sowing rates depend on the recommended plant density, soil and weather conditions, sowing date, variety characteristics, etc. On poor soils, if sowing is delayed, they are increased. On fertile soils, it is recommended to sow 2.5-3.5 million seeds per hectare, on medium fertility - 3.5-4.0, and on poor soils - the sowing rate is increased to 4.0-5.0 million seeds per hectare. The approximate seeding rate for rye plants in Polissya is 5.5-6.0 million, and in the Forest-Steppe - 5.0-5.5 million similar grains per 1 ha, or 150-180 kg/ha. The seeding rate of hybrid seeds is 1.5-1.8 million/ha for early sowing (15 September - early October), 1.8-2.4 million/ha at the optimum time (early October) and 2.5-3.0 million for late sowing (late October - November). Rye is sown using the usual row method with row spacing of 15-19 cm, leaving the tramline.

Rye reacts negatively to an increase in seeding depth. This is because it has relatively small grains and therefore lower germination energy. Plants that germinate from deeply embedded seeds must first form a subcotyledonous knee, which raises the tillering node closer to the surface. The growth of the subcotyledonary knee consumes the energy reserves of the grain endosperm, so seedlings appear later, are weakened, develop slowly, are less winter-hardy, plants bush poorly and have an increased tendency to lodging.

When seeds are sown to the depth of the tillering node, seedlings appear earlier, the secondary root system is formed at the same depth as the primary root system, which provides the plants with better nutrients and moisture. Such plants bush well and are more productive. *Crop care.*

The measures for autumn, winter and spring crop care and approaches to their selection are the same as for wheat. As a tall plant, winter rye is more prone to lodging than winter wheat. To prevent lodging of rye plants, use Campozan (3-4 l/ha) or a mixture of Tour (3 l/ha) and Campozan (2 l/ha). The optimal time for spraying is the beginning of stemming. Do not combine Campozan treatment with herbicide spraying.

Harvesting. The optimal harvesting time for rye plants is shorter than for wheat plants, because when fully ripe, it shatters more and is capable of seed germination. This feature is often ignored in production and leads to significant yield losses.

Therefore, rye should be harvested separately, at the end of waxy ripeness at a grain moisture content of 20-25 per cent, as it ripens worse in windrows, and by direct combining in the first days of full ripeness at a moisture content of 15-18 per cent. It is better to mow lying crops across or at an angle to the direction of lodging.

2.3.5 Winter triticale plants (*Triticale*)

Triticale plants are artificially created plants by crossing wheat plants (soft and durum) with rye. Depending on the wheat plant used (soft or durum), triticale plants are either hexaploid or octaploid. The protein content of triticale grains is 1.5-2 per cent higher than that of wheat plants and 3-4 per cent higher than that of rye plants. The gluten content is as high as in wheat plants and higher (25-38 per cent), but due to the rye plant genome, its quality (elasticity, stretchability) is lower. Triticale seeds are 9.5 per cent higher in protein nutrition than wheat seeds, and almost 40 per cent higher than barley and corn seeds.



Biological characteristics, varieties. In terms of most morphological characteristics and biological properties, triticale occupies an intermediate position between wheat and rye with some differences.

Temperature requirements. The seed germinates at a temperature of $+1...3^{\circ}\text{C}$. In terms of frost resistance, triticale occupies an intermediate position between rye and wheat, and can tolerate a decrease in temperature at the depth of the tillering node to $-18...20^{\circ}\text{C}$. In terms of winter hardiness, it is close to winter wheat plants. Plants are more resistant to ice crust, thaws, and grow faster and better in spring than winter wheat. **Moisture requirements.** Triticale plants have a well-developed root system, so its drought tolerance is much higher than that of winter wheat. Triticale plants are able to provide better germination in case of insufficient moisture reserves during sowing. However, triticale plants require more water than rye plants. The transpiration coefficient is 450-550. Prolonged precipitation can cause lodging of crops. Rainy weather during earing and flowering contributes to the damage of plants by septoria. Triticale plants do not tolerate drought during the period of intensive growth of the vegetative mass.

Soil requirements. Triticale plants are more demanding on soil than rye and less demanding than wheat. Its highest yields are on soils with medium and high bonuses. It grows well on sandy, sandy loam and loamy soils. Potential yields on fertile soils are higher than those of rye and lower than those of wheat plants. The optimum soil solution reaction is neutral or slightly acidic (pH 5.5-7.0). Winter triticale varieties are divided into three groups by use: *seed* - used in the baking, confectionery, fermentation and feed industries; *seed mowing* - for green mass, fodder, and mixed fodder; and *mowing* - for green fodder, hay, and grazing.

Seed and fodder varieties are widespread in Ukraine: ADM 11, Amphidiploid 52, Polissky 7, Charodiy, Slavetne, Uragan, Souvenir, Kyivske early, Region, Harne, Blagodatny, Buyana, Ladne, Amphidiploid 256; hybrid - SV Talentro.

Features of cultivation techniques. *Place in the crop rotation.* Different varieties of triticale differ significantly in their requirements for growing conditions (some are close to rye plants, others to wheat plants). The highest yields of triticale plants are grown after clean and occupied fallow land, a layer and a turnover of perennial

grasses, legumes, early potato plants, and rape plants, i.e. after the place in the crop rotation that is preferable for winter wheat plants in the respective regions.

The worst performing crops in the rotation are seeded spiked crops and silage maize. After the worst performing crop rotations, triticale plants are more productive than winter wheat and partially inferior to winter rye.

Soil cultivation. Preparing the soil for growing triticale is almost no different from preparing it for other seeded winter cereals. Ploughing, flat-cutting and surface tillage are used. Pre-sowing soil cultivation is similar to other winter cereals. Before sowing, cultivation is carried out to the depth of seed placement with simultaneous harrowing with heavy harrows. Triticale plants are very demanding on the quality of the compacted seedbed.

Fertilisation. *Triticale* is intermediate between wheat and rye in terms of nutrient removal. Fertiliser doses are determined by soil fertility, planned yields and moisture conditions. The main fertiliser application is 20-25 tonnes per hectare of manure and phosphorus-potassium fertiliser ($P_{45-75} K_{45-75}$). Phosphate (P_{10}) or complete mineral fertiliser is applied to the rows during sowing. For early spring fertilisation, nitrogen mineral fertilisers N_{30-60} are used. On irrigated soils, fertiliser doses are increased by 1.2-1.5 times. The response of triticale varieties to sowing dates varies. The yield of many varieties depends on the sowing date more than wheat plants. It is recommended to sow triticale plants in the middle of the optimal sowing time for wheat plants. Seeds with a purity of at least 98 per cent, germination rate of at least 90 per cent for grain varieties and 85 per cent for fodder varieties are used for sowing.

The seed must be carefully sorted. The coarse fraction is used for sowing. Small triticale seeds have low vigour and therefore their field germination rate is much lower than in the laboratory. To prevent the development of smut, alternaria, ergot, and to protect young plants from root rot, the seeds should be treated with fungicidal inlay method, and in the presence of soil pests, with the addition of an insecticide. Before treatment, the seeds should be warmed up against the sun for 3-4 days, periodically turning them. In order for each seed to be completely covered with a protective film, it is necessary to increase the consumption of the working solution to 12-13 l/t, because the seed of the triticale plant is wrinkled and has a well-developed tuft.

Triticale plants should be sown at the same time as wheat in the respective zones. Each plant should have 2-4 shoots by the time the growing season ends in autumn. In the Polissya zone, the best time to sow is the second decade of September, and in the Forest-Steppe zone - from 5 to 25 September. In the Western Forest-Steppe, the optimal sowing dates are 10-25 September, and the permissible dates are up to 5 October.

The main method of sowing is conventional row sowing. When setting the sowing depth, it should be borne in mind that with an increase in depth, triticale plants have more germination than wheat plants. If the soil is sufficiently moist, the sowing depth should be about 4 cm on light soils and 5-6 cm in adverse weather. The seedbed should be compacted. When setting the seeding rate, it should be taken into account that the field germination of triticale seeds is lower than that of winter wheat and rye. The average norms in Polissya are 5.5-6.0, in the Forest-Steppe - 5-5.5, in the Steppe -

4-5 million laboratory-germinated seeds per 1 ha. Norms should be differentiated depending on the biological characteristics of the variety, seed size, moisture, weediness of the field, and soil fertility.

Crop care. In spring, triticale plants grow back quickly, so spring care should be carried out early. Technological processes are the same as for other plants. During early spring feeding, nitrogen mineral fertiliser N_{30} is applied, and during the tube stage - N_{30-40} . The need for herbicides in triticale plants is less than in wheat plants, but if weeds are significant, the crops are treated with the same herbicides as winter wheat crops. As signs of powdery mildew, rust, Septoria, and root rot appear, the crops are sprayed with a fungicide solution, and in case of massive pest infestation (the same as on wheat and rye), they are sprayed with an insecticide solution. The preparations and their doses are the same as for wheat plants, but it should be borne in mind that the leaves and stems of triticale plants are covered with a waxy coating, so surfactants should be added to the solution. If lodging of crops is expected, then at the beginning of stemming, the crops should be treated with a mixture of Campozan M (0.75-1 kg/ha) and Tour or Cycocel (2 kg/ha).

Harvesting. Triticale plants are resistant to shattering, but overstay increases the fragility of the ear, so harvesting is carried out with seed combines by direct combining at the beginning of full grain ripeness. It can also be harvested separately, but this requires additional costs. If necessary, the straw is removed from the field or chopped and spread on the field.

2.3.6 Winter barley (*Hordeum*)

Barley has always been a leading seed and fodder crop in Ukraine, as well as in other CIS and Western European countries. Today, winter barley is sown on an area of 300,000 hectares in our country every year. This is due to the fact that its seeds are best balanced in terms of amino acid composition and are close to standard feed qualities. The seed contains 12 per cent protein, over 75 per cent carbohydrates and 2.1 per cent fat. 1 kg of grain contains 1.2 k.e. and 100 g of digestible protein. The protein complex includes more than 20 amino acids, 8 of which are essential. The protein of barley plants is more complete than that of other plants, but contains little lysine - 2.5-3.2 per cent. Barley is better digested by animals than oats. When barley is fed to dairy cows, they produce milk, which is used to make excellent butter. Barley is a good fodder for fattening pigs. Winter barley is about 2000 years younger than spring barley. In the world's crop production, winter barley accounts for about 10 per cent of the 80 million hectares of barley plants. In Ukraine, 90 per cent of its acreage is located in the southern region - Crimea, Odesa, Mykolaiv and Kherson oblasts. Winter barley overwinters well and produces high yields in western Ukraine as well.



Biological characteristics, varieties. Barley is divided into three types according to the degree of winter hardiness. *Winter barley* is grown only in winter crops. When sown in spring, they do not spike, or spike with a long delay, which

excludes their cultivation for seeds. Plants overwinter in the tillering phase. To move on to the next phases of growth and development, they need low temperatures ($+2...4^{\circ}\text{C}$) and long daylight hours. The requirements to the temperature regime in the early stages of organogenesis are similar to those of winter forms. When sown in spring, they ripen at the same time as spring barley, but have lower productivity. The most common varieties are Taina, Osnova, Taman and Rosava.

Spring crops are grown in the spring by sowing them in early spring. Autumn crops are prone to tubing and freezing.

Winter barley is the earliest maturing seeded bread plant. Its frost and winter hardiness is lower compared to wheat and rye. This is due to the fact that there are no typical winter forms of barley seed plants. The vernalisation stage of barley plants lasts 30-40 days (it can be completed during autumn, winter, winter and early spring sowing).

The individual development of winter barley plants has the same growth and development phases and stages of organogenesis as other winter cereal plants, but their duration is shorter. Consequently, the length of the growing season will be shorter, and it will mature 9-10 days earlier than winter wheat plants and 12-14 days earlier than spring barley plants.

Winter barley is the least frost-resistant among winter plants. Plants are damaged even at temperatures of $+10...12^{\circ}\text{C}$. Resistance to low temperatures and other unfavourable wintering conditions is sharply reduced at early sowing dates. The minimum temperature for seed germination is $+1...3^{\circ}\text{C}$. Winter barley grows well in spring at slowly increasing temperatures. It has a higher tillering coefficient than spring barley. Rapid warming in the spring causes rapid plant emergence into the tube, which does not allow for the formation of the required density of productive stems. The optimum air temperature during the growing season is $+20...25^{\circ}\text{C}$. Plants are characterised by resistance to high air temperatures. As an early maturing plant, barley is less affected by fervour than other winter crops.

Moisture requirements. Winter barley makes good use of winter moisture reserves due to the early emergence of the plants. For germination, the seed absorbs 48-50 per cent of its own weight in water. The transpiration coefficient is somewhat lower than that of other cereals, at 300-450. Precipitation during the earing - grain filling period contributes to high plant productivity.

Soil requirements. Winter barley is less demanding on soil fertility than spring barley. Barley plants have the same soil requirements as wheat plants, but it is more demanding on soil calcium content. It grows best on chernozems with a neutral or slightly alkaline soil reaction (pH 6.5-7.5).

The most suitable for intensive cultivation are high-yielding varieties resistant to lodging: Avans, Kozyr, Secret, Ogonkovsky, Metelytsia, Mikhail, Luxor, Luran, Dobrynya 3, Dniester, Voskhod. Among the winter barley varieties are two-handed varieties that produce crops both in autumn and spring sowing - Taina, Rosava, Pallidum. Winter barley varieties Dniester, Dobrynya 3, Mykhailo, Seim are characterised by field resistance to hard smut; Cinderella, Aborigine, Trudivnyk, Dostoinny - to flying smut; Dniester, Zimnyi - to black smut; Cinderella - to yellow rust; Askold, Seim, Cinderella - to powdery mildew; Dobrynya - to grid spot; Seim - to dark

brown spot; Borisfen - to rhynchosporium; Trudovnik - to Septoria.

Agricultural technology. *Place in the crop rotation.* Due to the fact that winter barley has an underdeveloped root system with a low ability to absorb nutrients from hard-to-reach compounds, it must be sown on fertile and weed-free fields. In the south of Ukraine, barley is more often sown after corn, while in the western regions it is sown after corn, potatoes, and legumes. The best place in the crop rotation for barley plants in southern Ukraine is clean fallow. It can be sown after winter and spring wheat plants and oat plants. The worst place in the crop rotation is rye. Barley is demanding on the content of readily available nutrients in the soil and responds well to fertilisation. To form 1 tonne of grain and the corresponding amount of straw, it consumes about 23-30 kg of nitrogen, 9-11 kg of phosphorus, and 17-23 kg of potassium from the soil. For winter barley in the southern regions, after the best place in the crop rotation, N P K₄₀₋₄₀₋₄₀ is applied, after the worst - N P K₆₀₋₆₀₋₆₀, in the Forest-Steppe on podzolic and dark grey forest black soils - N P K₃₀₋₄₅₋₅₀, on light grey - N P K₄₅₋₆₀₋₆₀, in the western regions on sod-podzolic soils - N P K₆₀₋₉₀₋₆₀. Phosphorus-potassium fertilisers are applied under the main tillage and in the rows during sowing, nitrogen fertilisers - in separate doses: after the worst place in the crop rotation N₃₀ for pre-sowing cultivation, the last amount in early spring fertilisation, after the best - the entire norm in spring fertilisation.

Soil cultivation. The main soil tillage depends on the place in the crop rotation and natural conditions. It is advisable to combine several operations with one machine. This eliminates the unnecessary use of heavy machinery, which severely damages the soil structure.

After high-quality harvesting of row crops, surface tillage is applied. In fields where there was corn, the field is disked and then ploughed to a depth of 20-22 cm.

Cultivation with needle harrows in passive mode is a particularly good option for pre-sowing tillage. Especially on areas with a large amount of post-harvest residues in the surface soil layer. In such conditions, needle harrows are the only implements that do not pull them to the surface and practically do not clog. A characteristic feature of pre-sowing soil preparation for winter barley is its later timing. In other respects, it does not differ from preparation for other winter seed crops. Winter barley reacts negatively to soil over-compaction, waterlogging and lack of oxygen.

Sowing. Winter barley is the most sensitive among winter plants to sowing dates. If sown early, barley outgrows in autumn. In warm autumn conditions, it can go into the tube by the time the autumn growing season ends, which significantly reduces its winter hardiness and leads to freezing. Delayed sowing results in underdeveloped crops that develop in worse hydrothermal conditions. The optimal time for sowing barley plants is in the second half or at the end of sowing winter wheat plants. It should be sown at a time when each plant has no more than 4-5 shoots. Approximate sowing dates in Zakarpattia are 20-25 September, in Lviv region - the first decade of October, in Chernivtsi region - late September-early October, in the Steppe region - the third decade of September, and in Crimea - 1-15 October.

If winter barley plants are sown too early, they are severely damaged by Hessian and Swedish flies, green-eyed moths, and are intensively affected by snow mould, rust diseases and powdery mildew in spring. The sowing method is conventional row or

narrow row sowing. When setting the seeding rate, a differentiated approach should be taken. On fertile and well-prepared soils with sufficient moisture, when appropriate agronomic measures (variety, fertilisers, growth regulators) ensure high plant bushiness, the seeding rate can be set at 3.0 million/ha. The best results are obtained by sowing 3.5 million germinating seeds/ha. And only when sowing is late and growing conditions deteriorate, the seeding rate should be increased to 4.0 million/ha (400 seeds/m²), which ensures the formation of 600-700 productive stems per 1m² and maximum yield. On fields with low plant growth, it is recommended to use the traditionally recommended high seeding rates (4.5-5.0 million/ha of germinating seeds, or 450-500 seeds/m²).²

Seeding rates and plant density largely shape the microclimate of the agrocenosis and significantly affect the development of diseases. Thickened winter barley crops create favourable conditions for the development of root rot, powdery mildew, and brown rust pathogens; sparse crops contribute to intense plant damage by Septoria.

Deep and uneven seed placement is the main reason for reduced field germination and the formation of low-yielding winter barley crops. In the Polissia and Forest-Steppe regions of Western Ukraine, which are characterised by sufficient soil moisture, the optimal sowing depth is 3-4 cm. The depth of seed placement is important for obtaining friendly and levelled seedlings. Deep sowing of seeds contributes to the defeat of seedlings by pathogens of mould, root rot, smut diseases. Seeds need heat, moisture and oxygen for germination. Barley requires better moisture conditions due to its filmy grain. Deep seeding increases the availability of moisture, but decreases the availability of oxygen. Winter barley is sown relatively later, at lower average daily temperatures, so deep planting increases the duration of the sowing - germination period. Barley is highly affected by smut, so the seeds must be treated with Raxyl (0.5 kg/t) or Vitavax at the rate of 2-3 kg/t by inlaying before sowing. Against powdery mildew, brown and yellow rust, septoria, helminthosporiasis and rhynchosporiasis, it is recommended to treat the seeds with Tilt Turbo 575 c.e.

Crop care. Against snow mould on winter barley, autumn fertilisation with ammonium nitrate is recommended at the rate of 0.7-0.8 c/ha at a temperature of +2...4⁰ C.

In the germination phase - the beginning of tillering on well-developed crops of early sowing dates and in warm weather at the beginning of massive aphid, cereal fly, cicada infestation, carry out edge or continuous spraying with one of the insecticides: Karate Zeon 050 CS micron (0.15-0.2 l/ha), Fury (0.07 l/ha), Kinmix (0.2 l/ha), Engio (0.18 l/ha), Nurel D 55 percent k. (0.75-1.0 l/ha).

During the tillering phase in autumn - winter, 2-3 g of Rodenfos, Storm briquettes (0.7-1.5 kg/ha) or Bacterodencid (2-4 kg/ha) are placed in the burrows of voles and other mouse-like rodents (3-5 colonies per 1 ha).

During the spring inspection of winter barley crops, especially in years with unfavourable wintering conditions, it should be noted that in case of damage or death of the aboveground mass of plants, the tillering node often remains alive. Such crops tend to quickly regenerate their vegetative mass, bush well, and then form a satisfactory yield. In the spring, they are harrowed and fertilised with nitrogen fertilisers. During the growing season, herbicides, fungicides and insecticides are used, as they are on

wheat crops. To prevent lodging, retardants (Ricocel, Cycocel, etc.) are used at the beginning of stemming. Winter barley, like rye, is more difficult to harvest than spring barley or winter wheat. Harvesting is complicated by the drooping and brittleness of the ear, the tendency to lodging, and the short optimal threshing time. It is advisable to harvest barley in a separate flow method, especially crops with a large number of headers, at the waxy ripeness stage and by direct combining at the beginning of full ripeness at a grain moisture content of no more than 16-18 percent. Visual signs to start threshing are as follows: the ear is still slightly drooping and brittle, the awns are ripe and break only when threshed. Delay in harvesting is associated with large yield losses, as the fragility of the ear increases during standing, the ear droops (bends to the ground) and does not thresh when mowed with a reaper, but falls to the soil. After winter barley plants, it is recommended to sow lupine for green manure. The yield of green mass of lupine from summer crops is 300-400 c/ha. Its ploughing is an important measure of biologisation of technologies for growing other crops in the crop rotation and restoring soil fertility.

2.4 EARLY SPRING CEREAL PLANTS

Cereal plants that can withstand spring frosts relatively well and are sown first at the beginning of spring field work are called early spring crops. They ripen earlier than other spring crops. These include spring winter wheat, barley, rye (spring), and oats.

Spring breads are less productive than their winter forms (for this reason, winter forms of wheat plants and rye plants are more common in Ukraine). Other bread plants are significantly inferior to winter wheat, triticale and rye in terms of winter hardiness and cannot withstand the harsh conditions in most of Ukraine. For this reason, spring crops, including wheat, barley and oats, predominate in production. Plants are moisture-loving and cold-resistant, and are physiologically active at temperatures above +5° C. Growth and development at the beginning of the growing season is rapid. Plants of long day.

2.4.1 Spring barley (*Hordeum*)



Barley is one of the oldest plants. Along with wheat, it was known as far back as the Stone Age. It was grown in Egypt in 5000 BC and in Greece, Italy and China since prehistoric times. On the territory of Ukraine - since the third millennium BC. Nowadays, barley is grown in a wide range of areas, from the Arctic to the subtropics.

Spring barley is a fodder, food and industrial

crop. According to the FAO, 42-48 percent of the gross grain harvest of barley plants is used for industrial processing, 16 percent for feed, 15 percent for food and 6-8 percent for beer production. Seeds contain up to 76 per cent carbohydrates, about 12 per cent protein, 7-11 per cent pentosans, 1.7-2 per cent sucrose, 3.8-5.5 per cent fibre, 1.6-2.1 per cent fat, 2-3 per cent ash, as well as enzymes and vitamins (carotene; groups B, D, E). Barley plant protein is of moderate solubility and satisfactory amino acid composition (1 kg of grain contains 5.5 g of lysine, 1.7 g of tryptophan, 2 g of methionine, 1.9 g of cystine). Due to its low gluten content, flour is not suitable for baking bread. If necessary, it is used as an additive to wheat or rye flour to bake better bread. Barley seeds are also used to make coffee substitutes and malt extracts. In terms of nutritional value, 1 kg of barley grain corresponds to 1.2 feed units, which account for 100 g of digestible protein. Its chemical composition is characterised by high fodder qualities and it is used as a highly nutritious energy and dietary concentrated feed for all types and ages of livestock and poultry, and especially for fattening pigs. The fodder properties of barley plants are much better than those of wheat. While barley plant protein lacks 20 per cent lysine for physiologically adequate animal nutrition, wheat plant protein lacks 43 per cent.

Barley straw and chaff are valuable roughage. In the south, barley is used for green fodder and hay in a mixture with legumes (vetch, peas). Seeds of two-row barley plants are the best raw material for brewing. The brewer's seed should be large, levelled, with a low protein content (9-12.5 per cent) and a high starch content (63-65 per cent). Brewing waste (brewer's grains) is used to feed animals.

Spring barley is an early maturing plastic plant with a wide variety of forms. It withstands air drought better than other spring crops, providing good and consistent yields. It grows mainly in the same regions as winter wheat. The western region is more suitable for the production of malting barley plants. Modern advances in genetics and breeding have made it possible to push the barley plant further north. Previously, barley was grown mainly for food in the form of cereals and flour, but now it is mainly used for animal feed and brewing. A few years ago, scientists discovered substances such as triglyceride and tocotrienol in barley plant protein that can significantly reduce blood cholesterol levels. Adding a small amount of these substances to poultry feed (25 parts per 1 million parts of the total feed) reduces the cholesterol content in their blood by 40 per cent. Barley plays an important role in global crop production. Its sown area is about 80 million hectares, or 10.4 per cent of the area under seed crops. Gross harvest reaches 160 million tonnes with an average yield of 2.43 tonnes per hectare.

Barley ranks second in the group of forage crops in terms of area under cultivation. Its area is distributed across the continents as follows: Europe - 14.8 million hectares, Asia - 12.2, North America - 6.9, Africa - 5.5, Oceania and Australia - 2.5, South America - 0.6 million hectares. Among the countries, is the leader (15 per cent), Ukraine is second (8.2 per cent), and Canada is third (7.9 per cent). In Ukraine, the area under spring barley plants is 4.0-4.5 million hectares. The average yield is about 2.5 tonnes per hectare. The highest yields were obtained in European countries: Belgium - 5.65, Switzerland - 6.4, France - 5.4, the Netherlands - 5.9, the UK - 5.4, Ireland - 6.0, Germany - 5.1, Hungary - 2.6, and Austria - 5.4 t/ha.

Biological characteristics, varieties. The barley plant genus includes 30 species, of which only one is a crop plant - sowing barley. It is the earliest-ripening seed plant (the growing season lasts 60-120 days).

After sowing, seedlings appear in 6-9 days. In 12-15 days after germination, tillering begins, and in 30-40 days - stemming. The tillering energy is higher than that of wheat and oat plants. In crops, productive tillering is usually 2-3. High tillering is not desirable for malting barley. In barley plants, tillering is unlimited in stages and shoot formation can continue under intensive moisture when the first shoots have reached full maturity. As a result, in rainy weather, the ripe stem grows with late tillering shoots. Heading occurs 45-65 days after germination. The period from earing to waxy ripeness is 30-45 days, and grain filling and ripening takes 20-25 days. Typically a self-pollinating plant with long daylight hours. In conditions of acute drought, fertilisation occurs before heading or may not occur at all.

Requirements for temperature. Seeds of barley plants begin to germinate at a temperature of +1...3°C, the optimum temperature for this is +18...20°C. Seedlings can withstand frosts down to -7...8°C, but during flowering and ripening, a slight decrease in temperature below 0°C leads to sterility of flowers and formation of frost-resistant grain. During the earing period, the optimum temperature for barley plants is +20...22°C, and during ripening +23...24°C. Barley tolerates high temperatures (heat) better than other breads of the first group, withstanding up to +38...40°C. At this temperature, the stomata of barley plants do not collapse within 25-35 hours, while in spring wheat plants, they become paralysed after 10-15 hours, and in oat plants, they become paralysed after 5 hours.

High temperatures and drought during tillering reduce the productive bushiness of barley plants, and during earing and ripening - grain fullness, weight, and 1000 grain weight.

Attitude to moisture. Barley is quite drought-resistant. The transpiration coefficient is 350-400. At the beginning of the growing season, it has an underdeveloped root system and plants do not tolerate spring droughts. Therefore, late sowing can lead to unfriendly emergence of seedlings and slower plant development at later stages of organogenesis. Moisture deficit during tillering reduces projective bushiness and causes significant asynchrony in shoot development. Drought from earing to ripening leads to the formation of shrivelled grain.

Soil requirements. Barley is a rather plastic plant and grows on a variety of soils. The most suitable for it are vegetated structural soils with a pH of 6.0-7.5. It does not tolerate waterlogging, and grows worse on sandy soils than rye and oats. Its root system is relatively poorly developed and has a mediocre absorption capacity, so it responds well to fertiliser application and its aftereffects.

For malting *barley plants*, the best soils are chernozems, dark grey and grey forest soils. High yields of barley plants with good malting qualities are obtained on sod-podzolic soils. Less suitable soils are sandy and sandy loamy sod-podzolic soils in Polissya, and surface glazed sod-podzolic soils with high acidity in the Precarpathian region.

When growing for brewing purposes, it is advisable to give preference to such domestic varieties as: Askold, Obolon, Hetman, Chudovyi, Vakula, Charivnyi,

Bidoriy, Dzherelo, Nosivskyi 21, Aspect, Avgit, Vylyk, Vivat, Sontsedar, Sobornyi, Helios, Yukatan, Etiquette, Kozak, Kazkovyi, as well as foreign varieties: Tolar, Gerzei, Kvench, Europrestige and Josephine. Valuable varieties include Pivdennyi, Vakula, Adapt, and Palidum 107, which are characterised by high heat and drought resistance. When growing barley plants for feed and cereal production, preference should be given to varieties characterised by high protein content, high productivity and environmental plasticity. Among them, the most adapted varieties are: Stalker, Adapt, Ilot, Donetsk 14, Santrum, Partner, Sovira, Vodograi, Zdobutok, Perseus, Priazovsky 9, Sozonovsky, Inclusive, Avgiy, Khadar, Psyol, Vzirets, Gosya, Nezabudka, Zdobutok, Lofant.

Requirements for brewing barley grain (DSTU 3769/98). In recent years, the use of spring barley grain for beer production has been increasing dramatically. In this regard, breeders, scientists and field technologists are faced with the task of creating varieties and developing technologies for growing this plant's grain that would meet the modern requirements of breweries for the production of domestic beer with quality on par with world analogues, i.e. competitive both in the domestic and global markets. The area of barley harvesting includes Vinnytsia, Volyn, Zhytomyr, Ivano-Frankivsk, Kyiv, Lviv, Rivne, Sumy, Ternopil, Khmelnytsky, Cherkasy, Chernihiv and Chernivtsi regions.

Seeds of barley plants for brewing are evaluated according to the following characteristics: External (colour, smell, shape, pest infestation, etc.), physical (nature, weight of 1000 grains, size, alignment, presence of impurities), physiological (germination ability, water sensitivity), chemical (moisture, extractability, protein and starch content, filminess), technological (water absorption capacity during soaking, germination intensity, i.e. the ability of the grain to germinate simultaneously on the fifth day).

For beer production, barley of the nutans variety, i.e. two-row barley with a higher percentage of grain alignment, is used. It must be of pure variety, biologically ripe, have a normal colour (yellow or light yellow) and smell, extractability of 79-82 per cent, protein content of 9.0-11 per cent, filminess of no more than 9 per cent, and starch content of 79-82 per cent. Low filminess (less than 7-9 per cent) and high germination energy - at least 95 per cent on the 4th day of germination - are also important. According to the requirements of DSTU 3769-98 for malting barley, grain moisture content, depending on the growing area, should be 14-15 per cent, the content of weed and seed impurities should be no more than 1-2 per cent, and grain size (grain residue in the sieve of 2.5 x 2.0 mm) should be at least 50 per cent. Infestation with barn pests is not allowed. The needs of the brewing industry stimulate the creation of new highly productive barley varieties that are more resistant to lodging and common diseases: powdery mildew, stripe blight, dwarf rust, dark brown spot, and fly ash.

Agrotechnology. *Placement in the crop rotation, place in the crop rotation.* Spring barley is the most demanding crop among cereals in terms of its underdeveloped root system, short growing season, and increased requirements for soil structure. It is not very competitive with weeds, so it should be sown after clean and fertilised areas in crop rotations. When grown for food and fodder purposes, it is better to place it after perennial legumes and annual grasses, seed legumes and rapeseed

plants, for breweries - after fertilised row crops: corn, potatoes, melons, sugar beet (in the zone of sufficient moisture). Barley is one of the best cover crops for sowing perennial grasses due to its relative short stature and early maturity.

Sugar beet and potatoes will be good rotations for malting barley plants if they have developed high yields using most of the organic and mineral fertiliser applied to them. On soils with a humus content of 3.5 per cent or more, the residues of the stover, due to their high nitrogen content, can contribute to an increase in protein content. Rapeseed is also not a good crop rotation, as it leaves a significant amount of nitrogen in the soil with its by-products. Seed-growing spiked plants are not suitable for malting barley plants. Seed legumes reduce the malting quality due to high nitrogen residues in the soil.

It is not recommended to place barley after spiked plants to avoid severe damage by root rot and other diseases, and after sunflower, pike perch, which dry out the soil and clog the soil with carrion. The optimal level of saturation of the crop rotation with spring seeds in the Forest-Steppe region of the country is up to 30 per cent, of which barley plants are 10 per cent. *Soil cultivation.* When growing barley plants after plants that leave the field early, it is better to use semi-steam and improved tillage. With semi-steam tillage, after harvesting, the place in the crop rotation is immediately peeled with disc tools LDG-15A, LDG-10A, BDT-7, BDT-3 in two traces. After 12-14 days, when the weeds sprout, they are ploughed with ploughs with skimmers to a depth of 20 cm. Later, as weeds sprout, the field is harrowed and, if necessary, cultivated, keeping it weed-free until winter. If the place in the crop rotation was overgrown with perennial weeds, then after harvesting, the field is disked in two directions, and after germination, the weeds are cultivated with PL-5-25, PL-10-25 ploughshares or OPG-3.5, KPE-3.8, KTS-10, KPS-9 flat-cutting tools. When the weeds sprout, the field is ploughed for winter. When barley plants are grown after potatoes, fodder and sugar beet plants, for which deep ploughing is done, after harvesting, ploughless cultivation with ploughshares, chisel cultivators or flat cutters can be carried out.

After the maize is planted, the field is disked in two directions with disc harrows and then ploughed to a depth of 23-25 cm. In areas of insufficient moisture, the field is cultivated with flat cultivators. On heavy floating soils, under irrigation conditions, good results are obtained by cultivating with milling cultivators with deep rippers KFG-3.6. On heavy soils, on slopes, in areas where water stagnation is possible in spring, in the pre-winter period, slotting should be carried out (ShP-3-70 or others). An important condition for preparing the soil for spring barley is to carry out the main tillage in the autumn, as its transfer to spring leads to a delay in sowing and, as a result, a shortage of yield.

However, if the main tillage has not been carried out since autumn, it is necessary to carry out surface tillage with disc tools in spring, avoiding a significant gap with pre-sowing tillage with combined units or tools that include plumes and rollers in order to level the surface and compact the soil. Under such conditions, these works should be carried out as soon as possible to avoid significant delays in sowing. Pre-sowing tillage is differentiated depending on soil and climatic conditions and the degree of soil vegetation.

On waterlogged soils with heavy texture and in cool, prolonged spring

conditions, it consists of loosening the soil by 5-6 cm and bringing it to a sowing condition as it matures. On light soils and under dry conditions, pre-sowing tillage is aimed at preserving moisture, which is achieved by minimising it using combined units that include loosening and levelling working tools and rollers and ensure uniformity of soil cultivation in depth, which significantly increases field germination, synchronisation of plant development in the early stages of organogenesis and increases yields.

For pre-sowing cultivation, instead of steam cultivators, which have poor depth control, it is advisable to use combined units such as RVK, combined tillage units such as APB, AG of the Europak system, lobe harrows and couplings of series-connected harrows.

Fertilisation. Barley is very sensitive to fertilisation, responding quickly with an increase in biomass and bushiness. It is quite demanding on nutrients, especially in the initial period of growth and development, it needs a large amount of easily available nutrients. A high level of nutrition leads to early lodging of crops.

It is not recommended to apply manure directly to barley. Uneven application and weed infestation cause variegated stems, lodging, uneven ripening, and thus deterioration of sowing and brewing qualities of the grain. Barley makes good use of the aftereffects of organic fertilisers. Therefore, they should be applied in the crop rotation, and only mineral fertilisers should be applied directly to barley. According to the generalised results of research conducted by scientific institutions in the Forest-Steppe and Polissya regions, on fertile soils (black soil, dark grey, etc.), spring barley should be fertilised with $N\ P_{45-60}\ K_{45-60}$. On poorer soils (sod-podzolic, light grey, etc.), the fertiliser dose should be increased to $N\ P\ K_{60-90}\ 60-90\ 60-90$. High-yielding, fertiliser-sensitive and lodging-resistant varieties provide maximum yields with an increase in the dose to $N\ P\ K_{90-120}\ 90\ 90$.

Phosphorus-potassium fertilisers are best applied under autumn tillage. It is advisable to apply nitrogen in two parts: part of the dose (20 per cent) together with the full dose of phosphorus and potassium fertilisers before sowing, and the other part for pre-sowing cultivation and as a top dressing at the fourth stage of organogenesis. It is advisable to add 50-75 kg of granulated superphosphate to the rows during sowing. Full fertilisation is more effective on podzolic, grey podzolic soils, podzolic chernozems, phosphorus and phosphorus-potassium fertilisation on ordinary and typical chernozems, and nitrogen-phosphorus fertilisation on chestnut soils.

When growing malting barley plants, as well as when sowing perennial legumes, the dose of nitrogen fertiliser is reduced by 25-30 per cent. It should not exceed N_{30-45} after fertilised row crops, and N_{60} after other crops in the rotation. In case of fertiliser shortage, efficient nutrient use is ensured by pre-sowing local application of complex fertilisers in doses of 10-18 kg/ha NPK, which provide the highest return on fertiliser in the crop, and nutrient use coefficients double compared to the main application.

If there is a lack of microelements in the soil, they are added during seed preparation for sowing or sprayed on crops during the growing season. Ploughing by-products into crop rotations is also effective, increasing the yield of spring barley plants by 0.5-0.8 t/ha.

Sowing. For sowing, barley seeds must be calibrated, with a weight of 1000

grains of 40-45 g. No other chemical protection measure provides such a payback and environmental safety as seed treatment. According to scientists, in the case of sowing with untreated seeds, the shortfall in spring barley grain yield is 0.4-1.0 t/ha. In modern technologies, semi-dry seed treatment with tank mixtures consisting of an aqueous solution of a film-forming agent and one of the fungicidal preparations - Benlat (2-3 kg), Vitavax 200 FF (2.5-3 litres), Raxil (1.5 kg) - is widely used at the rate of 20 litres of aqueous solution per 1 tonne of seed. It is advisable to add growth regulators (such as Fumar-10 mg/t) to the tank mixture, which increases the productivity of spring barley plants by 5-10 percent. With prolonged use of the same treatments, pathogens become resistant to them. Therefore, they should be alternated. In conditions of moisture deficit and high temperatures, the best results are shown by the following treatments: vitavax 200 FF, raxil, sumi-8 FLO. It should be noted that liquid forms of preparations are less stable during storage and require stricter regulation of shelf life.

All systemic treatments protect plants from smut diseases. Vincit 050, VITA-CLASSIC, Vitavax 200 FF, Quinto Duo, Fundazole are more effective against *Fusarium helminthic* root rot; Fundazole, Raxyl Ultra, Granivit, Corriolis are effective against cercospora; against septoria - vincit, derosal, quinto duo, kolchuga, corriolis, lamardor, sumi 8-FLO; against seed mould - viking, vincit forte, SULFOCARBATHION-K, maxim 035, quinto duo, tmted, vitavax 200 FF.

It should be borne in mind that some seed dressings (Raxyl Ultra, Vincite 050, Sumi-8 FLO) have retardant properties, so they should be used only for high-quality seeds and should be applied to a depth of no more than 2-3 cm. To increase plant resistance to viral diseases and other harmful factors, seeds are treated with microelements (compounds are selected based on the results of agrochemical soil analysis) and plant growth biostimulants (emistim S, b.p, 10 cm³ in 10 litres of water per 1 tonne of seed, agrostimulin, b.s.p., 5-10 ml/t, vermistim, p., 8-10 l/t, etc.

Spring barley is a cold-resistant plant, so it should be sown in the early stages as soon as soil conditions allow. The criterion for starting sowing is soil maturity, when it is well covered by tillage. Barley requires relatively low temperatures for seed germination, withstands frosts and responds better to early sowing than other seed plants. On light soils, it should be sown earlier than on heavy soils.

Under conditions of insufficient moisture in overly thickened crops, barley plants ripen prematurely, reduce yields and form small and tiny seeds, and in dry years such crops even die. The yield of barley plants is sharply reduced when crops are thinned. On fertile soils, where plants tillering is good, the seeding rate for spring barley plants is set at 3-4 million germinating grains per hectare, and on less fertile soils, where plants have less intensive tillering, it is increased to 4.5-5 million per hectare. Thickening of crops above 6.0 million seeds per hectare is impractical under all conditions and does not increase yields.

When barley plants are grown with perennial grasses (clover), the seeding rate is reduced by 15-20 per cent. Under favourable conditions, the optimal seeding depth is 4-5 cm. If the topsoil dries out and sowing is delayed, the depth is increased by 1-2 cm. In the Forest-Steppe, the most common sowing methods are conventional row sowing with 15 cm row spacing and narrow row sowing with 7.5 cm row spacing. In a zone of unstable moisture, the conventional row method promotes more efficient

use of solar radiation, as well as nutrients and moisture, and ensures higher yields.

Crop care includes a range of activities, including harrowing, post-sowing rolling, protection against weeds, diseases and pests, and species and varietal weeding for seed crops. To improve germination conditions and the emergence of friendly seedlings immediately after sowing or simultaneously, the area is rolled with ring-spur, ring-toothed rollers in a unit with light harrows. On waterlogged, heavy, sloping, flood-prone soils, as well as in cold, prolonged spring, it is not advisable to roll crops. Depending on the soil texture and crust density, use light or medium harrows or rotary hoes. It is not recommended to harrow crops after emergence, when the soil is too wet, the seeds are shallowly wrapped, as well as when placing crops on light soils or when sowing perennial grasses.

The most important thing in caring for barley crops is protection against weeds, pests and diseases. Crops are treated with herbicides and insecticides only when pests are present in quantities exceeding economic thresholds of harmfulness, and fungicides are used only based on the results of disease forecasts and agrobiological monitoring of crops.

The choice of herbicides depends on the species composition of the weeds. The following herbicides can be used for weed infestation of spring cereal crops mainly with annual dicotyledonous weeds: 2.4D 500, v.p. (0.9-1.7 l/ha), 2M-4X 750, v.c. (0.9-1.5 l/ha), dicopur MCPA, v.p. (0.7-1.0 l/ha), AGRITOX, v.p. (1.0-1.5 l/ha), luvaram, v.p.c. (1.2-2.0 l/ha). Spraying of crops should be carried out in the tillering phase of plants before entering the tube. For the spread of weeds resistant to 2,4-D, barley plants are treated with herbicides 18WP, w.p. (0.1-0.15 kg/ha), Arkan 750, v.g. (20 g/ha), Harmony 75, v.g. (15-20 g/ha + 200 ml/ha surfactant TREND 90), bromothril 22.5, k.e. (1.0-1.5 l/ha), grodil ultra, v.g. (0.1-0.15 kg/ha), diallen, v.r. (1.9-2.5 l/ha), lotus, k.e.e. (0.6--1.0 l/ha), lintur 70WG, v.g. (0.12-0.15 kg/ha), granstar 75, v.g. (20-25 g/ha) and other recommended products. For the spread of such malignant weeds as perennial root-sprouting weeds (thistles, various types of bindweed), you can use Lontrel 300, v.p. (0.16-0.66 l/ha) or Lontrim, v.c. (1.5-2.0 l/ha). The choice and dose of the herbicide depends on the stage of plant development and the main types of weeds, soil conditions, and weather conditions.

In the phase of germination - 3rd leaf (I-II stages of organogenesis) it is necessary to protect crops from pests at their number exceeding the EEI: leeches - 10-30 beetles per m², striped bread fleas - 30-50 units per m², Swedish flies 40-50 units per 100 swings of the net. Carry out edge or continuous spraying of crops with one of the recommended insecticides: Bi-58 new, c.e. (1.5 l/ha); antitbug profit, c.p. (0.045-0.05 kg/ha), decis F-LUX, c.e. (0.2-0.25 l/ha); karate zeon 050 ES, c.e. (0.15-0.20 l/ha); holy mountain, c.e. (1.0-1.5 l/ha); fastak, c.e. (0.1-0.15 l/ha); fury, v.e. (0.07 l/ha), etc.

In the tillering phase - tube formation (III-VII stages of organogenesis) of barley plants, it is necessary to protect crops from leeches (120-150 or more larvae per 1 m²). Selective spraying of crops in pest foci with one of the following preparations is carried out: accent, c.e.e. (1.5 l/ha); bi-58 new, c.e. (1.5 l/ha); decis pro, 25, v.g. (0.04 kg/ha); zolon 35, c.e. (1.5-2.0 l/ha); karate Zeon 050 ES, c.e. (0.15-0.20 l/ha); NUREL-D, c.e. (0.75-1.1 l/ha); Svyatogor, c.e. (1.0-1.5 l/ha); FURY, c.e. (0.07 l/ha); Shaman, c.e. (0.75 l/ha).

Diseases of the leaves and stems of the ear (powdery mildew, types of rust, helminthosporium, spotting, etc.) can be controlled during the growing season. In the phase of tube outlet - flowering (IV-IX stages of organogenesis), it may be necessary to protect crops from leaf spot, powdery mildew, rust, septoria of leaves and ears, fusarium of the ear. Crops are sprayed with one of the following recommended products: Alto Super 330 ES, c.e. (0.4 l/ha); ABACUS, m.e. (1.25-1.75 l/ha); Bayleton 25, c.p. (0.5-1.0 kg/ha); bumper super 490, h.e. (0.8-1.2 l/ha), derosal, h.p. (0.5 l/ha); impact 25 SC, h.p. (0.5 l/ha); Rex Duo, c.e. (0.5 l/ha); Topsin M, c.e. (1.0 l/ha); Fundazole, c.e. (0.5-0.6 kg/ha); Tilt 250 ES, c.e.e. (0.5 l/ha); folicur BT, c.e. (1.0-1.25 l/ha). In the phase of grain formation (IX-XI stages of organogenesis) it is necessary to prevent grain losses from pests in numbers exceeding the EEI: cereal aphids - 20-30 pcs./ear, bread beetles - 5-8 units/m²; cereal thrips - 40-50 units/ear, harmful bread bugs 8-10 units/m². Spraying of the edge strips or continuous spraying is carried out with one of the recommended insecticides: actara 25, v.g. (0.1-0.14 kg/ha), bi-58 new, c.e. (1.5 l/ha); decis pro 25, v.g.g. (0.04 kg/ha); Karate Zeon 050 ES, m.c.s. (0.15-0.20 l/ha); Fastak, 10 per cent c.e. (0.1-0.15 l/ha); Buldok, c.e. (0.25 l/ha); Mospilan, p.p. (0.050-0.075 l/ha), etc.

During the waxy and full grain ripeness phase (stage XII of organogenesis), it is very *Crop care*. Oat plants are an effective natural means of protecting against diseases of other cereal plants, which is of great importance for environmental protection by reducing the use of pesticides. Only pre-sowing seed treatment is a mandatory preventive measure. All other chemical protection measures should only be used if necessary, based on a thorough analysis of the phytosanitary condition of the crops.

important to prevent grain quality deterioration due to damage by bread bugs, bread beetles, Fusarium and other ear diseases. In high agro-ecological conditions, especially in years with excessive precipitation, the risk of lodging of barley plants increases. In such cases, it is advisable to apply one of the recommended retardants at the beginning of the plant's emergence into the tube (Cycotel (3 kg/ha), etc.).

Harvesting. *Barley* is harvested by direct harvesting and separate harvesting. Direct harvesting is used at full ripeness, when the seeds have 14-17 per cent moisture, and the separate method is used at the waxy ripeness stage with a grain moisture content of 30-38 per cent. It is very important to combine these two methods correctly. Delayed harvesting usually leads to significant grain losses. The seeds of barley plants ripen quickly.

Once ripe, the ear drops down and breaks off easily, so harvesting must be done in a short time. It has been established that seven days after reaching full ripeness, when the physiological connection between the seed and the plant ceases, starch partially transfers to soluble forms of carbohydrates, which leads to a decrease in the amount of starch in the grain and the weight of 1000 grains. The split harvesting method allows you to start harvesting three to five days earlier. This is especially important in weedy areas. Do not allow more than three to four days between mowing and swathing, especially for brewing varieties.

2.4.2 Winter spring wheat (*Triticum*)



Spring wheat seeds have high baking and cereal qualities and contain more protein than winter wheat seeds. Seeds of soft and hard spring wheat plants have a high protein content (14-16 per cent soft, 15-18 per cent hard) and gluten content of 28-40 per cent. Flour of strong varieties is an improver for weak varieties in bread baking. Seeds of durum spring wheat are used to produce the best varieties of pasta, vermicelli, and semolina. Spring winter wheat is also important for fodder. It is used to make mixed fodder, bran as concentrated feed, and

straw and chaff as roughage. The area under spring wheat in Ukraine has increased significantly since independence, from 9,000 hectares in 1990 to 495,000 hectares in 2016. Spring wheat, like winter wheat, is becoming an extremely important strategic seed crop for the country, increasing its food security. Ukraine has favourable conditions for its cultivation, and modern varieties have high yield potential of 5.0-6.0 t/ha, containing 14-16 per cent protein and up to 30-35 per cent high quality gluten. Experts estimate that the area under spring wheat should reach 1 million hectares, including 650,000 hectares of soft wheat, whose grain is used to make flour for high-quality bakery products, and 350,000 hectares of durum wheat, whose seeds are used in the cereal industry and flour for pasta production.

Biological characteristics, varieties. In its individual development, winter spring wheat goes through 12 stages of organogenesis, which correspond to the following phases of growth and development: seed germination, germination, tillering, earing, flowering, grain formation and filling, and ripeness. Wheat plants germinate 8-12 days after sowing, tillering begins 12-15 days after germination and lasts 15-26 days. At the beginning of tillering, spring wheat plants begin to form an ear. The lack of moisture, nitrogen and phosphorus during this period negatively affects the development of the ear and leads to a decrease in the number of ears in it. 35-40 days after germination, earing begins, and 3-5 days after that, flowering. Milk ripeness occurs 15-18 days after flowering, and wax ripeness, which lasts 8-10 days, occurs 10-15 days later. The vegetation period of durum wheat varieties is 85-105 days, and durum wheat - 110-115 days. The productive tillering of spring wheat plants is lower than that of winter wheat, barley plants and oat plants, and is 1-2.

By the beginning of tillering, the root system penetrates the soil up to 50 cm, and by the earing stage - 100-130 cm. Nodal roots appear in the 3-4 leaf stage and develop only when soil moisture is available in the area of the tillering node. The period of formation of the secondary root system in spring wheat plants is short - from the formation of the tillering node to the plants' emergence into the tube (III-IV stages of organogenesis). The secondary root system is able to effectively use the moisture of summer precipitation.

Temperature requirements. Seeds of spring wheat plants begin to germinate at temperatures of +1...2°C, seedlings appear at +4...5°C. Seedlings can withstand frosts

down to $-8...10^{\circ}\text{C}$, and in the tillering phase - down to $-7...9^{\circ}\text{C}$. Starting from the earing stage and until the grain reaches milky ripeness, plants are damaged by frosts of $-1...2^{\circ}\text{C}$. Optimal temperatures for tillering are $+10...14^{\circ}\text{C}$, for earing and grain filling $+16...20^{\circ}\text{C}$, for ripening $+23...25^{\circ}\text{C}$. High temperatures during the filling period adversely affect grain formation. At temperatures of $+38...40^{\circ}\text{C}$, stomatal paralysis in spring wheat plants occurs after 17 hours, resulting in the formation of puny seeds. Hard winter wheat is more demanding on heat than soft winter wheat.

Moisture requirements. During germination, spring wheat seeds absorb 50-55 per cent of their own weight in water, while durum seeds absorb 5-7 per cent more. The transpiration coefficient is 400-450. The critical period in relation to moisture is the period of tillering and plant emergence into the tube (IV-VIII stages of organogenesis). Lack of moisture during this period leads to an increase in the number of infertile ears.

Soil requirements. The best soils for wheat plants are loamy black soil, chestnut, grey podzolic soils with a pH of 6.0-7.5. Acidic soils need to be lime. Durum wheat varieties are more demanding on soils. Spring wheat has a less developed root system than winter wheat. Therefore, it responds well to the content of mobile nutrients in the soil. 3 1 tonne of grain, winter spring wheat removes 35-40 kg of nitrogen, 10-12 kg of phosphorus, and 20-30 kg of potassium from the soil.

Spring soft wheat plant varieties are mostly recommended for the Forest-Steppe and Polissya, including varieties of strong wheat plants - Aranka, Elegy Myronivska, Suite, Bukuriya, Daryna, Isolda, Chado, Kharkivska 27Azhurna; valuable - Etude, Krasa Polissya, Early 93, Staviska, Struna Mironivska, Trizo, Vitka, Kollektivna 3, Pecheryanka, Skorospilka 99, Trizo, Kharkivska 28, Elegy Mironivska, Krasa Polissya.. Among the zoned durum wheat varieties suitable for distribution in the forest-steppe zone are Naschadok, Slavuta, Spadshchyna, Kharkivska 27, Metiska; in the forest-steppe and Polissya zones - Giselle, Isolde, Kharkivska 41, Chado, Bukuria.

Agrotechnology. The best crop *rotations* for spring wheat plants are perennial and annual legumes, legume-cereal mixtures, and seed legumes (peas, soybeans). Winter spring wheat makes efficient use of fertilisers applied to the previous plant. Therefore, it is advisable to sow it after row crops, such as potatoes and corn, which were grown on well-fertilised backgrounds. It is not advisable to grow spring wheat after spring cereals, sunflower and other crops in crop rotations that dry out the soil, resulting in a sharp decrease in grain yield and quality. Spring durum wheat should be planted after the best legumes in crop rotations, in particular soybean plants, as it is more demanding on soil moisture and nutrients.

Soil cultivation. When growing wheat plants, semi-steam tillage is effective. After harvesting, the area is peeled to a depth of 6-8 cm and harrowed. After the emergence of weeds (after 10-12 days), early autumn ploughing is carried out to a depth of 20-22 cm (on sod-podzolic soils to the depth of the arable layer). After that, the soil is kept clean by cultivating and harrowing. If the field is infested with perennial weeds, improved tillage is used. A second peeling is carried out 10-12 days after the first peeling. If there are more rhizome weeds, the weeds are peeled with disc harrows to a depth of 10-12 cm, and if there are root weeds, with ploughshares to a depth of 14-16 cm. 12-14 days after the second peeling, after the emergence of

perennial weeds, autumn ploughing is carried out to the depth of the arable layer, and on black soil - by 25-27 cm. Before winter, the winter crop is harrowed and cultivated as weeds sprout and soil crust emerge. On heavy soils, it is advisable to carry out deep moldboardless loosening or slotting before the onset of winter.

After harvesting the maize plants, they are disked in 2 traces and then immediately ploughed to a depth of 23-25 cm. After potato and beet plants, the soil is ploughed without preliminary peeling. Cultivation in spring begins with closing the moisture with tooth harrows or rotary hoes and looping in 1-2 traces. After 3-4 days, cultivation is carried out in 1-2 traces to a depth of 6-8 cm, and on heavy soils - 10-12 cm and harrowing. In dry conditions and on light soils, pre-sowing cultivation is carried out to the depth of seed placement so that the seeds lie on a compacted bed during sowing.

Fertilisation. As already mentioned, winter wheat is demanding on soil fertility. It is economically beneficial to provide it with nutrients through the use of after-action organic fertilisers and the application of calculated doses of mineral fertilisers against this background. In the event of insufficient rainfall and their deficit in the spring, nitrogen mineral fertilisers, together with phosphorus and potassium fertilisers, are applied in full for autumn ploughing or pre-sowing cultivation. Under such conditions, the optimal dose of complete NPK fertiliser for the main application is 40 kg/ha a.i. Under conditions of optimal moisture supply, the dose of nitrogen can be increased to 60 kg/ha, with half of it applied at the IV stage of organogenesis. Winter spring wheat makes good use of fertilisers applied during sowing, so depending on the place in the crop rotation, soil type and moisture supply, it is advisable to apply 15-20 kg/ha of phosphate or 10-15 kg/ha of complex fertilisers to the rows during sowing.

To obtain a high quality grain yield from spring wheat plants, it is imperative to provide the plants with a sufficient amount of nutrients, primarily nitrogen, so under optimal water conditions, its split application during the spring and summer growing season is necessary. The best results for increasing yields and grain quality are achieved by nitrogen fertilisation of spring wheat crops at the IV stage of organogenesis (30 per cent of the total norm) and at the VIII stage of organogenesis (the remaining 20 per cent of the calculated norm).

Sowing. Field germination of spring wheat seeds often does not exceed 75 per cent. Therefore, it is necessary to prepare the seeds for sowing very carefully. They must meet the requirements of DSTU 2240-93 and have a laboratory germination rate of at least 92 per cent for soft and 87 per cent for durum wheat varieties, and a purity of at least 98.5 per cent and 98 per cent, respectively. After winter storage, the seeds should be warmed up at a temperature of +38...40°C for 2-3 hours (air-heat heating) or solar heating for 3-5 days. 3-5 days before sowing, the seeds are disinfected with systemic preparations such as Baytan, Vitavax or Fundazole (2-3 kg/t) and others. To treat seeds of spring wheat plants against flying smut, it is better to use Raxyl Ultra, t.c.s. (0.2 l/t); TMTD, v.s.c. (3-4 l/t), Vial TT, v.s.k. (0.3-0.4 l/t), kinto duo, hp (2.0-2.5 l/t), vincit 250, hp (2.0 l/t). Seeds can be treated both in advance (2-3 weeks) and immediately before sowing. Pre-treatment is particularly effective for protecting plants from smut diseases. In the case of forced sowing after spiked crops, in order to protect

crops from bread borer, scoopers and other soil pests in numbers exceeding the EEI, pre-sowing seed treatment should be carried out with Gaucho, W.P. (0.25-0.5 kg/t), Rubizh, E.E. (2.0 l/t).

Seed treatment with biostimulants and strains of nitrogen-fixing bacteria is also effective, but seed treatment should be carried out 10-12 days before treatment with the preparations. Spring wheat should be sown as early as possible when the soil is physically ripe. A one-day delay in sowing results in grain losses of 50-80 kg/ha on average, and 100-170 kg/ha in late and dry spring due to reduced productive bushiness, damage to plants by cereal flies and *Fusarium*. The seeding rate of durum and soft wheat plants in the northern regions of the zone is 5.0-5.5 and 5.5-6.0, respectively, in the central regions - 4.5-5.0 and 5.0-5.5, in the southern regions - 3.5-4.0 and 4.0-4.5, and under irrigation - 5.0 and 5.5 million germinating seeds per 1 ha. It should be borne in mind that spring wheat plants are weakly tillering, so the seeding rate should not be underestimated. In dry spring conditions, sowing rates should be increased by 10-15 per cent of the recommended rate. Seeding rates are also increased in weedy fields, on poor soils and in areas of sufficient moisture. Sowing is carried out using conventional row or narrow-row methods with seed drills, and in areas of wind erosion, with stubble drills. When sowing by the narrow-row method, the seeding rate is increased by 10-15 per cent. Seeds of spring wheat plants are sown to a depth of 3-4 cm, and 5-7 cm in dry conditions and on light soils. The main agrotechnical measures for caring for spring wheat crops are rolling, harrowing, plant protection against weeds, diseases, pests and lodging, and fertilisation with nitrogen and microelements. Rolling the crops after sowing is especially necessary in dry spring conditions. It is necessary to harrow spring wheat crops on heavy floating soils when intense precipitation falls after sowing and soil crust forms.

The whole range of agrotechnical measures (crop rotation, tillage, sowing dates, seeding rates, selection of resistant varieties, etc.) should be aimed at protecting spring wheat crops from pests. Under current conditions, it is virtually impossible to avoid chemical treatments of spring wheat crops without a significant reduction in yields due to the negative impact of pests. Therefore, pesticides should be used on spring wheat crops only based on the results of monitoring the phytosanitary condition of crops when the economic thresholds of harmfulness of harmful objects are exceeded. The timing of herbicide application is differentiated depending on the species composition of the agrophytocenosis. If annual dicotyledonous weeds dominate, crops are treated at the beginning of tillering, while perennial root-sprouting weeds are treated at the stage of full tillering.

In case of weed infestation of crops mainly with annual dicotyledonous weeds, the following herbicides can be used: 2,4-D 500, v.p. (0.9-1.7 l/ha), 2M-4X 750, v.c. (0.9-1.5 l/ha), dicopur MCPA, v.p. (0.7-1.0 l/ha), AGRITOX, v.p. (1.0-1.5 l/ha), luvaram, v.p.c. (1.2-2.0 l/ha). Spraying of crops should be carried out in the tillering phase of plants before the beginning of the tube. In case of spreading of weeds resistant to 2,4-D in spring wheat crops, the crops are treated with herbicides Satis 18WP, s.p. (0.1-0.15 kg/ha), Arkan 750, v.g.g. (20 g/ha), Harmony 75, v.g. (15-20 g/ha + 200 ml/ha surfactant TREND 90), bromotril 22.5, c.e. (1.0-1.5 l/ha), bromotril P 25, v.c. (1.0-1.5 l/ha), grodil ultra, v.g. (0.1-0.15 kg/ha), dicam plus, v.c. (0.8 l/ha), starane 200,

c.e. (0.75-1.0 l/ha), diallen super 464 SL, v.r.c. (0.5-0.8 l/ha). To prevent lodging of crops, especially on high agro backgrounds, it is necessary to apply retardants at the beginning of the plants' entry into the tube (IV-V stages of organogenesis). This measure is relevant for varieties that are less resistant to lodging and on durum spring wheat crops. If it coincides in time, it is combined with spraying against powdery mildew, brown leaf rust, root rot and other diseases with Tilt, Fundazole (0.6-0.8 kg/ha) or other fungicides. In the interphase period between the tube and flowering, the crops are treated against leaf spot, powdery mildew, rust, leaf and ear septoria, and ear fusarium pathogens with one of the recommended products: Alto Super 330 ES, c.E. (0.4 l/ha); ABACUS, MC (1.25-1.75 l/ha); Bayleton 25, W.P. (0.5-1.0 kg/ha); Bumper Super 490, E.E. (0.8-1.2 l/ha), Derosal, W.P. (0.5 l/ha); Impact 25 SC, W.P. (0.5 l/ha). From flowering to the end of grain filling, if necessary, the crops are sprayed against harmful turtle, bread moth and other pests with aqueous solutions of insecticides: Accent, c.e. (1.5 l/ha); Karate Zeon 050 ES, c.e. (0.15-0.20 l/ha); Svyatogor, c.e. (1.0-1.5 l/ha); Fury, c.e. (0.07 l/ha).

Harvesting. Spring wheat plants are harvested using two- and one-phase methods. The harvesting technology and quality assessment criteria are the same as for winter wheat. Separate harvesting begins at waxy ripeness. Seeds are harvested by direct combining at full ripeness. Delayed harvesting leads to significant yield losses (wheat seeds crumble).

2.4.3 Oats (*Avena*)



It belongs to ancient plants, although in ancient times oats were a weed infestation of wheat plants and barley plants. It was known in Europe in 1500-1700 BC. It has a fairly wide distribution, especially in regions with a humid and cool climate. As it moved north and into the mountains, being more hardy, it displaced other plants.

The high content of protein (12-18 per cent), starch (40-45 per cent), fibre (10.5 per cent), fat (4-5 per cent), ash (4-2 per cent), amino acids and minerals determines its feed quality: 1 kilogram of oat plant is

accepted as 1 feed unit. The digestibility of its organic matter is 70 per cent. The protein of the oat plant is highly soluble. 1 kg of grain contains 5.5 g of lysine, 0.69 tryptophan, 1.65 methionine, and 2.27 g of cystine.

The oat plant contains sterols, steroidal saponins, coumarin, glycoside, vanillin, vitamin E, retinol, thiamine, riboflavin, and organic acids. The grain contains a lot of starch, fat, and protein. Oat starch has small grains, is digested quickly and with little energy expenditure, fat is considered neutral, and contains a large amount of polyunsaturated essential fatty acids and hormone-like substances. Oats are considered a dietary feed, highly valued in feeding horses, breeding sires and young animals of all kinds. Due to its high content of unsaturated

fatty acids and a significant amount of fibre, it is included in the diet of fattening pigs in limited quantities. The film is high in fibre, low in protein, fat and minerals, and is equivalent to straw in terms of nutrition. The global area under oat crops is about 20 million hectares, or 2.8 percent of cereals. The main areas are concentrated in Europe and North America, with the largest in (14.8 per cent), followed by Belarus (14.1 per cent), Canada (8 per cent), Poland (7.3 per cent) and Germany (6.3 per cent). In terms of gross production, is the leader with 31.5 percent or 9.2 million tonnes. Canada harvests 10.1 per cent, the US 8.8 per cent and Germany 5 per cent. In Ukraine, oats are grown mainly in the Forest-Steppe and Polissya regions on an area of 0.4-0.5 million hectares. Its average yield is inferior to spring barley. However, it has a rather high productivity potential. The share of oat plants in world resources is quite significant, but its production is declining. One of the main reasons is structural changes in livestock farming, a decrease in the number of horses for which oats are the main feed; the second is relatively low yields; the third is the lower energy content of oat plants than other seed-feeding plants: if 1 kg of oat plants is equivalent to 1 k.d.-e, then 1 kg of corn plant grain is 1.34, barley plant grain is 1.2, sorghum plant grain is 1.1, pea plant grain is 1.14, soybean plant grain is 1.30, fodder bean grain is 1.15, lupine plant grain is 1.11, and vetch plant grain is 1.19.

Biological characteristics, varieties. *Requirements to the temperature.* Of the 10 species of oat plants, the most important is the sowing oat. It is a temperate plant, undemanding to heat. Its seeds germinate at a temperature of $+2...3^{\circ}\text{C}$. In the 3-4 leaf stage, tillering and secondary root formation begin. The optimum temperature for germination is $+10...18^{\circ}\text{C}$. Seedlings can tolerate frosts down to $-4...5^{\circ}\text{C}$. When the temperature drops to -10°C , the tillering node of oat plants is not damaged and the vegetation of plants continues with the onset of warmth. In the flowering and milky ripeness phase, the grains of the plant die at -2°C . The optimum temperature for flowering and ripening is $+20...25^{\circ}\text{C}$. Oats tolerate summer high temperatures and droughts worse than winter wheat and barley.

Moisture requirements. Oats are the most moisture-loving of the cereal plants. Sufficient relative humidity and frequent rains are the key to high yields. The yield of oat plants increases in parallel with the amount of summer rainfall. During germination, the seed absorbs 60-65 per cent of its own weight in water. The transpiration coefficient is 450-500. The first period of life is critical in relation to moisture - from tillering to panicle ejection. Intensive rains in the second half of the growing season cause the formation of a pod and delay the ripening of the crop.

Soil requirements. The oat plant has a well-developed root system, which is characterised by a high absorption capacity. In the tillering phase, the roots penetrate the soil to a depth of 70-80 cm, and in the grain formation phase - 1.5-2 m. The root system of oat plants is able to absorb phosphorus from hardly soluble soil compounds. Therefore, it is less demanding on soils than other cereals, except rye plants. Oats grows well on sandy, loamy and clayey soils and tolerates soil acidity better than other breads (optimal pH is 5-6). It grows well on drained peat bogs, so it is recommended to sow it as the first plant when developing drained land. Structural chernozems, dark grey podzolised soils with a slightly acidic reaction are the most

suitable for oat plants. It grows poorly on saline soils. Oats are a self-pollinating plant with *long daylight hours*. It grows well with early mowing. The grains in the panicles of oat plants ripen unevenly, which makes it difficult to determine the optimal harvest time. Its growing season lasts 100-120 days. A characteristic feature of the oat plant is its extended period of nutrient consumption. It responds well to nitrogen mineral fertilisers. With a harvest of 1 tonne of grain (including straw), it removes 30-40 kg of nitrogen, 10-15 kg of phosphorus and 25-30 kg of potassium from the soil. The best varieties of the filmy oat plant: Skakun, Sinelnikovskyy 1321, Zirkovyy, Spurt, Busol, Slavutych, Raiduzhnyy, Neptun, Parlamentskyy, Zakat, Zirkovyy, Polonez, Arkan, and naked-seeded - Abel, Marathon, Skarb Ukrainy, Solomon, Samuel.

Agrotechnology. *Place in the crop rotation.* Oats are more plastic than barley, so they are less demanding in crop rotation. Oat plants have high yields when sown after well-fertilised winter cereals and row crops, legumes, flax, and lupine. If the crop is high, it can be sown after wheat plants. It is not recommended to sow it after oats and sugar beet plants, as they share a common pest, the nematode.

Soil cultivation. Oats are a moisture-loving plant, so autumn and spring tillage should be aimed at accumulating and preserving moisture. After harvesting, the place in the crop rotation is subject to one- or two-time stubble peeling to a depth of 8-10 cm and ploughing or moldboardless tillage to a depth of 20-22 cm. For oat plants, it is important to ensure that the soil is settled with an efficient capillary system, as oats, due to their filmy grains (25-30 per cent), require more moisture for seed germination and further growth and development than winter wheat, rye or barley. In the spring, we harrow the seedbed and cultivate it to the depth of seed placement (5-6 cm), but depending on the field conditions before sowing, we can limit ourselves to one of these operations.

Fertilisation. Thanks to its well-developed root system, oats make good use of soil fertility and nutrients left over from the crop rotation.

Oats make good use of the aftereffects of organic fertilisers, so they are sown as the second or third plant after they have been applied. Oats respond positively to mineral fertilisers on all soils. Nitrogen mineral fertilisers are always the most effective against the background of phosphorus and potassium fertilisation. Physiologically alkaline nitrogen mineral fertilisers, such as sodium and calcium nitrate, are most effective on soils with an acid reaction. Fertilisers for oats are applied depending on the soil characteristics and place in the crop rotation at the rate of 30 to 60-90 kg/ha of active ingredients of nitrogen, phosphorus and potassium. With an average soil nutrient supply, 30-40 kg/ha of NPK is applied to oats. Phosphorus and potash fertilisers are applied for basic tillage or for spring cultivation. Nitrogen fertilisers, if the calculated dose does not exceed 40-60 kg/ha, are best applied for pre-sowing cultivation. If the dose is higher than 60 kg/ha, then part of the nitrogen fertiliser should be applied at the beginning of the tube. 50 kg/ha of granulated superphosphate or nitrophosphate (available at₁₀) is applied to the rows during sowing. Copper, boron and manganese fertilisers are also used on peatlands.

Sowing. When preparing the seeds for sowing, they are sorted so that the seeds from the first flowers in the spikelets, which are much larger than the others, are

included in the seed. If it is not possible to provide all areas with such seeds, they should be calibrated in size and sown at a higher rate. Seeds must meet the following requirements: germination should be at least 92 per cent, purity should be at least 98.5 per cent, and weeds should be no more than 20 per 1 kg. In autumn, before storage and in spring, air-heat or solar-heat heating is carried out. 5-10 days before sowing, the seeds are treated against volatile and hard smut, seed mould, Fusarium root rot with Benlat (2-3 kg/t) , Vincit (2 l/t) , Raxil (1.5 kg/t), Fundazol (2-3 kg/t) or another inoculation method. Oats are sown at the beginning of field work after wheat plants and barley plants. The best sowing method is narrow-row sowing. In areas where seeding rates do not exceed 4 million germinating seeds per hectare, the conventional row method is also effective. The approximate sowing rate in Polissya is 5.5-6.0 million, in the Forest-Steppe - 5.0-5.5, in the Steppe - 4.5-5.0 million germinating seeds per 1 ha.

Oat seeds are sown in the soil to a depth of 3-4 cm. On light soils and when the seed layer dries out, 4-6 cm, and on heavy clay soils and when excessive moisture is present, 2 cm.

In dry weather, after sowing or simultaneously with sowing, the field is rolled with ring rollers, and harrowed under conditions of sufficient moisture. If a substantial crust forms on the field after sowing, light harrows are used to destroy it and protect against weeds before the oat plants sprout. During tillering, the crops are sprayed with aqueous solutions of herbicides to control weeds: Amine salt of 2,4-D (1.5-2 kg/ha), Dialen (1.75-2.25 litres/ha), Lontrel (0.3-0.6 kg/ha) or 2M-4X (1.4-2.3 kg/ha). On crops where perennial grasses are sown, apply Bazagran M (2-4 l/ha) when the grasses have a trifoliate leaf. During the growing season, oats can be damaged by Swedish flies, aphids, oat thrips, moths, and the underground organs of young plants can be damaged by wireworms, false wireworms and other pests. Spraying against pests is carried out when their number exceeds the limit of economic damage. For this purpose, insecticides such as Karate Zeon 050 ES, c.e. (0.15-0.20 l/ha); Svyatogor, c.e. (1.0-1.5 l/ha); Fastak, c.e. (0.1-0.15 l/ha); Fury, c.e. (0.07 l/ha), etc. are used. In case of forecasting a severe damage to crops by linear stem rust, crown rust, powdery mildew, ascochytosis (white spot) , red-brown spot, red-brown bacterial spot to protect the stem, leaves and panicles, fungicides such as Alto Super 330 ES, c.e. can be used. e. (0.4 l/ha); ABACUS, μ .e. (1.25-1.75 l/ha); bayleton 25, w.p. (0.5-1.0 kg/ha); bumper super 490, e.e. (0.8-1.2 l/ha), derosal, h.s. (0.5 l/ha); impact 25 SC, h.s. (0.5 l/ha); Rex Duo, c.e. (0.5 l/ha); Topsin M, s.p. (1.0 l/ha); Fundazole, s.p. (0.5-0.6 kg/ha); Tilt 250 ES, c.e. (0.5 l/ha); Folicur BT, c.e. (1.0-1.25 l/ha). Grains of oat plants ripen very unevenly in the panicle - first in the upper branches, then in the middle branches and finally in the lower ones. While the overall ripeness of the grain makes it possible to start harvesting, the vegetative mass (stems and leaves) is still green and too wet. Because of this feature, the timing and methods of harvesting oat plants need to be approached very carefully.

Oat plants are harvested either separately or by direct combining. Separate harvesting of oats begins at the end of waxy ripeness, when 30-40 per cent of the grains are fully ripe in the upper part of the panicle. As a rule, crops that are lying down, have high moisture content and are weeded are harvested only in a separate way,

using reapers. Direct harvesting should be started when more than 90 per cent of the grain is ripe with a moisture content of 14-18 per cent. This method is usually used to harvest short, sparse and evenly maturing crops that are not weedy and without hilling, and are resistant to lodging and shattering. Harvesting should be done in a short time, as oats shatter quickly (most seeds are lost in the early stages of maturation). After harvesting, the seeds must be cleaned and dried immediately, as dust and fungal spores accumulate on the grain films, which germinate and cause grain spoilage when stored wet.

2.4.4 Triticale plants



The seed of the triticale plant contains 13-16 per cent protein, with up to 350 mg/ per cent of the essential amino acid lysine. The carotenoid content is 1.5-2.0 mg. This ensures its high nutritional value. The grain nature of triticale is somewhat lower than that of wheat, and amounts to 680-730 g/l, which is due to the longer elongation of the grains and lower endosperm hardness. Triticale seeds are effectively used for feeding cattle, sheep, goats, pigs, and poultry. More valuable is the feed produced with the content of triticale plant up to 40-50 percent of the seed component.

In poultry feeds, triticale seeds increase their energy and biological value due to a better balance in protein content, its easily soluble fractions, essential amino acids, carotene and other important components. A balanced feed contains up to 40-45 per cent triticale, as well as corn, soya and other mineral and biological additives. Triticale seed is also a valuable raw material for the production of high-quality alcohol. The alcohol yield from triticale grain is 1.7-1.9 per cent higher than that of rye and 0.3-0.6 per cent higher than that of wheat. The use of spring triticale is expanding every year, both for food and feed production and in other areas: green manure and mulch crops, the manufacture of disposable tableware, etc. Spring triticale is less demanding on growing conditions compared to spring wheat. The plants have a well-developed root system and leaf apparatus, which enables them to better tolerate drought and actively absorb nutrients. Due to the functioning of rye plant chromosomes in their genome, spring triticale plants are more resistant to sharp temperature fluctuations at the beginning of the growing season.

Agricultural technology. *Place in the crop rotation.* The best places in the crop rotation for spring triticale are perennial and annual legumes, legume mixtures, seed legumes (peas, soybeans), corn, potatoes. To obtain marketable products, it is allowed to sow spring triticale after winter wheat plants and sunflower plants.

Soil preparation. The best method of basic tillage for sowing spring triticale on black soil is moldboardless loosening to a depth of 20-22 cm with preliminary peeling with disc harrows to a depth of 6-8 cm.

After planting corn for seed, it is advisable to plough in all areas by 20-22 cm.

For spring triticale plants, especially when placed after sugar beet, it is necessary to perform moldboardless tillage using chisel-type tools to destroy the plough sole, which significantly improves the agrophysical properties of the soil, promotes soil moisture accumulation, allows you to start spring sowing 5-6 days earlier and increases the yield of spring triticale plants.

Fertilisation. The composition and doses of mineral fertilisers for spring triticale plants are determined depending on the supply of nutrients in the soil, which is related to soil fertility, place in the crop rotation, etc. According to the generalised results of research conducted by scientific institutions in the Forest-Steppe and Polissya regions, on chernozem and dark grey soils, after fertilising the crop rotation, it is necessary to apply $N_{45-60} P_{45-60} K_{45-60}$. on sod-podzolic, light grey soils, the fertiliser dose is increased to $N_{60-90} P_{60-90} K_{60-90}$. Potash and phosphate mineral fertilisers are recommended for basic tillage, 10-15 kg/ha of superphosphate at the time of sowing, and full mineral fertiliser at the rate of 20 kg/ha of each element on poor soils. It is advisable to apply nitrogen fertilisers for pre-sowing cultivation (70 per cent), and the rest - for fertilising during the phase of plant emergence.

Sowing. Among the varieties of spring triticale with a high level of productivity potential, the following should be noted: Kobzar, Zhayvoronok Kharkiv, Oberig Kharkiv, Solovey Kharkiv, Korovai Kharkiv, Legin Kharkiv, Losynivske, Zgurovsky, Arsenal, Victoria, Veresoch, etc. Seeds are treated with one of the recommended products included in the "List of pesticides and agrochemicals allowed for use in Ukraine" for the current year. This measure helps to disinfect seeds from external infections (hard, stem and dwarf smut, ergot, mould) and internal infections (flying smut, fusarium), protect germinating seeds and seedlings from soil infections by stem and dwarf smut, root rot, Septoria, and increase field germination. In addition, broad-spectrum seed treatment products provide long-term protection of seedlings from such dangerous diseases as powdery mildew, rust, Septoria and other spotting.

Sowing should be carried out as early as possible when the soil is physically ripe (when it is well loosened). The warming of recent years has made it possible to sow spring triticale plants even earlier, using the "February-March windows", which is quite effective. Spring triticale seedlings can withstand temperatures down to $-8...-9^{\circ}\text{C}$, so lowering the air temperature after sowing will not harm the plants.

The highest yield of spring triticale is formed at a sowing rate of 4.5-5.0 million seeds per hectare after the best place in the crop rotation, and after the worst - 5.0-5.5 million seeds per hectare. The seeding depth of spring triticale is within 4-5 cm.

Crop care. Immediately after sowing, roll the spring triticale plants with ring spur rollers if the seeder did not ensure proper rolling of each row. If soil crust appears after sowing, harrowing with light harrows is necessary before emergence. The main thing in caring for spring triticale crops is protection against weeds, primarily root sprouts. For their destruction in the tillering phase, it is recommended to treat the crops of spring triticale with the herbicide Lontrel 300, v.p. (0.16-0.66 l/ha) or Lontrim, v.c. (1.5-2.0 l/ha). If pests appear above the threshold of harmfulness, use insecticides karate zeon 050 ES, c.e. (0.15-0.20 l/ha); holy mountain, c.e. (1.0-1.5 l/ha); fastak, c.e. (0.1-0.15 l/ha); FURY, c.e. (0.07 l/ha).

Due to its high resistance and immunity to common foliar diseases, no fungicides

are used on spring triticale crops. Powdery mildew, stem rust, foliar and downy mildew do not affect modern intensive varieties. Brown leaf rust and leaf septoria show signs of damage late and do not spread. The only exception is the epiphytic development of leaf blight. In this case, the crops are treated with one of the following fungicides: Vincit 050 CS (2 kg/ha); Kinto Duo (2.5 kg/ha); Lamardor FS 400 (1.5 kg/ha) or Sumi-8 FLO (1.5 kg/ha).

When crops are infested with larvae of the turtle bug (6 specimens/m²) and bread beetles (5-6 specimens/m²) in the phase of milk and doughy grain, the crops are treated with Karate, 5 per cent c.e.e. - 0.15 l/ha; Decis doublet, 2.5 per cent c.e. - 1.2 l/ha or Volaton, 50 per cent c.e. - 1.6-2.0 l/ha (against bread beetles). Spring triticale plants are more resistant to damage by these pests compared to other spiked plants. Harvesting. Harvesting features of spring triticale are similar to those of rye. The seed is tightly enclosed by flower scales and does not crumble when ripe. It is more difficult to thresh than wheat seeds and, having a deep furrow, can be more severely injured, which should be taken into account when organising harvesting.

2.5 LATE SPRING BREAD AND CEREAL PLANTS

Cereal plants that are sown later than other cereal plants are called late spring crops. Plants are drought-resistant (except for rice) and thermophilic, physiologically active at temperatures above +10° C. They have an exclusively spring type of development, growth and development at the beginning of the growing season is slow. Plants of short day. Late spring cereals include breads of the second group or millet: corn, millet, sorghum plants, rice and buckwheat, which is classified as a late cereal plant due to the identity of its main product, although it differs from them in many morphological characteristics and biological features.

2.5.1 Corn (*Zea mays*)



Corn is one of the most valuable crops in the world. It is one of the world's oldest bread crops and is indigenous to the Americas. The remains of wild corn pollen, panicles, grains and cobs of primitive forms found by archaeologists in Mexico date back to 80,000 years before Christ, which is earlier than the appearance of humans. Ancient plant remains have also been found in Mexico. Even before the Spaniards came to America, all subspecies of the maize plant were common in the fields of the Indians. In the late 15th century, it was brought to Europe by X. Columbus (as a gift to the Spanish king). Initially, it was grown as an ornamental plant. It spread through Spain and Portugal to Europe, Asia and Africa. First as a valuable food plant, and later as a fodder plant.

Corn **ranks** first in global grain production. Its versatility is unrivalled. Globally, 15-20 per cent of grain is used for food, 10-15 per cent for technical purposes, and 70 per cent for fodder. In recent years, its use in phytoenergy has been

increasing. Its grain contains 65-70 per cent of nitrogen-free extractives, 10-12 per cent of protein, 4-8 per cent of fat (up to 40 per cent in the germ), vitamins A, B, B₁₂, B₆, E, C, essential amino acids, mineral salts and trace elements.

Such a composition of grain determines its high food, feed and technical value. 1 kg of corn grain contains 1.34 feed units and 78 g of digestible protein. However, corn protein is depleted in such important essential amino acids as lysine, methionine and tryptophan, the deficiency of which in feed causes metabolic disorders in animals, but is rich in zein, a protein of little feed value.

The use of maize with high-protein plants (rapeseed, fodder beans, lupine, soybeans), which contain 130-250 g of digestible protein with a sufficient amount of essential amino acids per 1 feed unit, will help to balance the feed by protein and prevent unproductive consumption. In 100 kg of corn silage harvested in the phase of milk ripeness of grain, there are 0.17-0.18 feed units, in milk-wax silage - 0.22-0.24, and in wax silage - 0.28-0.30. Corn is used for green fodder. 100 kg of green fodder corresponds to 16 feed units. In terms of feed nutrition, 1 hectare of corn provides about 6 thousand feed units and up to 300 kg of digestible protein, which is significantly higher than other seed plants.

Corn is the most valuable among cereal fodder plants in terms of energy content, characterised by a high content of starch (up to 70 per cent) and fat (4-6 per cent), and a low content of fibre (2-5 per cent). The lipids of the corn plant are rich in unsaturated fatty acids, such as oleic and linoleic acids. Since the grain of the corn plant is low in fibre, it is particularly effective for feeding to poultry. The high energy content of the grain (361 kcal per 100 g) makes it an important component of mixed fodder. The optimal proportion of corn in mixed fodder for pigs is 70-80 per cent, for poultry - 60-70 per cent, and for cattle - 55-60 per cent.

1 tonne of grain produces 56 kg of starch (or 60 kg of fructose or 38 litres of alcohol), 23 kg of feed with a protein content of 21 per cent, 5.2 kg of gluten flour and 2.5 kg of corn oil, which is a semi-drying oil (iodine number 113-133), meaning it has high taste. As a row crop, corn is a good choice for crop rotation, helps to clear fields of weeds, and has almost no pests and diseases in common with other seed plants. Thus, when harvested for seeds, it is one of the best crop rotations for spring cereals, and when harvested for silage, it is one of the best for winter wheat plants. When grown for green fodder, it is a good vapour-forming plant.

Corn is widely used in post-cutting and post-harvest crops. However, according to FAO forecasts, it will take the top spot over the next 2-3 years. The world's corn is grown on an area of about 220 million hectares, including 33 million hectares in the US, 30 million hectares in China, 13 million hectares in Brazil, 8 million hectares in Mexico and 6 million hectares in India, where 48.5 percent of the world's corn acreage is concentrated. In Europe, the area under corn is 14.2 million hectares: Ukraine - 4.6 million hectares, Romania - 3 million hectares, France - 1.7 million hectares, Hungary - 1.1 million hectares. Grain production of the corn plant increased from 104.5 to 669.6 million tonnes, or 6.5 times, accounting for 34.2 percent of global grain production. By continent, it is concentrated as follows: North America - 286.3 million tonnes (50.3% of global production), Asia - 139.2 (24.4%), Europe - 53.9 (9.5%), South America - 47.9 (8.4%), and Africa - 37.8 million tonnes (6.6%). Over

the past 14 years, its gross harvest has increased by 35.5 per cent. The US currently has 22.4 per cent of the world's corn crop and produces 45.1 per cent of its grain. China is the world's second-largest producer of corn grain, with 105.6 million tonnes and a yield of 3.52 tonnes per hectare. The average grain yield of corn in the world is about 5.5 t/ha. In Ukraine, the current production of corn covers 133 per cent of the domestic market, with an annual demand of 13-15 million tonnes. According to official statistics from the State Statistics Committee of Ukraine, corn is sown on an area of 5.3 million hectares. A record amount of corn was produced in 2013 - almost 32 million tonnes with a yield of 6.44 t/ha.

Biological characteristics, hybrids. In the ontogeny of corn plants, there are 12 stages of organogenesis and phases of growth and development: seed germination, germination, formation of the third leaf, formation of each unpaired leaf, ejection of the panicle, flowering of the panicle, flowering of the cob, formation of the kernel, milky state, milky-wax, waxy and full ripeness (Table 2.2). The phases are determined by the number of leaves on the main shoot, including the tube stage, which is difficult to determine by feeling.

The germination phase lasts until 5-6 leaves of the germinal bud develop (in breads of the first group, 2-3 leaves). At this time, the first tier of nodal roots is formed, and the transition to autotrophic nutrition is completed. In the phase of seven to eight leaves, tillering begins, the roots close in the aisles, which must be taken into account when setting the depth of row spacing and the width of the protective zones.

In mid-season hybrids, the tube stage coincides with the appearance of 11-14 leaves; in early-season hybrids, it begins with fewer leaves, and in late-season hybrids, with more leaves. In the phase of entering the tube, the panicle grows more actively than the stem. Active growth of the stem (stalking) begins after the panicle is ejected: the internodes of the stem elongate, including the last one, which completely removes the panicle from the sheath of the upper leaf. This is due to the non-simultaneous appearance of columns and fertilisation of flowers located in different parts of the cob.

During the milky ripeness phase, the kernels of the upper part of the cob contain the most moisture, because they are the last to start developing. In the following phases, the seeds of the upper part of the cob lose moisture faster than the seeds of the middle and especially the lower part, so in the phase of harvesting ripeness, the moisture content of the grain of the lower part of the cob is higher than that of the middle and upper parts.

Corn are a moisture-loving plant, so autumn and spring tillage should be aimed at accumulating and preserving moisture. After harvesting, the place in the crop rotation is subject to one- or two-time stubble peeling to a depth of 8-10 cm and ploughing or moldboardless tillage to a depth of 20-22 cm. For Corn plants, it is important to ensure that the soil is settled with an efficient capillary system, as oats, due to their filmy grains (25-30 per cent), require more moisture for seed germination and further growth and development than winter wheat, rye or barley. In the spring, we harrow the seedbed and cultivate it to the depth of seed placement (5-6 cm), but depending on the field conditions before sowing, we can limit ourselves to one of these operations.

Table 2.2

Phases of growth and development and stages of organogenesis of corn plants (according to F. M. Kuperman)

Growth and development phases	Stages of organogenesis		Performance elements
	panicles	cob	
Seed germination, seedlings	I. The growth cone is undifferentiated	-	-
Third to fifth leaf	II. Differentiation of the growth cone	I. Undifferentiated cone of lateral stem growth	Optimal plant density
	III. Growth in the length of the growth cone. Formation of lateral panicle branches	II. Differentiation of a shortened stem into nodes and internodes	Number of leaves, tillering ratio
Start of stemming	IV. Formation of spikelet flowers	III. Further elongation of the growth cone, segmentation of its base	-
Access to the tube (11-13 leaves)	V. Formation of flowers in ears	IV. Formation of spikelet scales. Formation of spikelet tubercles	Number of cob segments
	VI. Pollen formation	V. Differentiation of the spikelet tubercle	Formation of cob length and number of ears in rows
Throwing out panicles	VII. Growth of flower segments in length, completion of formation of pistils	VI. Formation of the embryo sac, growth of stamen columns	Number of flowers per head
	VIII. Throwing away the panicle	VII. Completion of the formation of sexual flowers	Fertility of flowers
Flowering of the panicle. Ejection of cob threads	IX. Flowering of the panicle	VIII. Ejection of stigma filaments	Heat resistance
		IX. Flowering, pollination, fertilisation	The graininess of the head of cabbage
		X. Formation of the embryo and grain, beginning of milk ripeness	Grain size
Milk ripeness	-	XI. Milk ripeness, accumulation of nutrients in the grain	Grain weight
	-	XII. Conversion of nutrients into reserve nutrients	-

This is due to the fact that the bottom of the cob is tightly covered with wrappers throughout the entire period of development, up to harvesting, while the wrappers on the top of the cob diverge at maturity, exposing the seeds, which

accelerates their drying. The agroclimatic conditions of the maize growing areas in our country are extremely diverse. Each of them has its own soil characteristics, moisture conditions and temperature regime, which significantly affect the growth, development of plants and the formation of seed productivity (Table 2.3).

Table 2.3**Agroclimatic conditions of corn growing zones**

Zone	During the period with temperatures above 10 °C				Annual amount of precipitation, mm
	duration of the period, days	sum FAR, MJ/m ²	sum temperature, °C	SCC	
Steppe	175	1671	3155	0,7-1,1	406-514
Forest-steppe	161	1491	2660	1,2-1,6	547-632
Polissya	157	1432	2595	1,4-1,9	609-838

When growing corn for seed in different zones of the country, it is extremely important to take into account the heat requirements of hybrids of different biological types. The need of a maize plant for heat resources for intensive growth and development of plants is usually limited by the date of stable transition of the average daily air temperature through the +10°

Relation to temperature. Corn is a thermophilic plant. The minimum temperature for seed germination is +6...8°C. In the field, seedlings appear at soil temperatures of +8...10°C. Seedlings are damaged by frosts of -2...3°C. In this case, the leaves damaged by frost turn yellow and partially die, but the growth point remains intact. Flinty forms of maize plants are more cold-resistant.

Cold nights (temperatures below +14 °C) and sharp fluctuations in day and night temperatures cause inhibition of growth processes in plants and contribute to the extension of the plant's growing season. Air temperatures below +15 °C cause yellowing of leaves in young plants, which is a consequence of a decrease in the intensity of photosynthetic activity. During the growing season, until the appearance of generative organs, an increase in air temperature to +25 °C does not harm the growth and development of maize plants. Later, after flowering of the panicles and appearance of columns of stigmata on the cobs, temperatures of +25 °C and above have a negative effect on the plants. Temperatures above +30 °C cause disruption of flowering and fertilisation. The maximum temperature at which the growth and development of corn plants stops is +45...47 °C.

Autumn frosts can also be a prerequisite for a decrease in maize yields in different growing regions. Temperatures close to 0 °C damage green leaves, and temperatures dropping to -2...3 °C are accompanied by damage to mature grain if its moisture content exceeds 20 percent.

For corn plant hybrids that differ in terms of maturity, the required amount of effective temperatures (above +10 °C) has been established, which, along with the provision of each climatic zone with heat and consideration of the plant's biological characteristics, makes it possible to scientifically substantiate the zoning of biotypes of

hybrids of different maturity groups according to their need for thermal resources in the country's zones (Table 2.4).

Table 2.4

Requirements of corn plants to the temperature regime

Ripeness group	The sum of the temperature, °C		Vegetation period, days	Number of leaves, pcs.	FAO, points
	active, > 5° C	effective, > 10° C			
Early ripening	2200	900-1000	90-105	12-14	100-199
Medium early	2400	1100	105-115	14-16	200-299
Mid-season	2600	1150	115-120	17-18	300-399
Medium late	2800	1200	120-130	19-20	400-499
Late-ripening	2900-3000	1250-1300	135-140	21-23	500-599

To estimate the maturity, the FAO term is used - a complex indicator that takes into account not only the temperature, but also the yield potential, the intensity of light use, and the moisture release to the seeds during maturation. According to this indicator, hybrids are divided into early maturing (FAO 100-199), medium early (FAO 200-299), medium maturing (FAO 300-399), medium late (FAO 400-499) and late maturing (FAO over 500). Corn seeds with a higher FAO have a higher yield potential. For Polissya, it is better to choose hybrids with FAO up to 180, for Forest-Steppe - 180-380, for Steppe - 260-500. *Moisture requirements.* Corn is a drought-resistant plant. Seeds require 37-40 per cent of water by weight to germinate. The transpiration coefficient is 220-300. Corn consumes the most water within 30 days, starting 10-15 days before the panicle is ejected and ending when the grain is milky ripe (this period is considered critical). Optimal soil moisture during the growing season should be at least 75-80 per cent of the HB.

Corn does not tolerate waterlogging, which can dramatically reduce grain yields. Due to the lack of oxygen in waterlogged soil, phosphorus uptake by the roots is slowed down. As a result, phosphorylation processes, energy processes in the root system and protein metabolism are disrupted.

Attitude to light. Corn is a light-loving, short-day plant. With a day length of more than 12-14 hours, its growing season increases. Corn does not tolerate shading well - in thickened crops, plant development is delayed and cobs are not formed.

Soil requirements. Corn is moderately demanding on soil fertility. Corn should be grown on well aerated soils with a deep humus layer and high water retention capacity.

Loamy and sandy loamy chernozems, dark grey, dark chestnut soils are the most suitable for maize. The optimal soil density is 1.1-1.25 g/cm³. It grows well on floodplain and peaty soils. The optimum pH is 6.5-7.5.

Nutrient requirements. To form 1 tonne of grain, corn takes 24-30 kg of nitrogen, 10-12 kg of phosphorus and 25-30 kg of potassium from the soil. During the growing season, the nutrients are absorbed unevenly by the corn plants. The use of

nitrogen continues until the grain is waxy, with the maximum demand occurring between the emergence of the panicle and flowering. Phosphorus uptake is more evenly distributed until the grain is almost fully ripe. Potassium is most intensively used by plants in the first half of the growing season and during grain formation and maturation.

In all countries of the world, the majority of maize acreage is planted with hybrids. First-generation maize hybrids provide higher yields than their parental forms (the phenomenon of *heterosis*), so first-generation hybrid seeds are used for sowing. In Ukraine, 45-50 hybrids are grown annually. The State Register of Plant Varieties of Ukraine includes more than 500 hybrids of different maturity groups (FAO 150-500), of which about 42 per cent are of domestic breeding.

Among the recommended hybrids of maize plants for seed and silage, the most common are *early maturing*: Borysfen 191 MV, Kharkivskiyi 199 MV, Dniprovskiyi 172 MV, Dniprovskiyi 177 SV, Dniprovskiyi 203 MV, Slavutych 162 SV, Mariyin 160 SV, Luch 170 MV, PR39G12, PR39G83, Dolphin, Kadr 195 SV, Rist SV, Restavratsiya SV; *mid-early* Dniprovskiyi 288 SV, Kadr 267 MV, Slavutych 224 SV, Bastion MV, Elita, Sandrina, PR39D81, Titus; *mid-season* Borisfen 301 MV, Sensor, Lebed MV, Dniprovsky 310 MV, Kadr 327 MV, Currency, Helga, Clarika, Anastasia, PR37D25, Pelican; *mid-late* Borisfen 433 MV, Hercules 450 MV, Dniprovsky 450 AMV, Kadr 443 SV, Furio, PR38A24. Three varieties are recommended in Ukraine: Zakarpatska yellow toothed, Dniprovska 298, Odeska 10.

Agrotechnology. In the Steppe, the best place in the crop rotation for a corn plant is winter wheat after black and fallow, legumes, acceptable - early seed crops, corn, undesirable - Sudan grass, sunflower. In farms in this zone, it is better to place corn for seed in the following crop rotation: black and fallow - winter wheat - winter wheat - corn; winter wheat after fallow - winter wheat - corn; corn for silage - winter wheat - corn. In the northern and northwestern more humid regions of the Steppe, corn is placed in the following crop rotation: fallow land occupied by perennial grasses on one mowing - winter wheat winter - corn; winter wheat winter on a layer of perennial grasses - winter wheat winter - corn. In the Forest Steppe, winter wheat, legumes, corn, and potatoes are good crop rotations. In the more humid regions (northern, northwestern and western), where sufficient moisture accumulates in the autumn and winter, corn produces high grain yields after sugar beet.

In Polissia, the selection of crop rotation depends primarily on soil fertility. The best places in the crop rotation for a corn plant are legumes, potatoes, sugar beet, winter beet, corn, and lupine. Corn can tolerate repeated sowing for 5-7 years, provided that fertiliser rates are increased and protection against pests and diseases is strengthened. Corn can be placed in short rotation crop rotations after favourable locations in crop rotations, where its share can be 30-75 per cent.

Soil cultivation. When growing a corn plant, a plough tillage is used. If the field is infested mainly with annual weeds, a semi-steam tillage system is used, and if it is infested with perennial weeds, improved tillage is used. The entire cultivation system in all zones should be aimed at maximising weed removal and, in conditions of insufficient moisture, at preserving and accumulating moisture in the soil.

After stubble cultivation, the crop rotation is carried out with disc cultivators LDG-5A, LDG-10A, LDG-15A, LDG-20, and on compacted and dry soils - with

ploughshares PCL-10-25, PPL-5-25 or disc harrows BDT-7 to a depth of 6-8 cm. If the field is infested with annual weeds, after germination, ploughing is carried out with ploughs with PTC-9-35, PNL-8-40, PNI-8.40, PLP-6-35, PLP-5-35, PL.5-35, PLP-4-35, PLP-3-35 skimmers to a depth of 25-30 cm (on sod-podzolic and grey podzolic soils to the depth of the arable layer). Ploughing should be carried out in a unit with sections of ring-spur rollers and harrows. After that, the field is tended as if it were a virgin soil, keeping it in a clean condition with a system of harrowing and cultivation.

If the field is clogged with perennial weeds, 1-2 more peelings are carried out before autumn ploughing after the first peeling during the period of mass emergence of these weeds on the peeled field. If rhizome weeds, such as wheatgrass, predominate, after the first peeling, when wheatgrass sprouts, the second peeling is carried out again with disc harrows across the direction of the first peeling and to a greater depth of 8-10 cm or 10-12 cm. After wheatgrass germination, the soil is peeled again, waiting for the emergence of seedlings and then ploughing (or after the second peeling).

If the field is dominated by root and sprouting weeds, such as field thistle and yellow thistle, bitter bindweed, field bindweed, the second and third peeling is carried out with ploughshares to a depth of 12-14 cm with a time interval determined by the appearance of rosettes of these weeds. In intensive tillage, it is necessary to carry out the peeling after the planting of row crops (tobacco, sunflower, corn and even sugar beet), because without preliminary peeling, post-harvest residues are poorly incorporated and reduce the quality of sowing and crop care. After late-season crops, ploughing should be carried out immediately after peeling if the soil is moist enough to crumble well and no clods form. After potato plants, ploughing is carried out without preliminary peeling.

Corn grows well on soils with a (deep) vegetated topsoil, so in all zones the main tillage (ploughing or flat-cutting) should be carried out to a depth of 25-30 cm. On grey podzolic and sod-podzolic soils, the ploughing depth should not exceed the depth of the arable layer, i.e. 20-22 cm.

Spring cultivation begins with closing the moisture with heavy tooth harrows BZTS-1,0. After that, the soil surface is levelled with levellers to improve the thermal regime in the seedbed and accelerate weed germination, as well as increase the effectiveness of basic herbicides. To level the soil surface, the company uses a trailed leveller VP-8, a mounted leveller VPN-5.6, a harrow train ShB-2.5 or cultivators KShU-12, KShP-8, USMK-5.4A. On farms with high planting capacity that use an integrated weed control system, corn is cultivated shallowly to a depth of 12-14 cm. In recent years, the soil-protective, energy-saving technology of direct sowing of corn without tillage - No-Till - has become widespread.

On fields infested with root and sprout weeds such as thistle (species), creeping wheatgrass, field bindweed, wild lettuce, Tatar lettuce, spurge, it is necessary to apply general herbicides in autumn: Roundup - 4.0-6.0 l/ha, Glyphosate - 4.0-5.0 l/ha, Glyphos Super - 1.6-3.2 l/ha, Uragan - 3.0-6.0 l/ha.

Pre-sowing soil cultivation involves early spring harrowing to seal in moisture and level the soil surface. The latter is carried out when the soil is physically ripe with

plume harrows or levellers at an angle of 45° to the main cultivation. In case of high weed infestation, it is advisable to carry out 1-2 pre-sowing cultivations. The first cultivation is carried out after the emergence of weeds to a depth of 10-12 cm. The second wave of sprouted weeds is destroyed using combined units such as RVK-3.6, Europak, KOMBI-8.8, BP-8 and others. The treatment is carried out to the depth of seed placement. The time gap between pre-sowing and sowing should be as short as possible. Soil-acting herbicides are applied before or immediately after sowing.

In case of high potential contamination of crops with annual cereal and dicotyledonous weeds, it is advisable to use soil herbicides: Dual Gold 960 ES, h.e.e. (1.0-1.3 l/ha), trophy 90, c.e. (2.0-2.5 l/ha), typhoon, c.e. (1.6-2.1 l/ha), frontier optima, c.e. (0.8-1.4 l/ha), harness, c.e. (1.5-3.0 l/ha), herb 900, c.e.e. (1.5-3.0 l/ha), gesagard 500 FW, h.c. (2-4 kg/ha), primex gold 720 SC, h.c. (2.5-3.5 l/ha), merlin 750, v.g. (0.1-0.15 kg/ha), stomp 130, h.e. (3-6 l/ha) and other recommended preparations that should be applied for pre-sowing cultivation or immediately after sowing the corn plant, but before the plant germination.

The fertilisation system for corn plants includes main fertilisation, pre-sowing fertilisation and top dressing. The largest amount of fertiliser is applied before sowing in the main fertiliser application. With intensive technology and cultivation of maize plants under conditions of minimal tillage, the entire fertiliser rate is often applied before sowing, incorporating fertiliser to different depths.

Mineral and organic fertilisers are the main fertilisers used. Organic fertilisers are applied in autumn for the deepest tillage of granite at the rate of 20-25 t/ha in arid steppe areas, 30-35 t/ha in forest-steppe areas and 35-40 t/ha on sod-podzolic and podzolic soils of Polissya. On poor soils, when high doses of organic fertilisers are applied, corn better tolerates lower temperatures at the beginning of the growing season, grows and develops well, and the time gap between flowering of the panicles and the cobs is reduced. In Polissya, organic fertilisers can also be applied in the spring for ploughing up the fallow land. When corn is grown outside of crop rotations on podzolic and podzolic soils, the rate of organic fertiliser is increased by 1.5-2 times. In these conditions, green fertiliser is effective. The average rates of mineral fertilisers on sod-podzolic and grey forest soils are $N_{90-130} P_{80-90} K_{60-120}$, in the Forest-Steppe on grey forest soils, and on podzolic black soils, leached, typical - $N_{90-120} P_{60} K_{60}$, in steppe regions on ordinary, carbonate and southern chernozems, as well as on chestnut soils - $N_{30-60} P_{30-60} K_{30}$, on irrigated soils of the Steppe - $N_{120-150} P_{60-90}$. In conditions of insufficient moisture, it is better to apply fertilisers for the main fertilisation in autumn, and in areas of sufficient moisture and on soils of light texture - phosphorus and potash fertilisers for autumn tillage, and nitrogen fertilisers in spring for cultivation.

To improve the nutrition of young plants, increase their resistance to adverse conditions, and enhance rooting, localised pre-sowing fertilisation is used. Fertilisers are applied simultaneously with sowing with the fertiliser drills at a distance of 3-5 cm to the side of the row and 4-5 cm below the seeding depth. Row fertilisation increases yields by 2-4 c/ha. Phosphate mineral fertilisers (50-60 kg/ha of granulated superphosphate) are used on the black soils of the Steppe, while in the Forest-Steppe and Polissya it is advisable to apply mineral fertiliser in the form of

nitrophosphate at the rate of N_{10-15} kg/ha of phosphorus.

During the growing season, maize plants are fertilised. The optimal time for fertilisation is from the 3rd to the 6th leaf and during the most intensive growth - before and during the emergence of the panicle.

In conditions of unstable moisture, traditional fertilisation of maize plants in the initial phases of growth with mineral nitrogen fertilisers (N_{20}) is often not effective. Therefore, it is more expedient to replace it with more technological foliar feeding of plants in the phase of 6-7 leaves with liquid complex mineral macro- and micronutrient fertilisers "Reakom Plus" at a dose of 4 l/ha or water-soluble micronutrient fertiliser "NutriVant Plus corn" at a dose of 4 kg/ha, which ensures a 7-10 per cent increase in grain yield.

A significant reserve for increasing yields and improving the quality of seed products is the use of growth regulators in the 9-10 leaf stage, namely humisol (8-10 l/ha), emistim S (15-20 ml/t) and others. They help to improve plant growth and development and increase their resistance to environmental stressors, which helps to increase yields by 10-15 per cent. *Sowing*. The system of seed preparation for sowing includes: drying to a moisture content of 13-14 per cent, inlaying, application of growth regulators, and dressing.

Seed encrustation is the application of a polymer film-forming solution containing biologically active substances to the seed coat. The solution of the latter is partially absorbed by the seed, and the rest penetrates the cracks and protects it from pests and diseases. The polymer film begins to swell, allowing water and air to pass through to the seed, when the soil temperature at the depth of seed placement reaches $+8...10^{\circ}\text{C}$.

To protect the seeds during the germination period from mould, root and stem rot, blister and fungal smut, it is necessary to treat and inlay the seeds with the addition of microelements and growth regulators to the working solution - Alios, t.k.s.c.s. (1-2 l/t), Vitavax 200 FF v.s.c. (2.5-3.0 l/t), Granivit, v.s.c. (2.5-3.0 l/t), Corriolis, t.c.s. (0.2 l/t), Lamardor 400, t.c.s. (0.2 l/t); in the absence of volatile smut - Fluosan, c.s. (3.0 l/t) and 10 l of water; Maxim 035, c.s. (1.0 l/t) and 5 l of water. If there is a lack of trace elements, the seeds are treated with salts of zinc, manganese, molybdenum at 0.5-0.6 kg/t with the addition of a film-forming agent Na KMC - 0.2 kg/t or PVA - 0.5 kg/t. To control soil pests (larvae of the May beetle, worms, and May beetles), insecticide treatments by inlay are effective. At seed factories, corn seeds are treated with Cosmos 250, h.p. (4 l/t); Cruiser 350 FS, h.p. (6-9 l/t); Semaphore, h.p. (2-2.5 l/t) with the addition of 10 l of water per 1 t of seeds.

According to generalised data from research institutions in maize growing areas, the optimal time for sowing maize is when the soil has steadily warmed up to $+8...10^{\circ}\text{C}$ at the depth of seed placement. Both too early and late sowing dates reduce the grain yield of the plant. Experimental studies show that at early (steady soil warming up to $+6...8^{\circ}\text{C}$) sowing dates, corn plants bloom earlier than at later dates. Early sowing makes better use of soil moisture reserves and avoids the negative impact of drought conditions during the growing season.

Corn for seed and silage is sown in a wide-row dotted method with row spacing of 70 cm. The seeding rate for corn for seeds is 15-25 kg/ha (1 sowing unit is 80

thousand seeds), for silage 30-40 kg/ha, and for green fodder, it is advisable to sow corn in a wide-row method with a row spacing of 45 cm and a seeding rate of 50-60 kg/ha, which ensures a stem density of 200-250 thousand plants/ha before harvesting. For sowing, the company uses Kinze seeders (productivity 8-10 ha/h), SUPN-8 (3-4 ha/h), UPS-12 (3-4 ha/h), SKPP-12A (6-8 ha/h), SUPN-12 (6-8 ha/h). The depth of seeding of corn plants depends on the physical properties of the soil, its moisture and temperature conditions. The optimum seeding depth for maize is 4-5 cm on heavy loamy soils, 5-6 cm on light loamy soils, 5-7 cm on black soil, and 6-8 cm on sandy loamy soils. When the top layer dries out, the seeding depth is increased by 1-2 cm.

The right plant density can increase corn plant productivity by 20-30 per cent. The optimal plant density, depending on soil and climatic conditions and biotypes of hybrids, ranges from 40-80 thousand/ha. For early maturing hybrids, the plant density can increase to 90-100 thousand/ha (Table 2.5).

Table 2.5

Optimal pre-harvest plant density of corn hybrids, thousand/ha

Zone	Early ripening	Medium early	Medium-ripe	Medium late and late ripening
Steppe	55-60	45-50	35-40	30-35
Steppe (irrigation)	80	70-80	60-70	50-55
Forest-steppe	75-85	65-80	55-70	50-60
Polissya	85-90	-	-	-

When placing corn plants in the best crop rotation and good moisture conditions, you should aim for the upper density limit, and in the worst and under insufficient moisture conditions, the lower density limit.

Crop care. In dry conditions, after sowing, it is advisable to roll the field with ring spur rollers, which will ensure better contact of the seed with the soil and help to raise soil moisture through the capillaries into the upper soil layers.

Pre- and post-emergence harrowing is not recommended on fields where soil herbicides have been applied. This is because the protective "screen" is destroyed and the effectiveness of herbicide application is reduced to 30-35 percent. With the correct application of basic soil herbicides, weeds are almost completely destroyed and there is no need for inter-row cultivation. If the effect of basic herbicides is insufficient, insurance herbicides are used in the 5-7 leaf stage of the corn plant: milagro 040 SC, hp (1.0-1.25 l/ha), titus 25, v.g. (40-50 g/ha), basis, 75 percent, v.g. (20-25 g/ha + 200 ml/ha surfactant TREND 9), master, v.g.g. (0.15 kg/ha), Callisto (200 ml/ha) + Milagro (1.0 l/ha), Tusk (385 g/ha), Stellar (1.0-1.25 l/ha) + adhesive metholate (1.0-1.25 l/ha). Inter-row tillage regulates its water-physical properties and destroys weeds. The first inter-row cultivation of corn is carried out at the stage of 5-7 leaves, and the second - at the stage of 9-10 leaves. If the bulk density of the soil (1.2 g/cm^3) corresponds to the biology of the plant and the number of weeds does not exceed the EWC, inter-row cultivation is not advisable.

If more than 18 per cent of corn plants are infested with corn stem caterpillars,

when their number of EBMs is reached, it is necessary to spray the crops with Denis-f-Lux, c.e. 0.4-0.7 l/ha; Karate Zeon 050, m.c.s. (0.2 l/ha), Regent 20, g (5-10 kg/ha), Kaizo, v.g. (0.2 kg/ha).

During the panicle ejection phase, the fire form of the trichogram is released against the corn moth at two times: at the beginning and during the period of mass egg laying by the pest.

Harvesting. The yield of a corn plant for green fodder and the quality of the green mass depend on the harvesting time. At relatively early harvesting times (at the 11-13 leaf stage), 80-90 per cent of the yield is from leaves and 10-20 per cent from stems. The share of leaves in the green mass decreases to 40-50 per cent in the phase of cob formation, and to 10-20 per cent in the milky ripeness of the grain. Therefore, when using a corn plant for green fodder, it is advisable to harvest it in the flowering phase of the panicles - the proportion of leaves is 60-70 percent and 30-40 percent of the stem. The height of the stem cut should not exceed 8-10 cm.

In the phase of milky-wax ripeness of the grain, when the moisture content of the green mass does not exceed 65-70 per cent and the dry matter content is 25-30 per cent, corn is harvested for *silage* with combines KC-2.6, KSK-100, Maral, Jaguar. The chopped mass is siloed with subsequent tamping in trenches and covered with film or straw. The moisture content of the silage should not exceed 75 per cent.

Depending on the intended use and storage conditions, maize plants are harvested without or with threshing of the cobs in the field. Harvesting of plants without threshing the cobs begins at a grain moisture content of no more than 40 per cent, and with threshing at 30 per cent.

2.5.2 Millet (*Panicum*)



Millet is native to China, where it was known as early as 2700 BC. It is grown in tropical, subtropical and temperate regions, mainly in the Northern Hemisphere.

Millet seeds are used to make cereals (millet) and feed animals, including poultry. 100 kg of grain contains 96 feed units and 8.4 kg of digestible protein. Green mass, chaff and straw are good fodder for cattle and sheep. Millet seed is an indispensable feed for

chickens; feeding it to adult chickens increases egg production and eggshell strength. Millet seeds are high in protein (10-14 per cent), starch (70-74 per cent), low in fibre, and contain manganese and zinc. Millet is not inferior to other cereals in terms of starch content, and it contains more protein than rice, pearl barley and buckwheat, with a fat content second only to oatmeal. In veterinary practice, due to the content of lipotropic substances, millet lowers cholesterol levels in the blood of animals and is therefore used to treat diseases of the cardiovascular system and liver. Under its influence, blood formation is accelerated, which is important in the treatment of anaemia. It is believed that a decoction of millet husks helps to remove droppings. The green mass is of fodder value; millet straw and chaff exceed wheat and oat straw in

fodder quality, and are close to hay. It has been observed that cows fed millet straw have improved milk taste and nutritional value.

Today, millet is grown on more than 40 million hectares in the world's crop production. The largest areas under millet cultivation are in India (14 million hectares), Nigeria (5.5 million hectares), Sudan (3.0 million hectares) and China (2.1 million hectares). The global production of millet is 29 million tonnes, of which 10.5 million tonnes are harvested in India, 5.9 million tonnes in Nigeria and 4.0 million tonnes in China. In Ukraine, millet is cultivated on about 160 thousand hectares, which are concentrated mainly in the Forest-Steppe and Steppe regions. The average yield is about 2.0 tonnes per hectare, while advanced farms harvest 4.5-5.0 tonnes per hectare.

Biological characteristics, varieties. In the ontogeny of a millet plant, the following phases of growth and development are distinguished: seed germination, germination, tillering, tube emergence, panicle ejection, flowering, formation, filling and ripening of grain.

Millet seedlings appear 7-9 days after sowing. The tillering begins 15-20 days after emergence and lasts for 10-15 days. Panicle ejection occurs 40-45 days after emergence. Flowering begins in 3-5 days, which lasts 13-18 days within the panicle and 30-35 days within the field. It takes 25-30 days from flowering to the onset of economic ripeness. The ripening period of millet plants in different parts of the panicle is 13-18 days. The vegetation period of early-ripening varieties is 60-80 days, and of late-ripening varieties - 100-120 days. At the time of grain ripening, the straw is wet and partially green.

Relation to temperature. Millet is a thermophilic plant. The biological minimum for seed germination is +8...10°C. Seedlings die at a temperature of -3.5°C, generative organs are damaged at -1...2°C. The vernalisation stage occurs at a temperature of +18...20°C for 7-10 days. Millet is demanding to the temperature regime during the growing season. It grows best during the germination-budding period at a temperature of +18°C, budding-panicle ejection +20°C, panicle ejection-flowering +23°C, flowering-ripening +21°C. As a drought-tolerant plant, millet tolerates temperatures of +30...40°C better than breads of the first group.

Moisture requirements. An important feature of the millet plant is its drought tolerance and economical water consumption. For germination, it uses only 25 per cent of the water by weight of the seed. The drought tolerance of the millet plant is due to its ability to temporarily stop growing and roll up its leaves, which reduces moisture evaporation. Millet is able to form nodal roots with minimal soil moisture. It makes good use of rainfall in the second half of summer. The transpiration coefficient is 140-290. At the same time, millet responds well to irrigation. Optimal soil moisture during the growing season is 60-80 percent of HB. The critical period in relation to moisture begins 20 days before the panicle is ejected and lasts until the end of flowering. Moisture deficiency during this period causes sterility of flowers.

Light requirements. Millet is a light-loving plant of short day. When the rows are placed from north to south, lighting conditions improve, resulting in a 6-8 per cent increase in yield. Cloudy weather in the second half of the growing season inhibits growth processes and extends the growing season. In the northern regions, the

growing season is longer than in the southern regions.

Soil requirements. Due to the low absorptive capacity of the root system, millet grows well on fertile soils with sufficient reserves of easily available nutrients. Structural chernozem, chestnut, dark grey podzolised soils with a high content of readily available nutrients and a pH of 5.5-7.5 are the best for it. Sandy, marshy and saline soils are unsuitable for millet. Millet tolerates soil salinity better than other plants. For every 1 tonne of grain produced, millet removes 30 kg of nitrogen, 14 kg of phosphorus, 35 kg of potassium, and 10 kg of calcium from the soil.

Millet is an early maturing, drought- and heat-resistant plant suitable for growing in arid areas and on saline soils. An exceptionally valuable biological feature of millet is its ability to provide good yields at late sowing dates, which allows it to be used as an insurance plant for reseeding winter and spring plants, as well as for post-cutting and post-harvest sowing. The disadvantages of millet are its slow development at the beginning of its life, which results in poor weed resistance and easy grain shattering.

According to the length of the growing season, varieties are divided into early ripening (50-60 days), medium early (60-80), medium ripening (80-100), late ripening (100-120), and very late ripening (over 120 days).

The best varieties are those adapted to the soil and climatic conditions of the growing area, resistant to lodging, diseases and grain shattering, highly productive, with good technological performance.

The Register of Plant Varieties Suitable for Distribution in Ukraine includes 20 varieties of millet, including Veselopodilske 16, Kyivske 87, Kyivske 96, Myronivske 51, Kharkivske 31, Slobozhanske, Omriane, Konstantynivske, Zolushka, as well as new varieties: Vitrylo, Kozatske, Yubileynoye.

Agricultural technology. Place in the crop rotation. Millet is very demanding on crop rotation, as it grows slowly before tillering and is suppressed by weeds. The best places in the crop rotation for it are a layer of perennial grasses, a layer turnover after winter cereals, legumes, potatoes, and beets. Millet grows poorly after Sudanese grass, barley plants, sunflower plants, sorghum plants, millet plants and corn plants in the area where the corn moth is distributed.

Soil cultivation. The main task of preparing the soil for millet is to clear the top layer of weeds by provoking the seeds to germinate in the spring. This is achieved by semi-steam or improved autumn tillage.

After cereals, seeds and legumes, cultivation should begin with stubble peeling to a depth of 6-8 cm, which helps to preserve moisture. Fields infested with perennial weeds should be disked with heavy harrows to a depth of 6-8 cm, and again after 10-15 days - to a depth of 10-12 cm. Ploughing should be done at a depth of 20-22 cm.

If pearl millet is planted after perennial grasses, the field should be disked after harvesting to crush the post-harvest residues and make them easier to plough. Spring tillage for pearl millet begins with loosening the soil with harrows or cultivators diagonally or across the field. To actively provoke germination of weed seeds and preserve moisture in the seedbed, the first and subsequent spring loosening should be followed by rolling the soil with ring-spur rollers. This simultaneously improves the agrophysical properties, water and air regimes of the soil. It should be noted that the

number of cultivations in the spring, including pre-sowing, should not exceed three.

Pre-sowing soil cultivation for millet is carried out with combined tillage machines that create a fine lumpy structure and compact the seedbed. *Fertilisation.* With a yield of 4.0 t/ha of grain and a corresponding amount of straw, millet removes about 130-140 kg of nitrogen, 60-70 kg of phosphorus, 85-120 kg of potassium, 40-55 kg of calcium and 30-35 kg of magnesium from the soil.

When growing millet plants, it is recommended to apply semi-rotted manure under the main tillage: in the Steppe - 12-15 t/ha, in the Forest-Steppe - 18-20 t/ha, in Polissya - 25-30 t/ha. If there is no semi-rotted manure, it is advisable to sow millet after a manured area in the crop rotation. In the Steppe, mineral fertilisers are more effective than organic fertilisers. Mineral fertilisers are applied at the rate of 45-60 kg/ha of active ingredient. In the Forest-Steppe, the effect of organic and mineral fertilisers is almost the same. In Polissia, full mineral fertiliser is applied at the rate of $N_{80} P_{60} K_{90}$, and in the Forest-Steppe - $N_{45} P_{60} K_{45}$. *Sowing.* Seeds with a purity of at least 98 per cent and a germination rate of more than 92 per cent are used for sowing. Weeds should be no more than 75 per 1 kg, and 7 per cent of the seeds should be fallen. Early treatment with seed inlay is necessary against smut and other pathogens (2-3 weeks before sowing). As film-forming agents, aquatic algae or glues such as NaKMC (2.5 per cent) and polyvinyl alcohol (PVA) (5.0 per cent) are used, to which the Vitavax treatment is added at the rate of 1.5-2.0 kg/t of seed. A tonne of seed requires 10 litres of working solution.

Millet is sown when the soil temperature at the depth of seed placement is +13...15° C, which in the southern and eastern parts of the Forest-Steppe is in the third decade of April - first decade of May, in the northern and central parts - in the second to third decades of May. On weedy fields, it is sown 7-10 days later, using this period for additional cultivation

Seeds of millet plants have low field germination: in Polissya - 50-55 per cent, in Forest-Steppe - 55-65 per cent, in Steppe - 75 per cent. This should be taken into account when calculating seeding rates in the relevant conditions. The optimum seeding rate for millet plants using the row seeding method is 4.0-4.5 million/ha of germinating seeds. For wide-row sowing, the rate is reduced by 25 per cent, and for strip sowing - by 10-15 per cent. In case of soil moisture deficit, as well as for post-emergence harrowing, it is recommended to increase the seed rate by 7-10 percent.

The sowing method depends on soil fertility, place in the crop rotation, and weediness of the field. On fertile soils, after the best place in the crop rotation, provided that the soil is sufficiently moist and the fields are free of weeds, a conventional row seeding method is used. If there is a lack of moisture, on weedy fields, preference is given to wide-row sowing according to the 45+15 cm scheme, and in the Steppe - 60+15 cm.

On heavy soils, if there is moisture in the top layer, millet seeds are sown to a depth of 2-3 cm. On soils with a light particle size distribution or if the top layer is dry, the seeding depth is increased to 5-6 cm.

Crop care. To improve the conditions for germination of millet seeds and weeds, the soil after sowing is rolled with ring-ribbed or smooth water-filled rollers ZKVG-1.4. Do not roll the crops on heavy soils and with high soil moisture. Weed

control on millet crops should be carried out in an integrated way, combining agrotechnical and chemical methods.

Crop care begins with pre-sowing (3-4 days after sowing) harrowing with medium tooth harrows across or diagonally to the direction of sowing. The machine speed is 5-6 km/h. In the case of a significant number of weed seedlings, when the plants are rooted in row crops, harrowing is repeated. On wide-row and strip crops, row spacing is loosened. The first time the row spacing is loosened after three true leaves of the millet plant appear to a depth of 4-5 cm. For the second time, the row spacing is loosened and light hilling is carried out with arrow paws to a depth of 6-8 cm at the beginning of the stemming phase. During the growing season, AGRITOX, v.p. (0.7-1.7 kg/ha) should be used against annual DICOTYLEDONOUS weeds before the plant enters the tube, and basagran, v.p. (2.0-4.0 kg/ha) in the phase of 3 leaves. In addition to the above, the following herbicides are also effective on millet: granstar 75, v.g. (15-20 g/ha), primexra gold 720 SS, h.p. (2.5-3.5 kg/ha), lontrel 300, v.p. (0.16-0.60 kg/ha), which should be applied no later than the tillering phase. Millet is the least sensitive to herbicides in the period from emergence to the end of tillering. In the phase of panicle ejection, millet plants are examined to determine the intensity of millet mosquito flight. If the threat is detected, the edge strips (50-100 m), and, if necessary, the entire field, should be treated with Bi-58 new, i.e. (0.7-1.0 l/ha).

Fertilisation of crops improves plant nutrition and, as a result, increases the yield of millet plants. The first fertilisation with nitrogen (N_{15-20}) should be carried out at the III-IV stages of organogenesis, the second and third, provided that nitrogen was not included in the main fertilisation, in the same amount at the VII and IX stages of organogenesis.

Harvesting. Millet is characterised by an uneven and extended ripening period. Harvesting begins when 75 per cent of the grain in the panicles is ripe. The main method of harvesting is separate harvesting. To prevent the seeds from bruising during mowing, rubberised pads are attached to the reel and the height of the reel is adjusted. The windrows are picked up by seed harvesters on the 3-5th day after mowing. New combines should not be used for threshing millet plants, as untreated threshing devices will drop seeds. On seed plots, millet is threshed twice: the first time with a drum speed of 500-600 min and the bottom of the header removed.

Under these conditions, 70-75 per cent of the grain is threshed and the films fall off to a minimum. Such seeds are used for seed. On the same day or the next day, the seeds are threshed a second time by increasing the drum speed. After the second threshing, the seeds are used as food or fodder.

Sometimes millet is also harvested by direct combining. When harvesting the millet plant, special attention should be paid to sealing the channels that can lead to grain loss. Immediately after threshing, the seeds must be thoroughly cleaned of impurities and dried. Cleaned seeds are stored with a moisture content of no more than 15 per cent. The drier the seed, the longer and better its sowing and food and consumer qualities are preserved.

2.5.3 Sorghum



It is one of the oldest crops in the world. Sorghum originated in Africa, where it is an important food crop. It has been known since the Neolithic period - 3000 BC - in India, China, Egypt and 2500 BC in Central Asia. It began to be grown in the 17th century and in Ukraine at the end of the 19th century. In Europe, the first mention of sorghum plants was made by Pliny the Elder (23-79), who said that this plant was brought to Rome from India. Sorghum is a widely used plant. It is close to the corn plant in terms of nutrition. Its seeds are a valuable

concentrated feed and raw material for the feed, starch and molasses and alcohol industries. In many countries in Africa, India and East Asia, it is an important cereal plant, and in temperate latitudes it is a fodder seed.

Sorghum seeds contain an average of 70 percent starch, 12-15 percent protein, and 3.5 percent fat. 100 kg of grain contains 119 feed units, about 15 percent protein, and a lot of lysine. Sorghum seeds are small and very hard, which should be taken into account when grinding them, as some of them remain ungrinded in conventional crushers and are poorly digested by animals.

Due to the unique combination of carbohydrates in its grain, its seeds are widely used as raw materials for the production of food products in the form of cereals, flour, liquid sugar and alternative energy sources such as ethanol. The green mass of the sugar sorghum plant is fed to livestock and used to make silage, which is not much worse than corn in terms of feed quality.

That is why many countries widely grow seed and sugar sorghum plants, which are 25-30 per cent more productive than corn in dry conditions. Unlike other drought-tolerant plants grown for seed, the stems and leaves of the remountant hybrids of sorghum plants remain green and juicy at harvest, and can be used for silage and green fodder. When feeding a sorghum crop harvested from 1 hectare, the yield of pork is 100-200 kg higher than when using corn. Sorghum seeds are processed into ethyl alcohol as an additive to petrol (bioethanol). From 1 tonne of sorghum grain, 330 litres of ethanol can be produced.

Sorghum is grown in 85 countries, mainly in arid regions where it is more productive than other seed crops, such as barley, corn and oats.

In terms of global production, sorghum is second only to wheat, corn, rice and barley. According to forecasts of the US Department of Agriculture (USDA), the production of sorghum is estimated at 65.2 million tonnes. Sorghum crops are concentrated in Asia, Africa and South America, with a small amount in Europe. The largest areas of sorghum seed are in India, with significant areas in the USA, Nigeria, Sudan, and Mexico. North America produces 21.1 million tonnes, Asia 18.6 million tonnes, Africa 15.8 million tonnes, Oceania and Australia 0.9 million tonnes, and Europe 0.61 million tonnes. The first place in terms of its production among the countries belongs to the United States, the second to India, and the third to China.

In Ukraine, sorghum is sown on an area of about 100 thousand hectares. In the severely arid region, which includes the Autonomous Republic of Crimea, Kherson,

Odesa, Zaporizhzhia, Donetsk, Luhansk, Mykolaiv, Dnipro and some other regions, sorghum has great potential to stabilise seed and fodder resources. The sorghum plant is characterised by stable productivity in harsh soil and climatic conditions (the yield plasticity coefficient is half that of barley plants). According to the state variety testing stations in Kherson, Mykolaiv, and Odesa regions, sorghum yields are 19-58 percent higher than corn yields on rainfed land and 14-15 percent higher on irrigated land. According to forecasts, sorghum plants (seed sorghum, sugar sorghum, broom sorghum, sorghum-Sudanese hybrid) can cover an area of 1.7 million hectares.

Biological characteristics, varieties. *Requirements for temperature conditions.* Sorghum is the most thermophilic plant among cereals. Sorghum seeds begin to germinate at a temperature of +12...13°C, with an optimum temperature of +25...30°C. Seedlings cannot withstand temperatures below 0°C. In terms of heat resistance, it is superior to all cereal seeds, and is not damaged by high temperatures of +40°C and more. The sum of active temperatures for the end of the growing season is 2250-2500°C.

Moisture requirements. Sorghum is the most drought-resistant plant. The transpiration coefficient is 180-200. Water consumption by sorghum plants is uneven: they use most of it in a relatively short period of time - 10 days before panicle ejection and 10 days after flowering. This period is usually 25-30 days, i.e. 20-25 percent of the entire growing season, and moisture consumption reaches 45-50 percent of total water consumption. The economical use of moisture and well-developed root system, adaptability of sorghum plant tissues to hot and dry conditions determine its high drought tolerance and importance when grown in the steppe zone.

However, despite its high drought tolerance, sorghum plants respond significantly to moisture conditions and provide significant yield increases when irrigated.

Light requirements. The length of day, intensity and composition of sunlight are important environmental factors for the sorghum plant. It is an exceptionally light-loving, short-day plant. The steppe zone of Ukraine is a favourable region for meeting the light requirements of the sorghum plant.

Soil requirements. Sorghum plants are undemanding to soils. It grows well on various types of soil, including light sandy and heavy clay. Fertile loamy and light chernozems are most suitable. Sorghum plants should not be placed on swampy, cold soils with a high water table.

Unlike other plants, sorghum tolerates saline soils well. It can withstand a concentration of soluble salts 1.5 times higher than that of corn. For this reason, sorghum can be the first plant to be planted on saline soils. It helps to reduce salinity, as a significant amount of sodium, chlorine and magnesium is taken out with the harvest. Sorghum varieties and hybrids are divided into three groups: *Seeded* - with open, easily threshed seeds (Kraevyd, Vinets, Anna, Slavyanske 210, Sprint 2, Maksym, Keiras, Donetske 8, Henicheske 209, Dniprovsky 39, Kovcheg, Skif, Gudok, Lan 59); *Sugar* - with semi-open seeds and up to 15 per cent sugar content in the stems (Agrarian 5, Krymske 15, Silo 42, Favorit, Medovyi, Troistyi, Dovista); broom, which has filmy seeds and panicle branches up to 40-90 cm long (Farmers',

Tavriyske 1, Tavriyske 2, Lyubyme 80, Rayivske, Karlykove 45, etc.). The production also uses varieties of herbaceous sorghum or Sudanese grass grown for green fodder, hay and silage (Holubkivska 25, Donetska 5, Dniprovskia 54, Luhanska 3, Myronivska 36, Myronivska 10, Fioleta), and sorghum-Sudanese hybrids (Yuvileinyi 75, Yuvilei 50, Slovianske Pole 15, Sokratom 87, Pochyn 11).

Agricultural technology. *Place in the crop rotation.* The best place in the crop rotation for sorghum plants are plants that leave fields clean of weeds - seeded cereals, seed legumes and tilled plants. Sorghum should not be sown after millet or Sudan grass.

When sorghum is returned to the same field after 2 years, the soil is almost completely cleared of sooty and rot pathogens, and the number of corn moths is significantly reduced. Sowing sorghum no earlier than three years after a layer of perennial grasses reduces the risk of thinning of seedlings by wireworms and false wireworms.

Soil cultivation. Given the arid climate of the region where sorghum plants are grown, all soil cultivation measures are aimed at preserving moisture.

Soil cultivation for sorghum plants, when placed after winter or spring spiked crops, begins with stubble peeling after harvesting in the crop rotation, to a depth of 6-8 cm. In case of a significant number of perennial weeds, when rosettes appear, a second peeling is carried out to a depth of 10-12 cm. 10-15 days after peeling, ploughing is carried out to a depth of 25-27 cm. If herbicides are used (Roundup or its analogues), ploughing begins 15-20 days after the herbicide is applied. In order to preserve and accumulate reserves of productive moisture in the soil, autumn ploughing should be levelled in autumn. Unleveled winter ploughing both in autumn and winter and in spring, before the onset of physical maturity of the soil, loses a significant amount of moisture in the seed layer (0-10 cm). Pre-sowing tillage includes early spring moisture closure with heavy tooth harrows in one or two traces across or diagonally to the ploughing. In fields where the main tillage was carried out in autumn with moldboardless implements, needle harrows BIG-3A or BMSH-15 should be used for harrowing in spring in the active state. If the field is free of weeds, one pre-sowing cultivation to a depth of 5-6 cm is sufficient. In the case of significant weed infestation, 2 cultivations are carried out: the first to a depth of 10-12 cm, the second (pre-sowing) to a depth of 5-6 cm. In years with insufficient moisture, an effective measure is to roll the soil with ring-spur rollers after the first cultivation, which helps to increase the temperature and moisture content of the topsoil, intensive germination of weeds, which are then destroyed by pre-sowing cultivation.

Fertilisation. The undemanding sorghum plant is very sensitive to fertilisers and the timing of their application. With a yield of 6-7 t/ha of grain, sorghum consumes 160-180 kg of nitrogen, 60-70 kg of phosphorus and 170-200 kg of potassium per hectare.

Sorghum plants are very sensitive to organic fertilisers, especially when combined with mineral fertilisers. Studies have shown that when 10-20 tonnes of manure and N₁₀ P₁₀ were applied in autumn for ploughing and sown in spring, the increase in grain yield of sorghum plants was 0.4 t/ha, and in some years up to 1 t/ha. In general, fertilisers not only increase yields but also improve quality.

During sowing, nitrogen and phosphorus mineral fertilisers are applied to

the rows ($N_{10} P_{10}$). A single application of a full dose of fertiliser in the spring before sowing or pre-sowing application of phosphate or complex fertilisers at 10 kg/ha a.i. is also effective. Under irrigation conditions, due to the higher productivity of the plant, $N P K_{909090}$ is applied. Potash fertilisers are not applied on saline soils.

It should be remembered that spring application of mineral fertilisers is less effective due to the rapid drying of the topsoil. Pre-sowing seed preparation is an important and crucial element of sorghum cultivation. Seeds of sorghum plants in grain varieties and hybrids are hulled or semi-hulled, and in sugar sorghum plants they are hulled and semi-hulled. The seed is coloured in different colours and shades. The coloured hulls of sorghum seeds usually contain the glucoside tannin. The presence of tannin in the grain of this plant somewhat complicates the process of processing it into starch and alcohol, but it also plays a positive role in the life of the seed: in conditions unfavourable for seed germination, tannin prevents it from moulding and helps to increase field germination.

Preparation of sorghum plants for sowing must include heating the seeds for 4-5 days in the sun, which increases germination energy and germination rate by 6-10 per cent. A mandatory measure is to treat the seeds against pathogenic microflora and soil pests, especially for naked varieties and hybrids that do not contain tannin in the shell. Fungicidal preparations Vitavax 200 FF, w.c.k. (2.5-3.0 l/t), Maxim XL 035 FS, t.c.k. (5.0 l/t) are effective against mould, root and stem rot, smut. To protect seedlings from wireworms and false wireworms (with more than 3-5 individuals per 1 m²), aphids and other seedling pests, seeds are treated with insecticide Cruiser 350 RS, t.c.s. (4.0 l/t) simultaneously with fungicide treatment.

Weeds reduce sorghum yields by 20-35 per cent. It is known that sorghum plants are highly sensitive to herbicides in the initial period of growth. When applying Primextra Gold 720 SS or Dual Gold 960 ES soil herbicides, the sensitivity of plants to them is reduced by mandatory treatment of seeds with Concept III 960 ES antidote, h.e. (0.3 l/t) before sowing.

Sowing of sorghum plants begins when the soil warms up steadily to +10...12°C at a depth of 10 cm. Filmy varieties and hybrids can withstand lower soil temperatures better and can be sown 3-4 days earlier than bare-seeded varieties. The depth of sowing of sorghum seeds is 4-5 cm. When the sowing layer of soil dries up, the sowing depth is increased by 2 cm.

The sowing method is dotted wide-row with row spacing of 45-70 cm. In the southern Steppe, the density of seed sorghum plants before harvesting should be 120-140 thousand/ha, in the northern part of Ukraine 140-180 thousand/ha; when growing short-stemmed varieties and applying fertilisers, it can be increased to 160-200 thousand/ha. The seeding rate by seed weight is 15-20 kg/ha. It should be noted that excessive thickening of crops is worse than moderate thinning, as sorghum plants are able to bush and compensate for the thinned stem to some extent. Excessive tillering leads to uneven panicle maturation and increased grain moisture content.

For green fodder, sorghum plants are sown in wide rows with row spacing of 45 cm at a sowing rate of 0.5-0.75 million/ha in the south and 0.75-1.0 million/ha of germinating seeds in the north.

Crop care. In the complex of measures, the care system should include: post-

sowing rolling, harrowing, inter-row cultivation, chemical weeding and protection against pests and diseases. After sowing, the soil must be rolled up with ring-and-tine rollers. Due to its slow growth in the initial period of the plant, sorghum is suppressed by weeds, which are developing intensively at this time. Therefore, one of the first agronomic measures is to harrow the crops with light tooth harrows 4-5 days before emergence, when the sorghum sprouts are 3-4 cm deep from the soil surface and the weeds are destroyed by the harrow tines. If heavy rain falls after sowing and a soil crust forms, which is detrimental to the emergence of simultaneous seedlings, it must be destroyed with harrows. When the sprouts of the sorghum plant are less than 1 cm from the soil surface, rolling is carried out to loosen the crust. Since weeds do not appear simultaneously, it is advisable to harrow the crops even after the sorghum plant has emerged. Depending on the weediness and density of the crops, 1-2 harrowing operations are carried out: the first when the sorghum plants have 4-5 leaves, and the second when they have 6-7 leaves. Harrowing is best done in the afternoon, when plants are less damaged. Harrowing with mesh and light harrows is quite effective, as it reduces damage to sorghum plants. On wide-row crops, after clearly defining the rows, the soil is cultivated in the inter-rows: the first time to a depth of 8-10 cm, the second time - to 6-8 cm using hilling machines.

To plan chemical weed control measures and determine the products to kill them, weeds need to be inspected promptly. Herbicides should be used in fields where there are more than 20 annual weeds and more than 1 shoot of perennial weeds per 1 m of². For vegetative plants against dicotyledonous weeds, herbicides are applied with 2,4-D amine salt (0.9-1.7 l/ha), and 50 per cent w.c. (1.2-1.6 l/ha), 60 per cent by weight (1.0-1.3 l/ha), Dialen (0.8-1.2 l/ha), Agritox 50 per cent by weight (0.7-1.7 l/ha), Pik 75WS by weight (15-20 g/ha), and Ladok new (2.5-3.0 l/ha). Crops should be treated with these herbicides, except for the latter, in the phase of 3 to 5 leaves of the sorghum plant. In later stages (6-8 leaves), the use of herbicides is detrimental to sorghum plants. To enhance the effect of insurance herbicides, 5-8 kg/ha of ammonium nitrate is added to the solution.

Banwell 4S 480 SL spray herbicides (0.15-0.2 l/ha), Dialen Super 464 SL spray herbicides (0.5-0.6 l/ha) should be applied in the third to fifth leaf stage. The use of these herbicides at a later date and exceeding the recommended rates will lead to a "sheathing" effect. That is, when there is a strong twisting of the stem, the sixth leaf cannot emerge from the fifth leaf, which even leads to rupture of the sorghum plant tissues. Herbicide Pik 75 WG v.g. (0.015-0.02 kg/ha) has a milder effect on sorghum plants, even when applied before the formation of the seventh leaf. It destroys virtually all types of dicotyledonous (both annual and perennial) weeds. To achieve the highest biological effectiveness, especially for the control of field bindweed and thistle, it is necessary to apply Pik 75 WG in combination with Side Kick surfactant (0.25 per cent). The herbicide Pik is particularly effective against sunflower carrion, and not only the carrion whose seedlings appeared during spraying, but also later sunflower seedlings that create problems during harvesting of sorghum plants are destroyed.

The best time for protecting sorghum crops from aphids (common cereal and sorghum) is from germination to the 5-6 leaf stage of the plant, when the pests are on top of the leaves. Later, in the later phases of plant development, aphids hide in the leaf

sheaths and it is much more difficult to detect them. In addition, in this case, systemic insecticides are used against pests. During the period of mass emergence of corn moth caterpillars and in the presence of more than 18-20 percent of plants with pest ovipositories, crops are sprayed with one of the insecticides: Decis, 2.5 per cent of c.e. (0.5-0.7 l/ha), Decis Forte, 12.5 per cent of c.e. (0.05-0.08 l/ha), Karate, 5 per cent of c.e. (0.2 l/ha), Karate Zeon, 5 per cent of c.e. (0.2 l/ha), Sherpa, 25 c.e. (0.32 l/ha).

The root system and stems of young sorghum plants are damaged by gnawing scoops. To prevent this, it is necessary to keep the crops free of weeds. If scoop caterpillars appear on the crops, which at the beginning of their development settle and feed on weeds, they must be destroyed by spraying with insecticides. It should be remembered that when planning chemical treatments, it is necessary to adhere to the anti-resistance strategy of using drugs, because the use of drugs of the same chemical group or with the same mechanism of action over time leads to persistent resistance of phytopathogens and *phytophages*.

Harvesting. To avoid losses during harvesting, it is necessary to optimise the timing of harvesting, timeliness and quality of harvesting. The harvesting period for a sorghum plant is determined by the purpose for which it is used. Sorghum plants are harvested for seed when they are fully ripe and hard on the bulk of the panicles. The morphological sign of full ripeness of a seed sorghum plant is yellowing of the stem at the base of the panicle. Grain spillage in the field at maturity is not observed not only in sugar filmy varieties and hybrids, but also in grain - hulled and semi-hulled varieties. It is also important to take into account the peculiarities of varieties and hybrids that lose their stem elasticity during aging and can bend and break under the influence of winds. Such sorghum plants should be harvested when they are ripe, without wasting time.

When harvested by combine harvesters, sorghum seeds are usually high in moisture and should be cleaned and dried immediately. To reduce the moisture content of the grain, desiccation is used at the beginning of full grain ripeness. For seed crops, if there is a threat of frost in autumn, it can be carried out at the stage of waxy ripeness of the grain. Urea and ammonium nitrate are less effective than Reglon Super 150 SL in water (3 l/ha), especially in years when the weather is cold and rainy in autumn. Desiccation is most effective in dry and warm weather.

To obtain high-quality raw materials for the intended purpose or silage, sorghum plants are harvested at waxy ripeness of grain, during which time the yield of sorghum syrup is up to 60-65 percent of the leaf-stem mass and the sugar content is up to 12-15 percent.

Sorghum plants are harvested for green fodder and hay mixtures and single-species crops 7-10 days before panicle ejection. If mowing is delayed, the fibre content in the vegetative mass of the sorghum plant increases significantly, the quality of the fodder deteriorates significantly, and the productivity of the flocked grass stands decreases.

The fresh green mass of sorghum and Sudan grass may contain poisonous cyanide compounds, so it should be fed after drying (cyanide compounds decompose in this process).

2.5.4 Soriz



Soriz is a versatile plant that is similar in taste and chemical composition to rice. Its cereal contains 11.1 per cent protein, 0.17 per cent lysine, 1.1 per cent crude fat and 88 per cent starch. In milled rice, these figures are respectively: 9.11, 1.12 and 84.3 per cent.

Sorghum groats can be used for dietary and baby food and as a raw material for extruded products and concentrates. Sorghum groats contain enough easily digestible carbohydrates and little fibre, which has a positive effect on the digestive glands and makes them suitable for baby food. The high protein content

binds water during cooking, which extends the shelf life of ready-to-eat dishes, which have a delicate texture with a pleasant taste and smell. The value of cereals also lies in the fact that they contain tocopherol (vitamin E), which can remove radionuclides from the human body. Therefore, it is important to increase sorghum production, which will help optimise and stabilise grain production in Ukraine.

Soriz has the ability to partially desalinate salt marshes. Given that Ukraine has more than 1 million hectares of saline and saline soils in the southern and steppe zones, sorghum cultivation is a natural fit. Sorghum is a young plant. Only 20 years have passed since research on the practical use of distant hybridisation between seed sorghum and its wild relatives to produce thin-stemmed forms of cereal grain was launched. Selection from sorghum is carried out in two main areas: the *first is the* creation of new and transfer of the best lines of the seed sorghum plant for yellow grain and vitreous grain by repeated backcrossing and selection; the *second* is the creation of herbaceous lines with a thin stem by crossing the seed sorghum plant with Sudanese grass and wild relatives. The material created is distinguished by its short stature, early maturity, and thin stem, which makes it possible to synthesise hybrids, including those for growing in thickened crops on sloping soils to reduce soil erosion. The original forms and hybrids of *sorghum* plants with vitreous seeds are allocated to the economic group of *sorghum* plants (*Sorghum oryzoidum*) or *sorghum*. The yield and gross grain yields vary considerably over the years, depending on weather and climatic conditions. In recent years, there has been a rise in temperature, an increase in dry days and a decrease in precipitation. The average yield of sorghum in the arid zone on non-irrigated soils over the past 10 years has been 4.24 t/ha, of corn - 2.83 t/ha, of spring barley - 2.09 t/ha

Biological characteristics, varieties. *Requirements to temperature.* Sorghum is close to the seed sorghum plant in terms of biological characteristics. It is a thermophilic plant. The minimum temperature for seed germination is +10...12⁰ C, the optimum temperature is +25...30⁰ C. Seedlings are very sensitive to low temperatures and die at -2⁰ C. The optimum temperature for flowering and pollination is +18...20⁰ C, and at the beginning of panicle ejection it can withstand temperatures of +45...50⁰ C without reducing productivity.

It is characterised by high heat resistance. It can tolerate temporary increases in temperature up to +75⁰ C without significant harm, as it can fall into an anabiotic state and resume vital activity when water and thermal conditions are normalised.

Moisture requirements. The transpiration coefficient is 150-200. To form a unit of dry matter, it requires 2.0-2.5 times less water than corn, sunflower or spring barley. Very economical in moisture consumption. It is demanding of moisture during germination, as the seed has high hardness and vitreous endosperm. Deep penetration of the root system and high suction power make it possible to use moisture inaccessible to other plants, which allows it to tolerate long periods of rainlessness.

The critical period in terms of water supply is the interphase period of germination and tillering. Insufficient water during this period cannot be fully compensated for by subsequent moistening.

Soil requirements. Soriz is not very demanding on soils. High productivity is observed both on heavy clay and light sandy soils. It can be grown on chernozems, chestnut soils and eroded slopes. It can withstand high salt concentrations in the soil. Sorizum is a light-loving, cross-pollinated plant of short day length with a growing season of 90 to 120 days.

Varieties: For culinary purposes - Odesskyi 302; for food concentrate use - Druzhnyi, Kvarts, Salut; for technical purposes - Titan.

Agrotechnology. *Place in the crop rotation.* In the crop rotation, sorghum is placed after cereals, spiked cereals, legumes, potato plants, melons and gourds. It is not advisable to sow after sunflower, Sudanese grass, sugar and broom sorghum plants to avoid carrion. Seed crops should be placed with spatial isolation of at least 500 metres from all other sorghum plants. *Soil cultivation.* The main and pre-sowing soil cultivation for sorghum is the same as for seed sorghum and maize. The same soil herbicides (Dual Gold, Harness, etc.) are applied.

Fertiliser application. Sorghum uses 23 kg of nitrogen, 10 kg of phosphorus, and 33 kg of potassium to form 1 tonne of grain and the corresponding amount of aboveground mass. Full mineral fertiliser is applied at the rate of N P K₆₀₆₀₃₀, as a rule, for ploughing. It is not recommended to apply superphosphate or ammophos to the rows during sowing, as this may lead to a decrease in field germination and yield. Nitrogen mineral fertilisers on soils with a light texture are best applied in the spring before cultivation. On soils with low fertility and, especially, on leached soils, manure is quite effective - up to 40 t/ha. Sorghum also responds well to manure after-emergence.

Sowing. Although sorghum is not affected by smut, its grain, unlike sorghum, is completely devoid of tannins, which makes it vulnerable to soil pathogens and pests. Therefore, sorghum must be sown with treated seeds. Good results are obtained by air-heat or solar heating (field germination improves by 10-15 per cent). Sowing begins when the soil warms up to +12...14⁰ C at a depth of 10 cm. With earlier sowing, seedlings are weakened, plants grow slowly and are quickly suppressed by weeds. To get good emergence, it requires a levelled field and sowing in moist soil to a depth of 5-6 cm. It is better to sow in wide rows (70 cm) with a density of 70-75 thousand/ha in the south of the country and 80-85 thousand/ha in the middle zone. With narrowed row spacing (45 cm) and irrigation - 120-150 thousand/ha. The direction of sowing should not coincide with the direction of ploughing and pre-sowing cultivation, as this can lead to uneven seeding depth and sparse seedlings. Vegetable and combined seeders are used for sowing. Sow 10-12 seeds per linear metre of row (7-8 kg/ha), with a

seeding rate increased to 10 kg/ha if sowing is delayed.

Crop care. All crop care measures should be aimed at keeping the soil free of weeds. Post-sowing rolling is mandatory. Pre-emergence (when the seedlings are 0.5-0.8 cm long) and, if necessary, post-emergence (in the phase of 4-5 leaves) harrowing is also used. During the growing season, it is advisable to carry out inter-row loosening: the first - in the phase of 4-5 leaves of sorizum, the second - when the plants are 25-30 cm high with cultivators with hillers. When weeds form 1-2 leaves, Loddock new herbicide (3 l/ha) is quite effective. Unlike the amine salt 2,4-D, it can be applied at any stage of sorizium development.

In order to reduce aphid damage and avoid edge treatments with insecticides, sorghum crops can be sown with dry-stemmed sudangrass, which is mowed for livestock feed before harvesting sorghum.

Harvesting. Soriz is a remontant plant and is characterised by uneven maturation. In addition, the stalks of sorghum remain juicy even when the grain is technically ripe.

In the case of separate harvesting, the plants are mown into swaths in the second decade of September, leaving stubble 15 cm high, which is capable of supporting a relatively heavy swath. In 10-12 days in the windrows, the seeds ripen intensively, form a full-fledged starch structure, vitreous and hardness, and dry the stems and leaves. The panicles are threshed at a grain moisture content of 18-20 per cent and reduced drum speeds of 500-600 per minute.

Soriz is harvested by direct combining after desiccation at full grain maturity. The cleaned soriz seed with a moisture content of 14 per cent is ready for long-term storage.

2.5.6 Rice (*Oryza*)



Rice is a staple food crop in many countries in the subtropical and tropical regions of the world. Rice is one of the oldest, most widespread and most important high-yielding crops in the world. It is grown on all continents. It is native to South and South Asia (eastern India, Indochina, southern China) and tropical Africa (upper Niger). Rice is cultivated in the northern regions of India, northern Indochina and southwestern China. Later, it spread to the whole of Indochina, from there to the Philippines, China, Korea, Japan, the Middle East, then to Africa and Europe, and Europeans brought it to America, Oceania and Australia.

For more than half of the world's population, rice is a staple food, especially in densely populated areas of monsoon climate Asia, where it accounts for up to 80 per cent of the diet. It is believed that there are more than 7,000 cultivated varieties of rice, of which more than 1,000 are found in India alone. The seed of the rice plant, when hulled, contains 14 percent moisture, 75.2 percent carbohydrates, 7-10 percent protein, 1.5-2.5 percent fat, within 12.5 percent fibre, and 4.5-5 percent ash. Rice groats are considered one of the best products for dietary nutrition due to their high nutritional value and digestibility. The seeds of the rice plant are

processed into flour, starch, powder, alcohol, etc. Rice straws are used to make good paper, very thin and strong (the best quality tissue paper), and are used to make hats, wicker decorative items, and baskets. Rice oil is used in the soap industry.

Rice is characterised by a relatively high calorie content: 100 g of its grain contains 360 calories (wheat plants - 330, corn - 348, sorghum plants - 332), up to 77.4 per cent of nitrogen-free extractives, which is also higher than in other cereals. Rice protein has a relatively high content of essential amino acids, especially lysine, valine, and methionine, and is more beneficial than the protein of other cereals. The digestibility and absorption of starch and protein in rice is 95.5 per cent. In many Asian countries (tropical and subtropical zones), rice provides about half of the total calories per day for each inhabitant. The consumption of rice in temperate countries is 2-6 kg per person per year, in tropical Latin America - 50-80 kg, in Africa - 40-70 (up to 100 kg), and in Asia - 80-150 kg.

Rice mucilage broths obtained from the rice plant and starch glue are used as an anti-inflammatory agent for gastrointestinal diseases. Rice broth slows down peristalsis, which is important in case of dyspepsia. Rice bran is used to treat hypovitaminosis.

Rice seeds are rich in starch and are used to make cereals and flour, but are more commonly consumed as whole grains, especially by Asian peoples. In China, for example, there is a distinction between the main meal (zhuchi) made from rice cereal and flour, and sushi, which is a dish made from vegetables, fish, and meat.

Today, the main rice crops are concentrated in Asia - 130 million hectares, or 88.8 per cent, in South and North America - 6.2 million hectares (4.3 per cent), and in Africa - 7.2 million hectares (4.9 per cent). The first place in terms of the area under rice belongs to India, the second to China, and the third to Indonesia. By continent, rice production is concentrated as follows: Asia - 90.7 per cent, South America - 3.3 per cent, Africa - 3 per cent, North America - 2.0 per cent, Europe - 0.4 per cent. Three countries - China, India and Indonesia - together produce 64.1 per cent of the world's grain production of this plant. In Ukraine, rice is grown in Odesa, Kherson, Mykolaiv regions and in Crimea. The total sown area in Ukraine is about 25 thousand hectares. The best farms harvest 6.5-9.0 tonnes per hectare.

Biological characteristics, varieties. In the ontogeny of a rice plant, the following phases of growth and development are distinguished: seed germination, germination, tillering, tube emergence, panicle ejection, flowering, grain formation and filling, ripening.

Temperature requirements. Rice is a thermophilic plant. The minimum temperature for seed germination is +11...13°C. Seedlings appear at water and soil temperatures of +14...15°C. Lowering the temperature to -1°C during emergence can lead to their death. During tillering, average daily water and soil temperatures should be at least +15...18°C, and during flowering +18...20°C. The optimum temperature for growth and development is +25...30°C. When the temperature drops to +11...12°C, plant growth stops. According to some characteristics, rice occupies an intermediate position between aquatic and terrestrial plants. However, most researchers consider it to be a hygrophytic plant.

The high water requirement of the rice plant is due to the peculiarities of the

root system, in particular, the insufficient number of root hairs and the low absorption capacity of the roots and leaves. During germination, the seed absorbs only 25-28 per cent of its weight in water. The transpiration coefficient reaches 800-1000, but when grown in flooded conditions (under a layer of water), it is significantly reduced and does not exceed 400-500. After the seed is pricked, respiration increases, the seed's need for oxygen increases, and in the absence of oxygen in flooded soil, the seeds die during germination. Therefore, after sowing, during the period from swelling to seed ringing (10-15 days), the field can be flooded with a layer of water of 5-10 cm for 5 days. After the seeds have been set and a 3-5 mm long coleoptile has formed, the water should be drained from the checks. Seedlings appear without a layer of water. During the tillering phase, when stem roots are formed, the crops are filled with a small layer of water (3-5 cm), as the tillering node is formed almost at the soil surface. When the plants enter the tube and eject panicles, the rice plant's water requirement is maximum. It can be flooded with a layer of water of 10-12 cm, and later increased to 15-20 cm. The plants should be covered with water to 1/3 of their height. A layer of water of 12-15 cm is maintained until the milky ripeness phase. If there is not enough water, the ratio between photosynthesis and respiration is disturbed. At waxy ripeness, the checks are freed from water to dry the soil before harvesting.

Soil requirements. To form 1 tonne of grain (including straw), rice takes out an average of 24 kg of nitrogen, 12 kg of phosphorus, and 30 kg of potassium from the soil. The best soils for rice plants are cohesive heavy clay soils with a high content of organic matter. It tolerates high salinity and soil acidity. The optimum pH is 5.0-6.5. Rice is a self-pollinating plant, with anthers ripening and cracking before the flowers open. However, cross-pollination is also possible, which in some cases reaches 7 per cent. Under unfavourable conditions, some of the ovaries do not develop, and the number of empty ears (threshold) can exceed 30 per cent.

The following rice varieties are common in Ukraine: Dniprovskiy, Dunai, Zubets, Mutant 428, Perekat, Spalchyk, Slavutych, Slavyanets, Ukraine 96.

Agricultural technology. *Place in the crop rotation.* Rice is grown under periodic or permanent flooding. For this purpose, special rice irrigation systems are built. They are built on fields with levelled terrain or a slope of no more than 0.003-0.005. The field where irrigation will be applied is divided into irrigation maps with an area of 15-50 hectares (700-1500 m by 150-200 m) by longitudinal shafts. An irrigation channel is laid along one long side of the map, and a drainage (discharge) channel along the other. The maps are divided into rectangular checks of 5 hectares each by cross shafts 30-35 cm high and 20 cm wide. Water is supplied to the checks through special passes. When arranging the checks, the soil surface must be horizontal and levelled. The deviation from the horizontal should not exceed ± 5 cm. Nowadays, checkpoints covering an area of 10-20 hectares are in practice. A canal is laid along the checkpoint, through which water is flooded into the checkpoint and discharged.

Rice grows well in permanent crops for 2-3 years. However, the maximum yields at lower costs are obtained by intercropping its permanent crops with other plants and by growing intermediate plants in fallow fields. The following crop rotations are common in rice-growing areas: I. 1,2 - alfalfa; 3-5 - rice; 6 - spring crops with alfalfa (rice in this crop rotation takes up 50 per cent); II. 1-3 - rice; 4 - legumes; 5, 6 -

rice; 7 - winter crops with alfalfa; 8, 9 - alfalfa (55 per cent under rice); III. 1-3 - rice; 4 - occupied fallow (75 per cent under rice); IV. 1-3 - rice; 4 - legumes (fallow land); 5, 6 - rice; 7 - winter crops with alfalfa; 8 - grasses for green fodder and green manure (62.5 per cent of the area under rice).

Soil cultivation. When growing rice plants, the company uses ploughs with skimmers to a depth of 25-27 cm, and when ploughing perennial grasses - up to 30 cm. The peculiarity of soil cultivation is that when rice plants are grown for several years in one place, specific weeds (tuberous weed, millet, etc.) multiply intensively and must be destroyed. Shallow sowing of seeds into the soil and flooding of crops with a uniform layer of water requires levelling the soil surface. Under the layer of water, the soil is compacted, and reduced harmful compounds accumulate in it, which do not decompose without oxygen and do not release nutrients.

After ploughing, the soil surface is not levelled to allow better ventilation and freezing. In the spring, 2-3 cultivations are carried out with chisel cultivators to a depth of 15-18 cm with simultaneous harrowing. After the second cultivation, the soil surface is levelled with a planter. Pre-sowing cultivation with simultaneous fertilisation is carried out to a depth of 8-12 cm, followed by harrowing with heavy rollers. To minimise soil tillage, a KFS-2.4 cultivator-cutter-sower is used.

Fertilisation. Rice is grown primarily on chestnut saline soils, where its potassium requirements are almost entirely met by soil reserves. Therefore, potash fertilisers (K_{30-60}) are applied only on chernozem and dark chestnut soils. Nitrogen and phosphorus mineral fertilisers are applied at 90-120 kg/ha in the first year of rice cultivation, and the rate is increased by 20-25 per cent in the second year. Most of the fertiliser is applied before sowing, and if sowing is carried out with seeders, 50 kg/ha of granulated superphosphate is added to the rows. During the growing season, 1-2 fertilisations with nitrogen-phosphorus fertilisers ($N_{30} P_{30}$) are carried out. Fertilisation is carried out in the 3-4 leaf stage and during tillering. The most effective phosphorus fertilisers are superphosphate and precipitate, and nitrogen fertilisers are sulphurous acid and ammonium chloride. Nitrate nitrogen fertilisers are not suitable for rice plants because they are easily washed out of the soil. Organic fertilisers are very effective on rice crops. They are applied at the rate of 40 tonnes per hectare of manure. The green mass of green manure plants is also ploughed in.

Sowing. In the countries of ancient rice cultivation (India, China, Pakistan, Vietnam, Indonesia), seedlings of rice plants are the most common. In countries where rice has been grown relatively recently, including Ukraine, rice is grown by sowing seeds in a permanent place. The seeds must have a purity of at least 98.5 per cent and laboratory germination of at least 90 per cent. Before sowing, the seeds are warmed up under sunlight for 5-7 days and then treated with a chemical. A specific technique is to soak the seeds in a 30 per cent solution of ammonium sulphate the day before sowing. Seeds that do not sink to the bottom in the solution are discarded.

Rice is sown when the soil warms up to $+12^{\circ}\text{C}$ at a depth of 10 cm and the water warms up to $+12...15^{\circ}\text{C}$. It is sown in a narrow row or cross-sowing method. The seeding depth is 1-2 cm. An agricultural technology for rice has been developed that allows sowing it to a depth of 6 cm. In this case, the seedlings should not be flooded.

If for some reason the seeds cannot be sown with a seeder, aircraft are used. After emergence, the crops are treated with herbicides and then flooded with water.

The germination rate of rice seeds in the field often does not exceed 50 per cent. To ensure that there are 250-300 plants per 1 m² at harvest time, 7-8 million seeds per hectare must be sown. With deep seeding, the seeding rate is increased.

Crop care. There are three ways to irrigate a rice plant: permanent flooding - a layer of water is maintained on the field throughout the growing season; reduced flooding - no layer at the beginning and end of the growing season; intermittent flooding - a layer of water is maintained periodically. In Ukraine, rice is grown using the reduced flooding irrigation regime (Table 2.6).

Table 2.6

Timing and agrotechnical requirements for flooding of rice plants
(after O.S. Alekseeva, 2008)

Duration of flooding	Basic agricultural requirements
The gap between sowing and flooding no more than 2 days	Flooding with water heated to +12...14 ⁰ C until the soil on the hills is wetted. The water layer is 10-12 cm. Duration 4-5 days, after which the water is discharged.
The emergence of stairs (2-3rd decades of May)	Seedlings should appear on 25-30 May, the germination phase begins with the emergence of the cones and ends with the formation of the 4th leaf. The soil is kept moist. After treatment with herbicides against millet weeds, a permanent layer of water is created so that it covers the plants at ¹ / ₃ their height.
Bushing (2-3rd decade of June)	The tillering phase begins with the appearance of the 5th leaf and continues until the formation of the 8th-9th leaf. The duration of the phase is 20-25 days. The water layer is 8-10 cm. Crops are fertilised with nitrogen fertilisers. Formation of liquefied crops density is possible by 5-10 July.
Tubing (2-3rd decades of July)	Duration 20-25 days, water layer at least 20 cm. No interruptions in water supply are allowed.
Panicle ejection and flowering (until 15 August)	It lasts 5-8 days. The water layer is at least 20 cm. Grain ripening lasts up to 36 days after panicle ejection and flowering. Before the beginning of wax ripeness, the water layer is at least 18-20 cm, during the wax ripeness phase, the water supply to the heads is stopped.

After sowing, the checks are immediately flooded with a layer of water of 12-15 cm and maintained until the seeds begin to germinate. When the seed is sprouted, the water layer is reduced to 5-7 cm and increased to 15 cm as the seedlings grow. During the tillering¹ stage, the water is reduced to 5 cm and the crops are fertilised with nitrogen fertilisers at . This water level is maintained until the plants are fully

grown. After that, the water layer is brought back up to 15 cm and maintained at this level until the pre-harvest discharge. The water from the checks is discharged 2 weeks before harvest so that the soil is dry enough for the machines to move through.

For the control of annual cereal weeds, the herbicide Ordram (6 l/ha) is used for pre-sowing cultivation. Annual cereal weeds are also destroyed by Auro Plus (1.3-2.0 l/ha) in the 1-2 leaf stage of rice plants. Facet (1.5 l/ha) is applied at the stage of 2-3 leaves of rice and 3-4 leaves of weeds. Sirius herbicide (0.2 l/ha), in addition to millet, destroys tuberous reeds. It is applied at the stage of 2-3 leaves of millet and 5-6 leaves of reed tuber. When the bulk of the weeds are damaged, the water layer is increased to 15 cm. By applying Yalan herbicide (2-6 kg/ha) before sowing, rice can be grown without deep flooding until the tillering phase. When growing a rice plant with a reduced flooding period, seeds are sown to a depth of 4-6 cm, water-charging irrigation is carried out, and only after emergence and spraying of crops with herbicides, the checks are flooded with a layer of water of 6-8 cm, gradually bringing it to 12-15 cm. At the beginning of tillering, the water layer is reduced, the plants are fertilised and treated with herbicides, and then flooded again with a layer of water of 12-15 cm.

At the beginning of tillering, the crops are sprayed with an aqueous solution of insecticides - Actellik (1-1.5 kg/ha), Sumiton (1.0 l/ha) or pyrethroids - to prevent rice mosquitoes, coastal flies and other pests. If the plants show signs of pyriculariosis, the crops are treated with a solution of Fundazole (1-1.5 kg/ha). The seeds of rice plants in panicles do not ripen at the same time and before the straw dries. Therefore, the crop is harvested mainly in a separate way. Harvesting begins when 85-90 per cent of the grain is fully ripe. Rice is cut with ZhRS-5, ZhRK-5, ZhNU-4.0 reapers at a cutting height of 15 cm. When the grain moisture content drops to 15-18 per cent, the swaths are threshed with SKPR-6 and SKD-6R combines with straw spreading in rolls. After 2-4 days, the swaths are threshed again at high drum speeds.

Rice can also be harvested by direct combining. For this purpose, 4-5 days before harvesting, the crops are treated with Reglon Super (1.5-2.0 litres/ha). Harvesting is done after the grain moisture content is reduced to 16-15 per cent, using double threshing.

Desiccation is carried out at the stage of full grain ripeness to reduce the moisture content of grain, stems and leaves 4-5 days before direct harvesting.

2.5.7 Buckwheat (*Fagopyrum*)



A very valuable food cereal plant. It contains 70-80 per cent starch, 10-12 per cent easily digestible protein, useful organic acids, a lot of vitamins B₁, B₂ and PP, mineral salts and glycoside P (rutin), which is of medicinal importance, and trace elements (boron, iodine, copper, cobalt). Buckwheat protein is dominated by easily soluble globulins and glutenins, which is why it is better digested and more nutritious than cereal protein (it is similar in quality to proteins of leguminous plants). It contains a lot of essential

amino acids: arginine (12.7 per cent), lysine (7.9 per cent), cystine (1 per cent), histidine (0.59 per cent), etc. Buckwheat ash contains a lot of phosphoric acid (48.7 per cent), potassium oxide (23.1 per cent) and magnesium oxide (12.4 per cent). In terms of iron content (1.7 per cent), it is higher than other cereal plants and is also rich in copper. Buckwheat contains much more lysine than wheat plants, and it is higher in argon than rice.

An important feature of buckwheat, unlike millet, is its ability to retain its nutritional and flavour qualities for a long time. This is because the fats contained in buckwheat do not oxidise.

Buckwheat is a valuable honey plant; bees can harvest 60-100 kg of honey from 1 hectare of buckwheat. Buckwheat honey is dark yellow, dark brown and reddish in colour, tastes good and has medicinal properties.

In terms of physiological value, buckwheat proteins are close to those of chicken eggs and cow's milk. Nutritionists compare buckwheat porridge to meat in terms of its composition and amino acid structure. Buckwheat is also important in fodder production. Small, tiny seeds and bran obtained from grain processing are used for fodder. Buckwheat straw is similar in fodder quality to barley straw and oat straw (100 kg of straw equals 35 feeding units). Chaff is also a nutritious feed (100 kg equals 50 feed units), which is most valued for feeding pigs. However, an excess of straw and chaff in the diet of animals causes diseases (hair loss in sheep, redness of the skin, etc.).

The husks that remain after buckwheat is processed into groats and contain up to 40 per cent potassium oxide are used as a valuable local potash fertiliser and raw material for potash production (K_2SO_3). The agronomic importance of buckwheat lies in the fact that, as a late-sowing plant, it is used for reseeding dead winter crops and early spring plants. Due to its early maturity, it is grown in post-mowing and post-harvest crops, as well as for green fertilisation, but in areas with sufficient moisture it is inferior to legumes.

Buckwheat is a good place in a crop rotation for other plants, especially when grown in a wide-row method. Crops grown in the rotation after buckwheat are well supplied with phosphorus and potassium from the crop residues.

The short vegetation period (60-80 days) allows buckwheat to be used as a safety crop for reseeding winter and early spring crops, and in some areas it can be grown even after the harvest.

Buckwheat is not only a food plant, but also a medicinal plant. Buckwheat porridge is recommended for gastrointestinal diseases, anaemia, and nervous disorders. The leaves and flowers of the buckwheat plant produce a valuable medicinal substance, rutin, which is used to treat vascular diseases. Buckwheat has long been used in folk medicine to treat bronchitis and hypertension. Buckwheat appeared as a crop plant about 2500 years ago. It has been established that it originated from the spurs of the Himalayan Mountains (India), from where it gradually spread to Mongolia, Tibet, Japan, Eastern Siberia and the Far East. In the first century, buckwheat penetrated to the south of , after which it became known to the Slavic peoples. However, it became widespread in our country only in the 15th and 16th centuries.

The global area under buckwheat is about 4 million hectares, including 2.4 million hectares in Europe. Buckwheat is grown in Germany, Poland, Austria, Hungary, France,

Sweden, China, the USA, Canada, Korea, and Japan. In Ukraine, buckwheat covers about 280 thousand hectares. The main areas under cultivation are located in Chernihiv, Sumy, Poltava, Kyiv, Vinnytsia, Khmelnytsky, Zhytomyr, Kharkiv, and Kirovohrad regions.

The average yield of buckwheat in Ukraine does not exceed 0.7-1.0 t/ha, with advanced farms harvesting 1.5-2.0 t/ha, and in favourable years - 2.5-3.3 t/ha.

Biological characteristics, varieties. Buckwheat is a remontant plant in terms of development. It has a very long flowering period. The plants have buds, flowers, unripe and ripe fruits at the same time. It can grow in conditions of both short and long daylight hours.

Kuperman distinguishes 12 stages of organogenesis in buckwheat plants: I - the period before the first true leaf unfolds; II - differentiation of the rudimentary stem into nodes and internodes, laying of the first true leaves; III - formation of the axis of inflorescences and bracts; IV - laying of the flower blade; V - laying of the rudimentary organs of flowers; VI - formation of stamens and pistils; VII - elongation of the pedicel and generative organs; VIII - removal of the bud from the bract; IX - flowering and fruit formation; X - fruit formation; XI - wax ripeness and seed ripening; XII - full ripeness.

Temperature requirements. Buckwheat is a thermophilic and demanding plant. Its seeds begin to germinate at a temperature of +6...7°C. At temperatures of +15°C, seedlings appear in 7-8 days (they die at -2°C). At temperatures above +25°C, buckwheat is inhibited, especially during the flowering phase. Nectaries dry out, fertilisation deteriorates, plants shed half-formed fruits, and many unfilled fruits - "ruddy" - are formed. It develops best at temperatures around +20°C and relative humidity of at least 60 per cent.

An increase in temperature to +30...35°C leads to ovary inflammation and death, and the yield decreases sharply, especially in dry years. The extended flowering period also leads to a decrease in the productivity of the buckwheat plant.

Moisture requirements. Buckwheat is a moisture-loving plant, as evidenced by its morphological features: the absence of pubescence and waxy coating - adaptations to drought and high temperatures - and a large evaporation surface of the leaves. To germinate, a seed needs 50-60 per cent of its weight in water. Buckwheat consumes 3 times more water than millet and 2 times more than winter wheat and barley. The transpiration coefficient of a buckwheat plant is 400-600. Plants require the most water during the flowering and fruit formation phases - 50-60 per cent of the total requirement. With a lack of water, plant growth stops, but development continues. Buckwheat is particularly adversely affected by the combined effect of air and soil drought, when the temperature rises to +30°C and the humidity decreases to 40 per cent. Under such conditions, the ovaries on the plants die off within 2-3 days.

Light requirements. Buckwheat is one of the plants that grows and develops well in conditions of short and long daylight hours. Reduced daylight hours result in a shorter growing season. Partly cloudy weather is most favourable for high yields.

Soil requirements. The best soils for buckwheat are structural soils with high aeration and sufficient nutrient reserves. These are dark grey podzolic, grey forest, black soil, coarse dusty loamy with optimal soil acidity (pH 5.5-6.5). Very heavy, waterlogged and saline soils are unsuitable. Buckwheat should not be grown on soils

that are excessively fertilised with manure, where there is a "fattening" of plants - excessive development of vegetative mass and a decrease in generative capacity. 1 tonne of grain takes out 30-45 kg of nitrogen, 13-26 kg of phosphorus, 36-72 kg of potassium from the soil, which is 1.5-3 times higher than the removal of nutrients by, for example, wheat. Buckwheat is most demanding on nutrients, especially nitrogen, at the beginning of the second half of the growing season, i.e. during the period of rapid development and accumulation of dry matter and formation of fruiting organs.

The main reasons for low and unstable yields of buckwheat are: insufficiently developed root system, discrepancy between the size of the assimilation surface of leaves and the number of flowers on the plant, long flowering and fruit formation period and its dependence on meteorological conditions, peculiarities of pollination of flowers associated with sexual dimorphism, etc. One of the reasons for the low seed productivity of buckwheat is also the prolonged intensive growth of vegetative organs with simultaneous flowering and fruit formation, which results in the distribution of photosynthetic products not in favour of the latter. However, the main reason for this is the imperfection of buckwheat cultivation techniques and the treatment of buckwheat as a secondary plant.

The introduction of new productive buckwheat varieties with seeds of high technological quality is an important way to increase grain production. The Register of Plant Varieties Suitable for Distribution in Ukraine includes 21 buckwheat varieties: Ukrainka, Antaria, Krupnozerna, Devyatka, Dikul, Oranta, Elena, Rubra, Slobozhanka (common morphotype) and Sumchanka, Krupinka, Yaroslavna, Ivanna (determinant morphotype). At least two or three zoned varieties should be sown, which differ in growth type and length of the growing season.

Agricultural technology. *Place in crop rotation.* Demanding in crop rotation due to its sensitivity to herbicides. Winter seed crops, row crops, beetroot, flax, seed legumes, and maize are equivalent crop rotations for buckwheat. Buckwheat is also grown post-mowing and post-harvest after annual grasses and early cereals. It is not advisable to sow it after oat plants, barley plants and in repeated crops. Buckwheat, due to its rapid growth and weed suppression under a dense leaf cover, is a good place in crop rotations for other agricultural plants. According to research institutions, spiked cereals sown after it are less affected by root rot than those sown after cereals in crop rotations. Buckwheat improves the agrophysical properties of the soil and significantly reduces its density. It absorbs phosphorus and potassium from hardly soluble compounds and transfers them from the lower soil horizons to the upper ones.

Soil cultivation. Autumn tillage is carried out by the type of semi-pair or improved fallow. In early spring, avoid deep loosening. It is advisable to seal in moisture and allow the maximum number of weeds to germinate. If the soil is waterlogged, as weeds sprout, cultivate to a depth of 10-12 cm. In case of weed infestation with rhizomatous or root-sprouting weeds, additional cultivation is carried out, and in dry springs - with the field being rolled.

Immediately before sowing, the soil is cultivated to the depth of seed placement with combined units that ensure complete weed control, levelling of the field surface, moisture conservation, and the creation of optimal agrophysical conditions for seed germination.

Fertilisation. Buckwheat responds well to fertilisers, although they often have a greater impact on the accumulation of vegetative mass than on seed production. To produce 1 tonne of grain, buckwheat removes 4.5 kg of nitrogen, 3 kg of phosphorus and 7.5 kg of potassium from the soil. Organic fertilisers cause increased growth of the vegetative mass, which reduces the grain yield of the buckwheat plant. On sod-podzolic soils, full mineral fertiliser is applied ($N_{45} P_{45} K_{45}$). On chernozems, phosphorus mineral fertilisers are mainly used (P_{45-60}). Potassium chloride fertilisers cause leaf spotting and reduce the intensity of photosynthesis. For buckwheat, it is more advisable to apply chlorine-free potash fertilisers - potassium magnesium, potassium sulfate, potassium nitrate, and ash. It is better to apply a full dose of fertiliser for one of the spring cultivations, and chlorine-containing potash fertilisers for autumn ploughing. After a well-fertilised place in the buckwheat crop rotation, it is advisable to apply mineral fertilisers to the rows during sowing at the rate of $N_{20} P_{20} K_{20}$ and fertilise with nitrogen at a dose of 15 kg/ha d.m. On fields with a sufficient level of fertility, you can limit yourself to fertilising plants at the IX stage of organogenesis with nitrogen at a dose of 15 kg/ha d.m.

Late foliar fertilisation of buckwheat plants with urea (10 kg/ha per year) or microfertilisers increases the protein content of the grain. Potash fertilisers containing chlorine have a negative effect on the productivity of buckwheat plants, and inhibit the plants. On fertile soils containing more than 3 per cent humus, plant-available forms of phosphorus and potassium of more than 10 mg/100 g of soil, and when buckwheat plants are placed after well-fertilised areas in crop rotations, the fertilisation system includes: pre-sowing application of granulated phosphorus or complex fertilisers in doses of 10-20 kg/ha a.i. on wide-row crops - fertilisation of plants during the growing season with nitrogen or complex fertilisers at a dose of 10-15 kg/ha d.m.

Sowing. For sowing, the seeds are used with a purity of at least 99 per cent and a laboratory germination rate of at least 92 per cent. Prior to sowing, the seeds are treated with Vitavax, Fundazole or other preparations at a rate of 2-3 kg/t.

For better growth and development of plants, seed treatment is combined with seed treatment with microelements (manganese, zinc, copper, boron) at the rate of 25-50 g/ha; nitrogen-fixing and phosphorus-mobilising bacteria (100 g/t), diazobacterin (200 g/t). To increase plant resistance to stressful situations, it is advisable to treat the seeds with growth regulators. To prevent plant damage by diseases, it is advisable to treat the seeds with AGATE 25-K at the rate of 20 ml/t.

Buckwheat should be sown after the soil has steadily warmed up to +10...12°C. When sown under these conditions, the seedlings appear on the 6th-8th day, and it begins to flower in late May or early June on the 30th-33rd day. With later sowing dates, buckwheat blooms in the hot, dry summer, which causes crops to burn and significantly reduce yields. Determinant varieties reduce yields at late sowing dates. With early sowing dates, there is a risk of crop losses from spring frosts.

There are two methods of sowing: wide-row sowing with a row spacing of 45 cm and regular row sowing with a row spacing of 15 cm. It should be remembered that buckwheat plants have increased lighting requirements, especially at the IV-VII stages of organogenesis, when the number of inflorescences and flowers and pollen fertility are being laid, so when choosing a sowing method, the degree of soil vegetation, its

weediness and the availability of machinery on the farm are taken into account. Wide-row sowing is the most suitable for plant biology, and in addition, in such crops, weeds can be controlled by agrotechnical methods, soil density is reduced, and root feeding of plants is possible. The advantage of ordinary row seeding is manifested on fertile soils, free from weeds and when sowing early maturing varieties. The seeding rate depends on soil and weather conditions, sowing methods and timing, and laboratory germination of seeds. Under optimum moisture conditions, it is 2.0-2.5 million seeds per hectare for wide-row sowing and 1.5-2.0 million seeds per hectare for determinant varieties; 3.0-3.5 million seeds per hectare for conventional row sowing and 2.5-3.0 million seeds per hectare for determinant varieties. In the absence of nitrogen fertilisers, as well as when planning post-emergence harrowing, the seeding rate is increased by 10-15 per cent. The seeding rate for conventional row sowing in areas of sufficient moisture is 80-100, and in dry conditions - 50-70 kg/ha. For wide-row and strip sowing, 35-40 and 50-60 kg/ha are sown, respectively. The depth of seed placement depends on the granulometric composition of the soil, its moisture content and temperature: on grey forest soils - 3-4 cm; on structural black soils - 4-5 cm; with insufficient moisture - 5-7 cm.

Crop care. After emergence, buckwheat plants rapidly increase their vegetative mass, cover and shade the soil surface, which inhibits seed germination, emergence and weed growth. There is evidence that buckwheat's root system has an inhibitory effect on weed growth due to the release of toxic substances called bioherbicides into the soil.

When buckwheat is sown in an insufficiently moist soil layer, post-sowing rolling is carried out to improve seed contact with the soil. For weed control and soil compaction, pre-emergence harrowing is advisable, and in the phase of the first true leaf in conventional row crops, post-emergence harrowing (machine speed - no more than 4-5 km/h). When harrowing with medium harrows in the phase of 1-2 true leaves, buckwheat crops are thinned out by 15-20 percent. When the first true leaf appears, buckwheat crops are harrowed across the rows or at an angle to them to destroy weeds. It is best to harrow in the daytime, when the plants lose their turgor and are less likely to be broken by the harrow tines.

For wide-row crops, loosen the row spacing two to three times, which improves the water regime and kills weeds. The first time the row spacing is loosened when the first true leaf appears in the plants (stage II of organogenesis) to a depth of 5-6 cm, the second time - at the beginning of budding (stage III) to a depth of 6-8 cm, the third time - at the beginning of flowering before closing the rows (stage IX) to a depth of 6-8 cm with nitrogen fertilisation and leaving a protective strip along the rows about 10 cm wide. During the third row spacing treatment, the buckwheat in the rows is hilled and weeds in the protective strips are destroyed in this way.

During flowering, apiaries are taken to the field at the rate of 2-3 bee colonies per 1 ha. The apiary should be removed before the start of mass flowering. Buckwheat is characterised by high humidity of the above-ground mass, uneven ripening, lodging, and a tendency to shed. The main method of harvesting is separate. Mowing into swaths is carried out when 70-75 per cent of the fruit is ripe in the early or late evening hours at a cutting height of at least 15 cm to ensure that the entire

aboveground mass dries quickly. Delayed harvesting leads to significant losses due to shedding of fruits in the early stages of setting. It is advisable to start threshing the swaths in 4-5 days, when the mass is dry, the moisture content of the stems and leaves is reduced to 30-35 percent, and the grain - to 15-16 percent. Delay in threshing the swaths is unacceptable, as it leads to significant losses due to grain shedding.

Only early maturing and short varieties that ripen together in a conventional row seeding method should be harvested by direct harvesting. Seeds harvested by direct harvesting are characterised by high moisture content and weediness, and therefore require additional drying and cleaning.

2.6 GRAIN LEGUMES

2.6.1 General characteristics of seed legumes

The global demand for protein is driving the intensive expansion of annual seed legumes. Today, they are second only to cereals in terms of total area under cultivation (together with soybeans). Seed legumes are among the oldest plants on the globe. They were grown as early as 7,000 years before Christ (lentils, peas, chickpeas) and as late as 4000-6000 years ago (soybeans, chickpeas, fodder beans). Seed legumes include about 60 species. They include soybeans, peas, beans, lupins, mung beans, cowpeas, vetch, cowpea, chickpeas, lentils, peanuts, cajun (pigeon peas), delichos (hyacinth beans), velvet beans, etc. Due to the fact that there are cold- and heat-tolerant, drought-resistant and moisture-loving pulses, they are grown on all continents. Seed legumes play a special role in solving the protein problem. They are the main source of amino acid-balanced, cheapest, environmentally friendly protein. In terms of protein content, seed legumes are 1.5-2.5 times higher than seed cereals (Table 2.7).

Table 2.7

Chemical composition of seeds of cereal legumes, percentage

Plants	Water.	Protein	Starch	Fat	BER	Crude fibre	Ash
Peas	10-15	16-35	20-46	1,3-1,5	48-55	3,0-6,0	2,0-3,1
Lentils	12-14	25-34	47-60	1,3-1,4	48-55	3,5-4,0	2,0-2,5
Beans	12-15	22-30	50-56	2,0-2,3	45-52	5,0-5,5	2,5-3,0
Chyna	12-14	25-34	24-25	1,0-1,2	42-52	4,0-5,4	2,5-3,0
Chickpea	12-14	25-34	47-60	4,0-7,2	45-52	4,0-5,4	2,5-3,0
Fodder beans	10-14	25-35	50-55	1,0-1,3	46-54	3,4-6,0	2,6-4,3
Soybeans	14-16	30-60	22-34	13-26	19-30	2,9-1,1	4,5-6,8
Fodder lupine	14-18	30-48	18-39	3,6-14	18-21	11-18	2,5-4,0

The grains of annual cereal legumes (soya, peas, fodder beans, lupine, vetch, chickpea, chickpea, etc.) contain more protein (20-50 per cent) but less fat (except for soya plants - 20 per cent). Proteins are valuable for their amino acid composition. In terms of the content of essential amino acids (lysine, tryptophan, arginine, valine, etc.) in their seeds, legumes are 1.5-3 times higher than the protein of cereal plants. Legumes are richer in riboflavin, but poorer in carotene. In terms of energy content, they are close to barley plants, slightly inferior to corn. They contain a significant amount of essential and critical amino acids, and soybeans also contain essential fatty acids.

In legume protein, more than 80 per cent of the fractions are soluble in water and saline, which makes it highly effective in monogastric animals. In ruminants, this causes the protein to break down quickly into ammonia, which is soon excreted from the body. The grains of almost all legumes contain various anti-nutrients (enzyme inhibitors, in particular trypsin, alkaloids, etc.) that reduce their value. Most of these anti-nutrients are protein-based and can be inactivated (neutralised) by heat treatment. An important feature of pulses is the biological fixation of atmospheric nitrogen, which occurs due to the development of nodule bacteria on their roots. In doing so, the plants not only meet the basic need for nitrogen, but also enrich the soil with environmentally friendly nitrogen and increase its fertility. Peas, soybeans, lupins, chickpeas, chickpeas, vetch, and beans generally do not require nitrogen fertilisation.

Seed legumes, in symbiosis with nodule bacteria, absorb nitrogen from the air. Studies have shown that from 100 to 400 kg of air nitrogen is recorded per 1 hectare of seed legumes. Most of it is taken out with the harvest and only 25-40 per cent remains in the post-harvest residues. Lupine is particularly active in absorbing atmospheric nitrogen (up to 400 kg/ha), which makes it one of the best green manure plants, helping to improve soil fertility, especially on poor sod-podzolic soils.

The fodder value of legumes lies not only in the fact that they have a high fodder value themselves, but they also improve the quality of other plants' fodder by enriching it with protein. It is known that for proper animal feeding, one feed unit should contain 110-115 g of digestible protein, while in fact it contains 95-98 g or 83-87 per cent of the norm. At the same time, the seeds of legumes contain 174-276 g, and the green mass 160-205 g of digestible protein per feed unit. Therefore, it is possible to bring feed rations to physiologically complete levels with the help of legumes.

In addition to enriching the soil with nitrogen, legumes can also improve its structure, enrich the topsoil with phosphorus, potassium, and calcium, and improve its chemical properties. Lupins, fodder beans and, to a lesser extent, peas are able to absorb phosphorus from hardly soluble compounds (the phosphorus in their root residues becomes available to subsequent plants). Due to this, they are a good place in crop rotations for cereals and industrial plants. In world agriculture, pulses are grown on an area of 100-110 million hectares with a gross grain harvest of about 90 million tonnes. The largest sown areas are concentrated in China, India and the USA. Among them, the most common are soybeans (50 million hectares), beans (25 million hectares), peas (14-15 million hectares), and chickpeas (10-12 million hectares).

Taking into account the value of pulses, Ukraine needs to constantly increase their production, including by expanding the area under cultivation, which currently covers about 1.6 million hectares, and gross grain harvest reaches 3.2 million tonnes.

Biological characteristics of leguminous plants. When growing pulses, it should be remembered that their seeds can germinate with twice as much water absorption (110-140 percent of their weight) as seeds of cereal plants, which is especially important for heat-loving plants sown in late spring and in southern Ukraine. Seed legumes that bring cotyledons to the soil surface do not tolerate deep seeding, which can lead to significant seedling thinning.

After the first true leaves appear, the growth of pulses is often delayed, especially in cold spring, and the plants turn yellow, which is due to insufficient nitrogen, as nodule bacteria do not yet fix nitrogen from the air and can live parasitically at the expense of plant nitrogen. In such cases, low doses of nitrogen (N_{20-30}) applied under pre-sowing cultivation are extremely effective. A characteristic feature of legumes is the tendency to prolonged flowering and fruit formation, which makes harvesting difficult and, with a slight overstay, can lead to loss of the most valuable seeds of the lower beans. Harvesting pulses is also difficult because some of them (peas, chickpeas, lentils, beans) lodge heavily; others (lupins, fodder beans) have high stem and leaf moisture at harvest time, and some (soybeans, bushy forms of beans) have very low bean placement on the plant.

In their individual development, seed legumes go through the following phases: seed germination, germination, branching, budding, flowering, bean formation, ripening, and full seed maturity.

Seed *germination* begins with the emergence of a root from under the seed coat, which grows rapidly and takes root. There are two types of germination: *above-ground* (epigeous) and *underground* (hypogeous). During above-ground germination, the cotyledons are taken out of the soil due to the growth of the hypocotyl. The hypocotyl sprouts in a loop, straightens and pulls out the cotyledons, which open, turn green and carry out photosynthesis. Following the cotyledons, the leaves of the bud open. Above-ground germination is characteristic of plants with trifoliate and palmate leaves (soybeans, most types of bean plants, lupins), while underground germination is characteristic of plants with pinnate leaves and some plants with trifoliate leaves. From a biological point of view, plants with underground germination are more advanced than those with aboveground germination because they have a greater "safety margin" of ontogeny: in the event of the death of the aerial part of the main shoot, they can form lateral shoots from buds located in the axils of the lower leaves, sometimes even cotyledons.

Seedlings are seedlings with one or two unfolded leaves. Plants with trifoliate leaves have simple, so-called primordial leaves, while all other plants have true leaves with fewer leaflets than usual. The first leaves of plants with trifoliate leaves are opposite, those with pinnate and palmate leaves are mostly alternate, appearing almost simultaneously.

The other phenophases of different legume seeds have both common features and differences, with the exception of fruit formation, which in all plants is carried out in the form of two subphases: *formation* and ripening. First, the ovary grows actively, developing from the walls of the ovary. It accumulates photosynthetic products and water, and the dry matter mass increases and reaches its maximum value 10-17 days after flowering (in the pea plant). Throughout the entire period of formation, the green

colour of the bean hardly changes. Simultaneously with the formation of the achene, embryogenesis occurs in the cotyledonary sac, i.e. the gradual transformation of the zygote into an embryo.

From an economic point of view, ripening is the process of forming the yield and consumer qualities of fruits, seeds or other plant organs (parts). The ripening of pulses, as well as grain breads, is accompanied by filling: it is as a result of filling - the accumulation of photosynthetic products in the seeds - that the harvest is created and the quality of the grain is formed. In pulses, the ripeness of the grain is determined by the ripeness of the bean (the colour of the pericarp). A change in the colour of the pericarp indicates that the bean is ripe. In a bean plant, for example, the green colour first turns whitish, then changes to yellow-green, green-yellow, yellow, straw-yellow or another colour typical of a ripe bean. According to the colour of the pericarp, the bean's ripeness is also marked: yellow-green, green-yellow, etc.

During the ripening of leguminous plants, the accumulation of photosynthetic products in the cotyledons (filling); polymerisation of organic compounds, conversion of soluble substances into insoluble ones (reserve); metabolic and, after filling is completed, physical dehydration of the seed; dehydration of the ovule, the moisture content of which is always higher during the filling period and lower than that of the seed after filling is completed; reduction of the dry weight of the pericarp as a result of the outflow of a certain amount (sometimes up to 50 per cent) of its substances to the seed; increase in the weight and size of the cotyledons and germinal axis; acquisition by the seeds of the ability to germinate and reproduce productive plants in natural conditions, i.e. formation of its sowing and yielding qualities.

Seeds of cereal legumes (except lupine) do not have natural dormancy and do not require post-harvest ripening. Its physiological maturity (the ability to germinate and reproduce a productive plant) occurs somewhat earlier or simultaneously with technical maturity, and therefore, under favourable conditions, it can germinate in beans both on the "roots" before mowing and in swaths. Mowing the plants at the optimum time (technical maturity) and timely threshing of the swaths can prevent this undesirable phenomenon to some extent. Seed legumes react differently to environmental conditions. Peas, lentils and fodder beans are the least demanding on heat. Their seeds germinate at topsoil temperatures of $+2...3^{\circ}\text{C}$. These plants are able to withstand spring frosts. For example, peas and lentils can withstand temperatures down to $-7...8^{\circ}\text{C}$ during the germination phase, and lupins and fodder beans can withstand temperatures down to -6°C . They are not sensitive to cold snaps during the growing season, but they are very demanding on moisture and produce high yields only in areas of sufficient moisture.

Unlike pea plants, lentil and bean plants, chickpea and chickpea are drought-resistant plants, although they can germinate at $+6...7^{\circ}\text{C}$.

Soybeans and beans are the most demanding to heat. The minimum temperature for germination of seeds of these plants is $+8...10^{\circ}\text{C}$, and bean plants die when the temperature drops to $-0.5...1^{\circ}\text{C}$ and soybean plants - to -2.5°C . At the same time, soya is very demanding on moisture.

Annual lupine seeds germinate at $+4...6^{\circ}\text{C}$, but can grow and develop in cool weather and tolerate drought.

Attitude to moisture. The high moisture requirements of pulses are already apparent during germination, when seeds burst into flame and germinate after absorbing 100-160 per cent of their weight in water. The optimum soil moisture for all plants, which ensures active fixation of atmospheric nitrogen by nodule bacteria and the highest yield, is a moisture content in the range from 90 percent of the HB to the capillary breakdown moisture content (about 60 percent of the HB). It should also be noted that excessive moisture is harmful to all legumes, causing disease and lodging of crops (peas, chickpeas).

Light requirements. According to their light requirements, seed pulses are divided into three groups: long-day plants (peas, lentils, chickpeas, lupins, fodder beans); short-day plants (soybeans, most varieties of beans); and day-length neutral plants (some varieties of beans, chickpeas). However, each plant has varieties that are neutral to day length. Short-day plants extend the growing season in northern regions, and long-day plants extend the growing season in southern regions. It should be noted that many seed legumes (soybeans, beans, peas, fodder beans) are shade-tolerant plants that grow and develop well in thickened crops, and therefore are valuable components for mixed crops. *Soil requirements.* Medium loamy, slightly acidic or neutral soils containing sufficient phosphorus, potassium and calcium are most suitable for pulses. Light sandy soils with an acid reaction of the soil solution are of little use for most pulses. On acidic ($\text{pH} < 5.5$) soils, it is mandatory to apply micronutrient fertilisers containing molybdenum.

Among the legumes, yellow and blue lupins are the least demanding on soils, forming a significant yield on sandy soils, even with an acidic soil reaction ($\text{pH} 4-4.5$). The only exception is white lupine, which requires fertile slightly acidic or neutral soils. Fodder beans are the most demanding on soil fertility.

2.6.2 Peas (*Pisum*)



Peas are grown primarily as a food and fodder crop. On average, a pea seed contains up to 28 per cent protein, 52 per cent carbohydrates, 1.6 per cent fat, and 2.5-3 per cent ash. Pea protein is better absorbed than wheat protein, due to its higher content and better ratio of amino acids. 100 g of its grain contains 336 calories (100 g of wheat plants contains 347 calories, and 171 calories of chickpea plants). The protein content is about the same as in raw meat. The seeds of the pea plant boil well, and food products made from them are highly nutritious and have a pleasant taste. Pea groats, flour, canned seeds and unripe sugar snap pea beans are used for food purposes. The green, unripe seeds ("green peas") and unripe fruits of vegetable varieties of the pea plant contain up to 25-30 percent sugar, many vitamins (A, B₁, B₂, C) and minerals. The seeds of the pea plant are used as concentrated feed and as a protein component for mixed fodder. 1 kg of grain contains 1.17 feed units and 180-240 g of digestible protein, and 1 kg of green mass contains 0.13 feed units and 25 g of protein. Green mass, hay, and straw of pea plants are used for animal feed, the feed value of which, due to its high protein content,

is much higher than that of cereal plants. Pea-grain mixtures are used to make silage, grass meal, and green fodder.

With high agricultural technology, peas leave 50-70 kg/ha of nitrogen in the soil and are a good crop rotation for cereal plants. It is also important as a green manure and green manure plant.

It was apparently introduced into the plant together with wheat, barley, millet, and beans. Central Asia, the areas between the Mediterranean and the Himalayas, is considered to be the homeland of the pigeonpea plant. It was known in Mediterranean countries (Spain, Italy, and the Balkan Peninsula) 5,000 years before Christ. It probably appeared on the territory of Ukraine in the III-II millennium BC, as evidenced by archaeological excavations in the Chernivtsi and Ivano-Frankivsk regions.

Over the past 14 years, pea grain production has increased by almost 1.8 times. The global area under the crop is 14-15 million hectares. It is growing rapidly in France, Ukraine, Canada and other countries. In Ukraine, the area under crops has significantly decreased and, according to the State Statistics Committee of Ukraine, is about 350 thousand hectares. The largest sown areas are concentrated in the Forest-Steppe region (55 per cent of the total sown area). Peas are also grown in the Steppe (25 per cent of the sown area) and Polissya (up to 20 per cent).

Biological characteristics, varieties. *Relationship to temperature.* Peas are the earliest maturing of the legumes. Peas are less demanding on heat than lentils, beans, chickpeas, chickpeas and other legumes. Peas are an early sowing plant, and their seeds germinate when the soil warms up to $+1...2^{\circ}\text{C}$. However, under such conditions, seedlings are weakened and appear late (after 15-20 days). The minimum temperature required for the normal development of seedlings and the formation of vegetative organs is $+4...5^{\circ}\text{C}$. With its increase to $+10^{\circ}\text{C}$, the seed germinates within 5-7 days. Seedlings can tolerate short-term spring frosts down to $-4...5^{\circ}\text{C}$. More cold-resistant varieties of diaper, many of which are wintering. The optimal average daily air temperature during the period of vegetative organs formation is $+12...16^{\circ}\text{C}$, for the formation of generative organs and seeds $+16...22^{\circ}\text{C}$. Temperatures above $+26^{\circ}\text{C}$ adversely affect the quantity and quality of the pea plant yield.

Attitude to moisture. Peas are more demanding on moisture than beans, lentils, chickpeas, and chickpeas. Seeds require 110-115 per cent of water by weight to swell and germinate, while cereal varieties require up to 150 per cent. The critical period before the lack of moisture is quite long - from the laying of generative organs to full flowering. The transpiration coefficient is 400-450.

Attitude to light. Peas are a light-loving plant. Under shade conditions, it stretches out and fruit formation is inhibited. The photoperiodic response of a pea plant is closely related to the spectral composition of light. Long-wave rays predominate in the light of a long day, which contributes to the accelerated development of the pea plant and significantly increases its yield. It is characterised by self-pollination, but cross-pollination is also possible in dry and hot weather.

Peas are a long-day plant. Therefore, in the southern regions, under conditions of short days, the first period is lengthened, and the second period is shortened under the influence of high temperatures and moisture deficit. In the northern regions, the opposite is true: the germination-flowering period is shortened, and the flowering-

ripening period is extended under conditions of sufficient moisture and low temperatures

Attitude to soils. The best soils for growing pea plants are chernozems and vegetated varieties of other types of soil, loamy in texture and high in phosphorus, potassium, molybdenum, boron, and calcium. The optimum pH is 6.8-7.4. On heavy, very dense and acidic soils, the root system is located shallowly, and the vital activity of nodule bacteria is inhibited. Heavy, clay, acidic, waterlogged soils are unsuitable for growing pea plants. On light, poor soils, pea plants produce low yields; they are more suitable for growing field pea plants. According to the use of the main product, pea varieties are divided into three groups: *seed*, *fodder*, and *vegetable*. Seed varieties are characterised by high grain yields, fodder varieties produce a higher yield of green mass than seed varieties, and vegetable varieties are grown to produce "spatula" and green peas. The Register of Varieties includes more than 40 varieties of pea plants, most of which are recommended for cultivation in the Forest-Steppe and Polissya regions. Noteworthy varieties include Ulus, Bersek, Glyans, Gotivskyi, Deviz, Cuddy, Yezero, Camelot, Camerton, Starter, Cardiff, Modus, Necklace, Petronium, Rialto, Svit, Hardy, Tsarevych, Yavor, Zinkivskyi, Lavr, Cleopatra, Oplot, Ataman, Veselyk.

Agricultural technology. Place in crop rotation. Due to the slow growth of plants in the early stages of organogenesis and insufficient development of vegetative organs, it is advisable to place pea crops in fields with minimal weed infestation and the absence of perennial root and sprout weeds.

Peas should be placed in the crop rotation after well-fertilised areas in the crop rotation. The best among them in the Forest-Steppe zone are tilled plants, maize, as well as winter and spring seeded crops; in Polissya - maize, winter wheat, tilled plants. In the crop rotation, it is more expedient to place peas between two seed cereal plants or between a seed cereal and a technical non-legume plant. The saturation of crop rotations with peas should not exceed 15 per cent, and the term for returning them to their original place of cultivation should not be earlier than in 5-6 years. If pea plants are returned to the same field earlier, they suffer from soil "pea fatigue", which is caused by the development of various diseases, especially root rot, and negatively affects yields.

In areas with an arid climate, it should not be sown after sugar beet, sunflower, Sudan grass, and sorghum. Peas should not be grown after other legumes and pea plants, as this promotes the development of *Fusarium*, nematodes, nodule weevil and seed beetle. Do not place pea crops close to perennial legumes that harbour weevils. **Soil cultivation.** The system of soil cultivation measures involves ensuring a good phytosanitary condition of crops and creating favourable water and air conditions for the growth of pea plants and the vital activity of nodule bacteria. When growing pea plants, maximum attention should be paid to weed control. For this reason, improved or semi-steam tillage should be applied with double stubble cultivation and early autumn ploughing or other types of basic tillage. In general, the basic tillage for peas is the same as for early spring cereals.

When sowing pea plants after cereals, it is necessary to peel the stubble, and after 2-3 weeks deep (25-27 cm) ploughing to create favourable conditions for the vital activity of nodule bacteria. According to the results of research conducted by the State

Institution of Agricultural Research and Development of the National Academy of Agrarian Sciences of Ukraine, timely peeling followed by ploughing reduced the number of weeds in pea crops by 64-78 per cent.

After sugar beet, ploughing is carried out to a depth of 20-22 cm without preliminary peeling.

Pre-sowing cultivation for peas involves closing moisture by harrowing and pre-sowing cultivation to a depth of 6-8 cm. If there is insufficient moisture in the arable layer, spring levelling of the soil should be avoided, as it ensures mixing of the dried top layer with the wetter one. In this case, it is advisable to sow as soon as possible after the conventional spring tillage, which is cultivation to the depth of seed establishment. On light soils, rolling is used before sowing. It should be noted that peas respond positively to deep loosening of the topsoil with heavy cultivators such as KPE-3.8 and AGCH-4. The use of such machines will improve the nitrogen-fixing capacity of the plant. *Fertilisation.* Peas, especially food-grade grain varieties, require fertile soils. For the formation of 1 tonne of grain and the corresponding amount of straw, it uses 45-60 kg of nitrogen, 17-20 kg of phosphorus, 35-40 kg of potassium, 25-30 kg of calcium, 0.8-1.3 kg of magnesium and trace elements - primarily molybdenum and boron.

It responds well to organic and mineral fertilisers. However, organic fertilisers in the form of semi-rotted manure or compost at the rate of 18-20 t/ha are applied only on poor sandy soils, supplemented with phosphorus fertilisers. On more fertile soils, such fertilisation causes intensive growth of green mass (fattening), which delays the harvest.

Fertiliser doses are set depending on the place in the crop rotation, taking into account the nutrient reserves in the soil. According to generalised research data from scientific institutions, in the Forest-Steppe they are $P_{30-60} K_{45-60}$. Nitrogen mineral fertilisers in the amount of 30-90 kg/ha per year are best applied in spring. When determining the dose of nitrogen fertiliser, it is necessary to take into account the ability of the pea plant to biological nitrogen fixation (50 per cent of the total removal of elements with the crop).

Phosphate mineral fertilisers are very effective in growing pea plants. Potash fertilisers are effective on the non-chernozem soils of Polissya.

Shredded straw can be used as a fertiliser for peas in the crop rotation. In the early autumn, in order to optimise the mineralisation of by-products, nitrogen is added at the rate of 10 kg of d.m. per 1 tonne of straw

To improve nitrogen nutrition through symbiotic nitrogen, plants are infected with nodule bacteria by inoculating the seeds with rhizotorphin. Molybdenum and boron fertilisers enhance nitrogen fixation. Treat the seeds with molybdenum and boron fertilisers or apply molybdenum or boron-enriched superphosphate to the rows during sowing when 1 kg of soil contains less than 0.3 mg of molybdenum or boron available to plants. It is preferable to apply one of the microfertilisers in the rows with superphosphate and the other with treated seeds.

Sowing. Preparation of pea seeds for sowing includes dressing, micronutrient treatment and inoculation, and in case of high humidity, preliminary air and heat treatment is also necessary.

3-4 weeks before sowing, pea seeds are semi-dryly treated with fungicides Fundazole, 50 per cent w.p. (2 kg/t), Vitavax 200 FF (2.5 kg/t), Maxim 025 FS, c.s. (1 l/t), Maxim 035 FS, c.s. (1 l/t). The effectiveness of the treatments increases when used in tank mixtures with growth regulators.

In order to stimulate the formation of nodule bacteria in the rhizosphere of the root system of pea plants and increase grain yield, it is advisable to nitrate the seeds with rhizotorphin, rhizoagrin or rhizohumin at a dose of 0.6-1.2 kg/t on the day of sowing pea plants. Inoculation with rhizotorphin can only be carried out when the seeds have been treated with Fundazole. It is not advisable to combine inoculation with other preparations, as most bacteria are killed. Simultaneously with nitrigenization, it is best to treat the seeds with molybdenum preparations at the rate of 20-30 g of ammonium molybdenum acid per 1 tonne of seed. Treatment with trace elements should be planned if non-molybdenum superphosphate was used as phosphate fertiliser.

In case of liming of acidic soils or when the amount of boron in the soil does not exceed 0.3 mg/kg, spray the pea seeds with boric acid (25 g/kg). In this case, it is also recommended to apply fertilisers containing boron for pre-sowing cultivation.

Peas are sown at the earliest possible time, when the soil is physically ripe, ensuring that the seeds are sown to a given depth and are of high quality and uniform. A 7-12-day delay in sowing in Polissya can result in a 2-3% yield reduction, and in the Forest-Steppe - 3-4 c/ha. Sowing depth is 4-5 cm on medium and heavy soils, 6-8 cm on light soils. When applying soil herbicides, the seeding depth should be 6-8 cm. The seeding rate is set depending on the biological characteristics of the variety, quality and class of seed, so that at the time of harvesting there are at least 130-140 plants per 1 m². The following seeding rates are recommended: 0.8-1.0 in the Steppe, 1.0-1.3 in the Forest-Steppe, and 1.1-1.4 million seeds per hectare in Polissya. For tall varieties, the sowing rate is reduced to 0.8-0.9 million seeds/ha, for medium-sized varieties - increased by 0.1-0.2 million seeds/ha. For large-seeded varieties, the norms are reduced by 10-15 per cent, and for small-seeded varieties, they are increased by 10-15 per cent. Weight standards for large-seeded varieties are 240-300 kg/ha, and for small-seeded varieties - 150-200 kg/ha.

Crop care. The first step in caring for pea crops in dry spring is post-sowing soil rolling, which promotes better contact between the seeds and the soil, draws water to the seedbed, increases germination and plant resistance to disease and pest damage. It is not used in high humidity conditions. The complex of crop care operations involves protecting crops from weeds, pests and diseases. With medium and high levels of weed infestation, pre- and post-emergence harrowing of crops with medium harrows is an effective and proven measure. Harrowing of pea crops ensures loosening of the field surface with the elimination of soil crust, helps to destroy weed seedlings in the "white thread" phase and creates optimal aeration conditions to improve the symbiotic activity of nodule bacteria. The first application is carried out 3-6 days after sowing, when the seedling length does not exceed 1.5 cm, and the second - in the phase of 3-4 leaves of the pea plant at a plant height of 8-10 cm. To prevent injury to plants, harrowing is carried out during the day, when plants lose their turgor and are less damaged. The greatest effect in weed control is achieved by combining agronomic and chemical

methods. On fields heavily infested with annual cereal and dicotyledonous weeds, pea plants are treated with herbicides Gesagard 500 FW, hp, 3-5 l/ha (pre-emergence spraying); Pivot, v.p, 0.5-0.75 l/ha (pre-emergence or post-emergence spraying, in the phase of 3-6 leaves of pea plants); for annual DICOTYLEDONOUS weeds, AGRITOX, 0.5 l/ha; Basagran, 0.5 l/ha, 3 l/ha in the phase of 5-6 leaves of the pea plant; for annual cereals and dicotyledons - Fusilade Forte 150 ES, c.e. (0.5-1.0 l/ha - against annual cereals and 1.0-2.0 l/ha - against perennial cereals); Ephesus, v.r.k, 3 l/ha - against annual dicotyledons (spraying of crops in the phase of 5-6 leaves); Pulsar, v.r., 0.75-1.0 l/ha - against cereals and annual dicotyledons (spraying of crops in the phase of 3-6 leaves), Select 120, c.e., 1.2-1.6 l/ha - against perennial cereals (at a weed height of 15-20 cm).

Protection measures against pests and diseases. In Ukraine, root rot, downy mildew and ascochitosis are the most damaging diseases of pea plants. Against root rot and ascochitosis, seeds are treated 2-3 weeks before sowing. Against diseases (ascochitosis, peronosporosis, rot), foundationol, w.p. (1 kg/ha), Rex T, c.s. (0.5-1.0 l/ha) are effective when applied in the budding-beginning of flowering phase of pea plants. Among the pests on pea crops, the most common are bulbous weevils, aphids, pea moth, moths, thrips. Pea mosquito, pea grain. To protect against tuberous weevils at the beginning of the pest's settlement, edge treatments are carried out, and with an increase in the number of beetles to 15-30 per 1 m², continuous spraying is used during the growing season with preparations: Karate, (0.1-0.125 l/ha), Fastak 10 per cent c.e. (0.1-0.2 l/ha), Lightning, c.e. (0.15-0.165 kg/ha). Against aphids found on the edges of the field and their number is 10-15 per plant, edge treatments are carried out. In the case when aphids have settled throughout the field and their number has reached 20-30 specimens per plant, Decis Pro, 25 WG, WG (0.07 l/ha), Karate 050 ES, EC (0.1-0.125 l/ha), Danadin 400, EC (0.5-1.0 l/ha), Aktara, 25 WG (0.1 kg/ha) are used for continuous spraying. Pea plants are sprayed with the same preparations as against aphids, moths, moths, thrips during the flowering phase. To destroy pea borers immediately after harvesting, before the beetles leave the seeds, fumigation is carried out.

Harvesting. The main method of harvesting is separate harvesting, which is carried out by starting mowing when 60-75 per cent of the beans are brown and the seed moisture content is 33-38 per cent. Peas are mowed across the direction of lodging, and short-stemmed peas that have lodged are mowed towards lodging. In cases where pea plants are weedy or ripen unevenly, when 75 per cent of the beans are brown, desiccate the pea plant with Reglon (3-4 l/ha) or Roundup (3.0 l/ha) at a grain moisture content of 45 per cent. The weediness of crops during this agronomic measure should not exceed 5 weeds/m². It is advisable to harvest weakly laid and weed-free crops by direct combining, which improves its quality and seed suitability, reduces the risk of crop losses, and saves time and material and technical resources.

The introduction of modern lodging-resistant short-stemmed semi-dwarf varieties with a whiskered leaf type allows direct harvesting of pea plants. Pea plants are harvested when the beans are 100 per cent ripe and the grain moisture content is 15-17 per cent.

Taking into account the tendency of pea plants to uneven ripening, the harvested seeds should be passed through seed cleaning complexes and dried with a moisture content of more than 17 per cent by active ventilation or in shaft-type dryers. The main requirement for the drying process of pea seeds is sufficient ventilation, heating to a temperature of no more than 35-45⁰ C and reducing the moisture content by no more than 4 per cent in one pass.

2.6.3 Soybean (*Glycine*)

Soy is the world's main protein and oilseed crop. It contains the most valuable properties of the entire plant world. Soybeans are the main leguminous plant that can solve the problems of vegetable protein and fat, improve the nitrogen balance of the soil and increase food production.

Its seeds contain 38-42 per cent of protein, 18-23 per cent of fat, 25-30 per cent of carbohydrates, enzymes, vitamins and minerals. The protein content of soybean grain and meal is 3-5 times higher than that of cereal grains, 6-7 times higher than that of cereal grains, and 2 times higher than that of veal, 3 times higher than that of eggs, and 11 times higher than that of milk. Soybean protein is also biologically complete: it contains all essential amino acids, as well as vitamins - provitamin A (carotene), B₁, B₂, C, D₁, E, K, enzymes (urease, lipoxidase, lipase, protease, catalase). Unlike proteins from other plants, soybean proteins are close to animal origin and have almost the same amino acid composition, which makes it possible to produce a wide variety of food products from the seeds. The chemical composition of the soybean plant is distinguished by its content of phosphatides, such as lecithin and nephalin, which are essential for nourishing nervous tissue.



Soybean seeds are used to make milk, cheese, confectionery, food flour, etc. A new area of food use of the soybean plant is the production of substitutes for sausages, chicken and turkey meat. Green beans are also used for food in boiled and canned form. Lecithin and gelatin are obtained from the soybean plant. Soy flour can be used as an additive in baking and pasta.

Soybeans are used as an important fodder plant. It is grown for green fodder and silage in pure sowing and in a mixture with other plants: corn, sorghum, Sudanese grass, etc. The nutritional value of soybean fodder is quite high. Thus, 100 kg of green mass corresponds to 21 feed units and contains 3.5 kg of digestible protein. Soybean hay is also nutritious, containing 15.5 per cent protein, 5.2 per cent fat and 38.5 per cent carbohydrates. Straw and chaff are valuable fodder for sheep. 100 kg of straw corresponds to 32 feed units. Valuable concentrated feed is soya meal and cake. 1 kg of soybean seed contains 1.31-1.47 feed units and 275-338 g of digestible protein. The amount of protein in the cake reaches 47 per cent.

As a row crop, soybeans are of great agronomic importance. Thanks to nitrogen fixation, soybean plants meet their nitrogen needs by 70-80 per cent and improve the nutritional regime, leaving an average of 1 ha of nitrogen in the soil after harvesting

with root and post-harvest residues: 60-80 kg of nitrogen, 20-25 kg of phosphorus and 30-40 kg of potassium, which equates to 10-15 tonnes of organic fertiliser. Therefore, it is a valuable place in the crop rotation for most plants. In areas of sufficient moisture, it can be grown as a green manure plant.

Initially, soya was used only in the centre of its origin - Southeast Asia, in particular in China. It has been known in China since 6,000 years before Christ. It was the Chinese who introduced soya to the plant. They developed ways to process and use it for food. In Europe, it has been grown since the end of the eighteenth century. In , soybeans have long been grown by settlers in the Far East, and in the European part - since the 70s of the nineteenth century. It plays an important role in shaping the seed, food and fodder balance. Soybean meal has become the protein base of feed mixtures, which are used to successfully develop the most intensive industries in America, Western Europe, Southeast Asia and other regions - livestock, poultry, dairy and pig farming. Expanding the area under soybeans is a way to improve soil fertility, strengthen the economy and increase food resources.

In terms of production and consumption, it ranks first in the world among both high-protein and oilseeds. It is highly adaptable to regional conditions, versatile in use, balanced in protein and functional in its activity. The total area under soybean cultivation is over 100 million hectares, with 0.8 per cent in Africa, 41.2 per cent in North America, 29.2 per cent in South America, 26.9 per cent in Asia and 0.9 per cent in Europe. Soybeans are an important crop in 50 countries. Its main crops are concentrated in the US (27 million hectares), Brazil (13.3 million hectares), China (8 million hectares), and Argentina (7.1 million hectares).

In terms of production, soybeans are 2.3 times larger than all annual seed pulses combined. The countries of North America produce 53.0 per cent of the world's soybeans, South America - 28.5 per cent, Asia - 16.6 per cent, Europe - 11 per cent, and Africa - 0.4 per cent. The main producers of soybeans are the United States (75.1 million tonnes), Brazil (31 million tonnes), China (13.8 million tonnes) and Argentina (18.7 million tonnes). The global production is over 250 million tonnes. In Ukraine, the area under soybean has increased significantly in recent years and, according to statistics, amounts to 1.2 million hectares, with an average yield of 1.62 t/ha. The biological potential of modern varieties is 14-17 t/ha. A record yield of 10.8 tonnes per hectare was recorded in the USA. In terms of hydrothermal resources, Ukraine's soybean belt, which covers the Northern and Central Steppe and the Forest-Steppe, is the most important region in the country. In this area, soybeans can be grown on an area of up to 1 million hectares.

Biological characteristics, varieties. In the ontogeny of soybean plants, the following phases of growth and development are distinguished: seed germination, germination, formation of the first trifoliate leaf, branching, budding, flowering, bean formation, beginning of bean yellowing, and ripening. The vegetation period is divided into three periods of growth and development: formation of vegetative organs (stages I-II of organogenesis), formation of generative organs (stages III-VIII of organogenesis), formation and ripening of fruits (stages IX-XII of organogenesis). The growing season lasts 100-160 days.

Requirements to temperature. The plant is demanding of heat. The sum of the

effective temperatures required for growth, development and yield formation depends largely on the variety and ranges from 1700 to 3200⁰ C. Soybean seeds germinate at temperatures of +6...7° C. Seedlings appear at a temperature of +12...14°C. During the germination and germination phase, the optimum temperature is +20...22° C, during flowering +22...25° C, bean formation +20...23° C, during ripening +18...20° C. Temperatures above +35° C adversely affect the growth, development and formation of nodules. Young plants tolerate frosts down to -2.5° C relatively easily. Autumn frosts down to -3° C do not have a negative impact on the seed yield. At the initial stages of plant growth and development, soybeans are characterised by high drought tolerance.

Requirements to moisture. The soybean plant's moisture requirements are determined by its high transpiration coefficient of more than 600. During germination, the seed absorbs 130-160 percent of its own weight in water, which requires a water reserve in the soil of about 30 mm in the 0-20 cm layer. However, the moisture requirements for different periods of growth are different. At the beginning of the growing season, soybeans can withstand drought. The greatest demand for moisture is during flowering and bean filling, which lasts 40-48 days. During this period, the plant uses 10.2 per cent of its total water consumption. Lack of water during this period leads to disruption of flowering and fruiting (falling of flowers and fruits). The water consumption coefficient ranges from 1500 to 2500 m³ of water for the formation of one tonne of seeds. Favourable conditions for the growth and development of soybean plants are formed at a CEC of 1.0 to 1.7

During the growing season, soil moisture should be in the range of 75-80 per cent HB, and relative humidity should be 70-75 per cent. In conditions of waterlogging of soybean crops, the activity of nodule bacteria decreases.

Relationship to light. Soybean is a light-loving plant of short daylight hours. When shaded, its internodes are elongated, and the ability to branch and form beans is reduced. In early-ripening varieties, the light response is less pronounced, as the response of varieties to photoperiodism is closely related to their growing season. Early-ripening varieties respond less to day length than mid- and especially late-ripening varieties.

Soil requirements. Soybeans grow well on a variety of soils, except for saline soils and those prone to waterlogging. However, soybean plants are quite demanding on soil fertility. While soybean plants are largely supplied with nitrogen through biological fixation, the soil must have sufficient phosphorus and potassium. In this regard, sufficiently fertile loamy and sandy loamy chernozems rich in phosphorus, potassium and humus with a neutral soil solution reaction (pH 6.5-7) are most suitable for soybean plants.

Soybeans have high requirements for soil density. Its favourable parameters are in the range of 0.9-1.3 g/cm³, the optimal ones are 1.0-1.2 g/cm³. In compacted soil (more than 1.3 g/cm³), soybean plants develop a weak symbiotic apparatus, the intensity of nitrogen fixation decreases, the bulk of the root system is located in the upper soil layer, so the plants are difficult to tolerate drought and do not have sufficient nutrition.

Nutrient requirements. Soybeans consume about 90 kg of nitrogen, 40 kg of phosphorus, 40 kg of potassium, 45 kg of sulphur, 150 kg of calcium and 50 kg of

magnesium to produce 1 tonne of grain. During the period of growth and development from germination to flowering, soybean plants absorb only 18 percent of nitrogen, 15 percent of phosphorus and 25 percent of potassium. The bulk of the nutrients are taken up by the plant between budding and grain filling - 80 per cent of nitrogen, 80 per cent of phosphorus and 50 per cent of potassium.

In conditions of insufficient moisture and low moisture reserves, it is necessary to grow varieties of the early ripening group (the period from germination to ripening is 80-90 days): Annushka, Bilyavka, Legend, Diona, and early ripening varieties (90-105 days) - Zolotysta, Omega Vinnytska, Artemis, Angelica, Ustia, Elena, Yug 30, Versiya, Vasylykivska, Vorskla. With sufficient moisture, medium-early ripening varieties are used - Themis, Podilska 416, Agat, Oriana, Nakhidka, Fairy, Diamond, Medea, Skela, Yatran, Eldorado, Phaeton, Strategy, with a growing season of 105-125 days. Promising varieties in the Forest-Steppe are Anastasia, Albina, Hoverla, Hudson, Danaya, Zlatovlaska, Irina, Poema, Poltava, PVS-00.8, PVS-00.1

Agrotechnology. *Place in the crop rotation.* According to the intensive technology, high yields of soybean plants are obtained when they are placed on weed-free fields after winter wheat plants, spring barley plants, buckwheat plants, corn plants, potato plants, and, under conditions of sufficient moisture, sugar beet plants. Special crop rotations can be saturated with soybeans up to 40 per cent (with greater saturation, yields decrease).

It is inappropriate to plant it after legumes and perennial legumes, and in the eastern and left-bank forest-steppe - after sunflower plants. In field crop rotation, soybeans are returned to their original place after 3-4 years, and in short crop rotations - after 2-3 years.

Soil cultivation. Soybeans are extremely demanding on the quality of primary and secondary tillage, which varies from region to region and must be differentiated depending on the place in the crop rotation, topography, weediness of the field, etc.

The main cultivation includes one- or two-time stubble peeling after harvesting in the crop rotation, ploughing to a depth of 25-27 cm, which effectively ploughs up post-harvest residues and levelling the field. On fields infested with thistles and bindweed, layer-by-layer cultivation is used, with 2-3 peeling operations along and across the field with peelers or cultivators-plane cutters.

After harvesting the early crops in the crop rotation, high efficiency in weed control is achieved by peeling the stubble followed by ploughing after germination of the weed seeds. This reduces the number of annual weeds by 35-40 per cent and perennial weeds by 95-98 per cent. If peeling is carried out annually, the number of weeds in crop rotation fields is reduced by 40-50 per cent, which is important when growing soybeans. Fields after sugar beet and potato plants are mostly not disked, but are limited to autumn ploughing to a depth of 22-25 cm. If effective herbicides are available, no-till, minimal or zero tillage is possible. It is estimated that fuel consumption for growing a soybean plant with no-till and minimum tillage is 20 per cent lower than with conventional tillage, and 70 per cent lower with zero tillage.

Pre-sowing soil cultivation should be aimed at creating favourable conditions for uniform seed sowing and promoting mass emergence of seedlings. It includes moisture closure, levelling of the seedbed, cultivation, and, if soil herbicides are applied, their

incorporation. On levelled, unweeded seedbeds, it is sufficient to carry out one pre-sowing cultivation with KPS-4.0 or USMK-5.4 cultivators; on fields infested with dead wood and weeds, two cultivations are required: I - destroys the germination of carrion and weeds (depth 8-10 cm), II - before sowing to a depth of 5-6 cm with simultaneous harrowing and levelling to create a dense seedbed for the seeds to be sown.

Pre-sowing cultivation for soybeans is carried out the day before or on the day of sowing to the seed placement depth at an angle to the direction of ploughing and sowing. It is necessary to preserve the soil structure from excessive soil compaction and to cultivate only the seed placement zone. For pre-sowing cultivation, we use USMK-5.4 cultivators, combined units RVK-5.4, RVK-3.6, ARV-8.1 and others to a cultivation depth of 4-6 cm. This is especially important for soybean plants, which require 130-160 per cent of water by weight when the seeds swell. Pre-sowing tillage and sowing should preserve the effect of soil capillary forces so that the soybean seed sown on the seedbed swells quickly, germinates and sprouts together.

Fertilisation. Soybeans have high nutrient requirements. Soybean plants absorb significantly more nitrogen and phosphorus from the soil than winter wheat, corn, peas, buckwheat, etc. It has been established that soybeans use 72-101 kg of nitrogen, 24-41 kg of phosphorus, 22-44 kg of potassium, 23-28 kg of calcium, etc. to form 1 tonne of seeds and the corresponding amount of by-products. The supply of nutrients during the growing season is uneven for soybean plants. Thus, from germination to flowering, it absorbs 16.6 per cent of nitrogen, 10.4 per cent of phosphorus, and 24.7 per cent of potassium; from flowering to the beginning of seed formation and before seed filling, respectively, 78.5, 50 and 82.2 per cent.

Therefore, it is possible to solve the problem of complete provision of plants with available forms of macro- and microelements during the growing season by using multicomponent, chelated foliar fertilisers such as Crystalon, Reakom, Vuksal, Aquarin, etc. in the soybean fertilisation system. The biological properties of the plant make it possible to make good use of the aftereffects of both mineral and organic fertilisers, to fix molecular nitrogen in the air in symbiosis with nodule bacteria, and to absorb hard-to-reach forms of phosphate.

For basic tillage, it is recommended to apply manure or compost at a rate of 20-25 t/ha. For Northern Forest-Steppe conditions on grey forest soils, it is recommended to apply 60-90 kg/ha of phosphorus and potassium fertilisers and 30-45 kg/ha of nitrogen fertilisers in spring, 30-40 kg of NPK per hectare for the Eastern Forest-Steppe, N P K₆₀₆₀₆₀ for the Central Forest-Steppe, or pre-sowing application of superphosphate (50 kg/ha) or nitroammophoska, 20-25 kg/ha of ammophos in rows simultaneously with sowing for the Left Bank Forest-Steppe. On chestnut soils of the Steppe, the dose of potassium is reduced to 30-45 kg/ha.

As a legume, soybeans meet their nitrogen requirements by fixing atmospheric nitrogen by only 30-50 per cent, and therefore require nitrogen fertilisation in the initial period. Nitrogen mineral fertilisers in a dose of 30-60 kg/ha are applied for pre-sowing cultivation.

If mineral fertilisers were not applied for ploughing in autumn, they should be applied for pre-sowing cultivation in spring in a moderate dose of nutrients - N P K₆₀₄₅₃₀

Soybean crops are also fertilised during budding with a complete mineral fertiliser of 20-25 kg/ha of nitrogen, phosphorus and potassium.

For normal growth, soybeans require fertilisation with trace elements, of which molybdenum and cobalt play the most important role. They are needed for the mobilisation and assimilation of nitrogen and other functions. To relieve stress from herbicides and unfavourable factors, foliar fertilisers are applied at the most critical phases of growth and development: true leaf, budding, and grain filling..

Sowing. For sowing, we use cleaned seeds with high germination and germination energy, which are capable of producing friendly and strong seedlings. Prior to sowing, soybean plants are treated with Fundazole, 50 per cent w/w (3.0 kg/t), and Vitavax 200 FF, w/w (2.5-2.6 kg/t) to protect them from diseases (peronospora, white and grey rot). On the day of sowing, soybean seeds are treated with strains of nitrogen-fixing and phosphorus-mobilising bacteria, or with rhizotorphin (200 g/ha) with the addition of trace elements (0.5-1.0 per cent ammonium molybdenum solution) and growth stimulants.

When processing, it should be remembered that direct sunlight has a detrimental effect on nodule bacteria. Soybeans, compared to other plants, have increased heat requirements during the sowing and germination period. It is these requirements that the sowing dates must meet.

Their main criterion is the level of soil temperature -12⁰ C at a depth of 10 cm. If soybean seeds are sown early in unheated soil, they are susceptible to diseases and, as a rule, the seedlings are sparse and unfriendly. Sowing should not be delayed either, as a one-day delay in sowing results in a 1-2 day extension of the plant's growing season and a decrease in yield. The seeding rate is 600-700 thousand seeds (90-100 kg) per 1 ha. In farms with high planting capacity and when using highly effective herbicides, a conventional row seeding method is used with row spacing of 15 cm, increasing the seeding rate to 0.8-1.2 million germinating seeds per hectare. Since soybeans bring cotyledons to the soil surface during germination, deep seeding of its seeds is unacceptable, the optimal depth is 3-4 cm. When the sowing layer of soil dries out, the sowing depth is increased to 5-6 cm.

Crop care. The main objective of soybean crop care is to reduce the damage caused by weeds and the competition of plants for solar energy, mineral nutrients and water.

Post-sowing soil rolling is effective, especially in dry weather, for getting friendly and uniform emergence. Harrowing soybean crops (cotyledon leaf stage) when the weeds are in the "white thread" stage or have just appeared on the soil surface is an effective measure. Harrowing is carried out with light or medium harrows at a tractor speed of 3-4 km/h across the sowing area during the day, when the turgor of the plants decreases. If necessary, 15-17 days after germination (3-4 true leaf stage), inter-row tillage is carried out to a depth of 5-6 cm.

The application of soil herbicides to kill weeds (millet brome, bindweed, marestail, white quinoa, etc.) usually eliminates mechanical tillage. On fields with high potential contamination of the topsoil with seeds of annual, mainly cereal weeds, it is advisable to use Treflan 480, k.e. (2.0-5.0 l/ha) before sowing with immediate incorporation into the soil, or after sowing Harness (1.5-3.0 l/ha) or Trophy 90, k.e.e

(1.5-2.0 l/ha), which do not require immediate incorporation. During the growing season of soybean plants, in the 1-3 true leaf stage, basagran is effective for weed control, 48 per cent a.i. (1.5-3.0 l/ha). In the 2-4 true leaf stage, soybean crops are treated with Blazer 2C, 1.5-2.5 l/ha, at a weed height of 5-8 cm. Against annual and perennial cereal weeds in the phase of 4-5 true leaves of soybean plants, use ARAMO 50, c.e. (1.0-2.0 l/ha), Fusilade Super 125 es, c.e. (1.0-3.0 l/ha), Galaxy Top, c.e. (1.5-2.5 l/ha).

At a weed height of 5-20 cm, it is advisable to use targa, 10 per cent c.e. (1.0-2.0 l/ha), shogun 100 E.S., c.e. (0.8-1.2 l/ha), regardless of the phase of plant development - select 120, c.e. (0.4-0.8 l/ha). Against cereals and annual dicotyledonous weeds, pivot is quite effective, 10 per cent a.i. (0.5-1.0 l/ha) before sowing, before germination or in the phase of 2-3 true leaves of the soybean plant.

Soybean plants are most vulnerable to pests during the periods of generative organs laying and seed formation. If there is a threat of pests spreading, the crops are treated with Bi-58 Novy, 40 per cent of the c.e. (0.5-1.0 l/ha), Arrivo, 25 per cent of the c.e. (0.4 l/ha) and other insecticides; in case of peronosporosis, bacterial spot, cercosporosis, anthracnose and other diseases, they use alliette, 80 per cent w.p. (1.2-1.8 kg/ha), rovril 50 vp (1.5 kg/ha) and other fungicides.

Given the slow growth of nodules of nitrogen-fixing bacteria on the roots of plants (less than 5 per plant) and the cultivation of intensive varieties, it is effective to apply nitrogen and phosphorus fertilisers at a dose of 20-30 kg/ha in the budding phase, as well as the use of fertilisers containing a set of macro- and microelements. In the phase of green bean formation in the lower tier of the agrocenosis, foliar fertilisation is applied, which includes such components as nitrogen, phosphorus, potassium and molybdenum and boron. When grown under irrigation, soybeans are watered 4-5 times during the growing season (during the budding phase, bean formation, and grain filling). The irrigation rate is 500-700 m³/ha.³

Harvesting. In cases when ripening is prolonged due to excess moisture and weeds, it is advisable to desiccate the crops with 20 percent of Reglon (2-3 l/ha).

Soybeans are harvested by direct combining at full ripeness with a grain moisture content of 16 per cent. The threshing drum rotation speed is up to 500 revolutions per minute. The cutting height of the plants should not exceed 6-7 cm, as about 6-7 per cent of the beans are placed at a height of up to 5 cm, so the cutting unit is set to the lowest cut. Seed loss of the soybean plant increases if the crops are thinned or weeded.

The optimum combine speed for harvesting soybean plants is 3-4 km/h. Immediately after harvesting, the grain heap is cleaned and, if necessary, dried in a mild mode. The optimum seed moisture content is 12-14 per cent. Long-term storage of soybean grain is possible at a moisture content of 12 per cent and below.

For normal growth, soybeans require fertilisation with trace elements, of which molybdenum and cobalt play the most important role. They are needed for the mobilisation and assimilation of nitrogen and other functions. To relieve stress from herbicides and unfavourable factors, foliar fertilisers are applied at the most critical phases of growth and development: true leaf, budding, and grain filling.

2.6.4 Beans (*Phaseolus*)



Beans are a valuable food legume. Its seeds contain 20-30 per cent protein, about 2.5 per cent fat, 50-60 per cent starch and up to 4.5 per cent sugar. The protein of the bean plant is similar in composition to meat proteins.

Beans are a good crop in the rotation of spring crops and, in the south, winter crops. They can be grown in repeated crops, sown after winter crops for green fodder, as well as in compacted crops with corn, potatoes, etc., particularly in household plots.

Beans (large-seeded species) originate from South America, and small-seeded beans (mung beans, adzuki) from South Asia.

Beans were introduced to Ukraine in the early 18th century as an ornamental plant, and later they were grown as a vegetable plant. The works of one of the first agronomists, A.T. Bolotov, already highlighted the peculiarities of bean cultivation.

Beans are grown for their green seeds, called flajoles, and their green fruits, called spatulas. Only the so-called asparagus or sugar bean varieties, which do not have a hard parchment layer in their fruit, are suitable for growing spatulas. Varieties with a parchment layer are called peeling varieties and are only grown for green or ripe seeds.

The global area under beans is more than 25 million hectares. The largest areas are in India, Brazil, Mexico, the USA, Hungary, Bulgaria, and Romania. In Ukraine, beans have long been grown in the southern and forest-steppe regions on an area of 25,000 hectares.

Biological characteristics, varieties. The phenology of the bean plant is characterised by the dates of emergence of seedlings, primordial and first trifoliate leaves, budding, flowering, bean formation and seed ripening (by periods of milk, wax and full ripeness). These phenophases are the technological benchmarks for timely sowing, fertilisation, plant care activities, and determining the best harvest time.

Temperature requirements. Beans are one of the most thermophilic plants among the legumes. Its seeds begin to germinate at +8...10°C. When the temperature drops to -1...2°C, the plants die. Beans require different temperatures depending on the stage of development. Thus, the optimum temperature for germination is +18...22°C, and for budding +20...25°C. At temperatures above +30°C, especially in drought, the flowers and ovaries dry up and fall off. A sharp fluctuation in temperature during the day is quite harmful for the bean plant.

Requirements to moisture. Beans are a moisture-loving plant. To germinate, a seed needs 106-114 per cent of its own weight in water. The best conditions for growth are created when the soil moisture content is 70 per cent of HB. High yields are obtained in regions where the annual rainfall is at least 450-500 mm. It is more drought-resistant than peas and lentils. The critical period for it during drought is the flowering and grain filling phases. Waterlogging is harmful to bean plants, especially when it is accompanied by a decrease in temperature.

Light requirements. Beans are a light-loving plant, but they also grow well in shade. This biological feature makes it possible to grow them in compacted crops, in

particular varieties with a climbing stem. *Soil requirements.* The best soils for bean plants are chernozems and grey podzolic soils, light in texture, with a sufficient amount of lime. Beans grow poorly on heavy soils, acidic, swampy and sandy soils. Soils with a high level of groundwater are completely unsuitable for it.

Lack of nitrogen causes yellowing of seedlings, and lack of phosphorus inhibits plant growth. Lack of potassium causes chlorosis, and leaves and stems turn yellow. According to the length of the growing season, common bean varieties are divided into 5 groups: very early maturing - 60-75 days; early maturing - 76-90 days; mid-season - 91-105 days; late maturing - 106-115 days and very late maturing - over 115 days. The main requirement for varieties is plant resistance to the most common and dangerous types of pests. The Register of Varieties includes 12 high-yielding standard bean varieties suitable for mechanical harvesting: Bukovynka, Veselka, Dnipryanka, Dokuchaevska, Dvadedytsia, Zlatko, Mavka, Nadiya, Pervomaiska, Perlyna, Yarynka, Shchedra.

Agricultural technology. *Place in the crop rotation.* The best places in the crop rotation for bean plants are winter and spring seed crops, sugar beet, and corn. In the south-western regions of Ukraine, it can be grown in post-mowing crops after winter crops for green fodder. The period for returning it to its original place of cultivation is at least 4-5 years.

Fertilisation. Beans are picky about nutritional conditions. To produce 1 tonne of grain and the corresponding amount of straw, it needs 50-60 kg of nitrogen, 40-50 kg of potassium, and 15 kg of phosphorus. About 90-95 per cent of the required amount of elements is absorbed during the period from germination to the formation of green beans, i.e. during the first 50-60 days.

The yield of a bean plant is significantly increased by the application of fertiliser, especially organic fertiliser. However, it is more advisable to apply manure under the previous plant.

Since beans only meet up to 50 per cent of their nitrogen requirements through symbiotic nitrogen fixation, the amount of mineral nitrogen should be at least half of the total calculated dose.

The following rates of mineral fertiliser application are recommended: on sod-podzolic and grey forest soils - $N_{45-60} P_{45-60} K_{45-60}$, on black soil - $N_{30-45} P_{45-60} K_{45-60}$ kg/ha of active ingredient.

Trace elements such as molybdenum, boron, manganese, magnesium, zinc and copper have a positive effect on the yield of beans and grain quality.

A mandatory element of the cultivation technique is the pre-sowing inoculation of seeds with preparations based on active strains of nodule and phosphorus-mobilising bacteria.

Tillage. *Winter tillage* for beans is no different from tillage for spring seeded plants. From the beginning of spring work until sowing, bean plants are tilled to preserve moisture, protect against weeds, level the field and loosen the soil. With the onset of physical ripeness, cultivation on light soils begins with harrowing or cultivation with harrowing, while on loamy and clay soils, cultivation is carried out only. As weeds appear, two to three cultivations are carried out before sowing the plant to a depth of 10-12 cm to 6-8 cm. The number of cultivations depends on weed

infestation and soil moisture. In the case of insufficient moisture, the depth of cultivation and their number are reduced. Immediately before sowing, cultivation with harrowing or cultivation with modern combined units is carried out.

Sowing. For sowing, it is necessary to use selected, high-quality seeds with a germination rate of at least 95 per cent and a moisture content of 14 per cent. Two weeks before sowing, the seeds are treated with Fundazole (3 kg/t) along with bacterial fertiliser and trace elements such as molybdenum, boron, magnesium, zinc, manganese and copper.

Beans are sown when the threat of spring frosts has passed and the soil at a depth of 10 cm warms up to +13...15° C. The best method of sowing is wide-row sowing with a row spacing of 45 cm. The seeding rate for small-seeded varieties is 400-500 thousand seeds/ha, for large-seeded tall varieties - 300-350 thousand seeds/ha of germinating seeds at a sowing depth of 4-5 cm, on cohesive and moist soils - 3-4 cm, on light sandy loam soils and with a delay in sowing - 6-7 cm.

Crop care. After sowing, the crops are rolled with ring or scarred rollers. Soil crust and weeds are destroyed in the pre-germination period using rotary hoes or by harrowing when weed seedlings are in the "white thread" phase and the length of the bean plant seedlings does not exceed 1 cm.

The most effective method of weed control remains the combined method, in which the harrowing system is combined with herbicide treatment. For the destruction of annual dicotyledonous and cereal weeds, it is recommended to apply Gezagard herbicide (3 kg/ha) for pre-sowing cultivation, and Bazagran (1.5-2.0 l/ha) in the 3-6 leaf stage. In the phase of germination - the first trifoliate leaf, inter-row cultivation is carried out to a depth of 5-6 cm, the second - to a depth of 7-8 cm, the last - to the same depth, but before the rows close. If necessary, inter-row cultivation is combined with fertilisation. The germinating seeds and seedlings of bean plants can be damaged by larvae of the May beetle, sprout fly, sandy hoverfly, grey weevil, black beet weevil, etc. Alfalfa aphids and spider mites cause damage to vegetative plants. Seeds are damaged by bean seed beetle during storage. Among them, the most dangerous are the sprout fly and the bean seed beetle. A number of agronomic measures are used to combat the sprout fly: high-quality pre-sowing tillage, sowing at the optimum time. To prevent the emergence of the bean seed fly, it is necessary to spray bean crops during the budding period with the insecticide Bi-58 new, k.e. and other products approved for use on the plant. If necessary, spraying is repeated after flowering. If thrips or aphids appear on the plants, spraying is carried out with the above preparation.

If there are signs of anthracnose, white rot or rust, the crops are treated with products approved for use on the plant.

Harvesting begins when 70-80 per cent of the beans have browned and hardened seeds and the leaves begin to dry and fall off. To prevent losses, it is best to harvest in the morning. The harvester header is set to the lowest possible cut (6-8 cm), as about 10 percent of the beans are placed at a height of up to 5 cm. To reduce grain damage, the threshing drum speed is reduced to 400-500 rpm.

After threshing, the seeds are cleaned of soil and impurities, and, if necessary, dried to a moisture content of 14-15 percent at a coolant temperature of +40...45° C. The seeds of the food bean plant are dried at a temperature of +65° C for an hour, which leads to the death of the bean seed beetle.

2.6.5 Lentils (*Ervum*)

Lentils are a valuable food and fodder plant. It is grown primarily for its seeds, which are among the top legumes in terms of protein and nutritional value. Lentil seeds contain about 32 per cent protein, 2 per cent fat and 54 per cent nitrogen-free compounds.

The seeds of the lentil plant are used in the food industry to make canned food, various biscuits and other products. Straw is as nutritious as hay and legume-cereal mixtures. Lentils are a valuable crop rotation for many cereal plants, including winter wheat, maize and millet. The homeland of the large-seeded lentil plant is the Mediterranean Sea, and the small-seeded lentil plant is the Middle East. The global area is about 3.5 million hectares. The main reason for the insufficient distribution of the plant is its stunting, which creates problems during harvesting. Lentil production in the world over the past 10 years has ranged from 3.3 million tonnes to 4.55 million tonnes in 2020: Canada, India, Turkey, Bangladesh, Australia, Nepal, the USA, China, Syria, and Iran. Canada and Australia grow lentils almost exclusively for export. Red lentils account for approximately 75 per cent of gross production, green lentils 20 per cent, brown lentils 5 per cent and other types. The main producers of green lentils are the United States and Canada, while the rest of the world grows mainly red lentils. In Ukraine, green lentils are traditionally more common, with all varieties in the State Register belonging to this type. On average, 70 per cent of the lentil plant grown is consumed in the regions where it is grown.



Biological characteristics, varieties. The growth and development phases of lentil plants are the same as those of chicory plants, with the difference that before flowering the stem grows slowly and branches weakly, and with the onset of the flowering phase, growth and branching intensify. The main shoot and branches remain at the second stage of organogenesis almost until the end of the growing season.

Requirements to temperature. The minimum temperature for germination of lentil seeds is +4...5°C, the optimum temperature is +15...18°C. Seedlings easily tolerate frosts down to -2...3°C. At temperatures of -6°C, the tops of the leaves freeze, but the crops do not die. During the growing season, the optimum temperature for growth and development is +17...20°C.

Moisture requirements. Lentils are undemanding to moisture, so they are common in arid conditions. It requires 80 per cent moisture by weight of the seed to germinate. Lentils tolerate drought better than peas, but during dry spells, especially during flowering and bean formation, ovary drop and inflammation of leaf and bean tops are observed.

Light requirements. This is a long daylight plant. Flowering is long, especially

in rainy and cloudy weather. This explains the uneven ripening of the beans. The growing season lasts 85-110 days. The most suitable soils for lentils are sandy loam and light loamy soils. Acidic, heavy, and swampy soils are unsuitable. On fertilised soils, it develops excessive vegetative mass, reducing seed production.

The zoned varieties of lentil plants include: Krasnogradskaya 100, Krasnogradskaya 49, Luganchanka, Svitanok, Dniprovskaya 3.

Agricultural technology. *Place in the crop rotation.* Lentils grow very slowly at first and are therefore suppressed by weeds. The best crop rotations for lentils are winter wheat, corn, potatoes, and sugar beet. Lentils are a good place in crop rotations for all spring cereals, including maize.

Lentils should not be returned to their original location until 5-6 years later. It is not advisable to place it close to perennial legumes.

Soil cultivation. After stubble cultivation, peeling is used in crop rotations. As weeds germinate, ploughing is carried out to a depth of 25-27 cm. Without preliminary peeling, fall ploughing is carried out after potato and sugar beet plants.

Spring tillage involves closing the moisture with heavy harrows and pre-sowing cultivation with harrowing, which requires the application of soil herbicides Gesagard (3.0 kg/ha) or Dual Gold (1.2 litres/ha).

Fertilisation. Lentils are demanding on nutrients, particularly phosphorus and potassium. It is recommended to apply phosphorus-potassium fertilisers for autumn ploughing at the rate of 40-60 kg/ha of active ingredient. Nitrogen fertilisation is less effective than creating optimal conditions for symbiotic nitrogen fixation. These include seed treatment with rhizotorphin, soil moisture in the range of 60-80 percent of HB, soil temperature of +20...24°C, oxygen access, neutral or slightly alkaline soil solution reaction, and sufficient macro- and microelements, especially phosphorus and molybdenum.

Sowing. Most lentil varieties contain tannin in the seed coat, which has fungicidal properties, so seed treatment against seedling rot is only recommended for non-browning varieties. Seed contamination by pathogens is allowed to be no more than 10 per cent. To prevent the development of fungal diseases transmitted with seed, it is recommended to treat the seeds with Vitavax 200 FF (2.0-2.2 l/t), Lamardor FS 400 (0.15-0.20 l/t) or Maxim XL 035 FS (1 l/t) two to three weeks before sowing, simultaneously with inoculation of the seeds with nodule bacteria. The technique for inoculating lentil seeds is the same as for other legumes.

Since the seedlings can withstand spring frosts, lentils should be sown at the same time as early spring plants. Even a slight delay in sowing leads to a sharp decline in yield. Experiments at the Kharkiv Experimental Station have shown that the most effective method of sowing is a narrow-row method, in which lentils, like peas, lie down less and produce higher yields. Seeding rates are set depending on the growing conditions. In the southern forest-steppe and steppe regions, it is recommended to sow 2-2.5 million grains per 1 ha, which is 120-130 kg/ha for large-seeded varieties. The seeds are sown to a depth of 4-5 cm, and if the soil moisture is insufficient, the depth is increased to 8 cm. Crops must be rolled.

Lentil crops are cared for by breaking up the soil crust and weeding out the flat-seeded vetch. To kill weeds and crust, the seedlings are harrowed across the rows.

During the growing season, when lentil plants are in the two- to five-node phase, weeds are controlled with Pulsar (0.5-0.7 l/ha), Zenkor (0.6 l/ha) or Select (0.8-1.2 l/ha) herbicides.

Harvesting. Lentils are harvested for green fodder at the beginning of flowering and for hay when they are fully flowered. To preserve the colour of the seeds and prevent yield losses, separate harvesting should begin when 65-70 per cent of the beans are fully ripe. As the lentil seed loses its colour due to rain and sun, the crop is threshed as it dries.

2.6.6 Chinoy (*Lathyrus*)



In our country, chinoy is used mainly as a fodder plant: it is sown for seeds, green fodder and hay. The seed of the cowpea plant contains 29-34 per cent protein, 45-47 per cent starch, 1 per cent fat, 4-5 per cent fibre and 2.5-3 per cent ash. In terms of taste, it is inferior to peas, lentils and beans. Since prolonged feeding of chickpea can cause latirism, a disease of the nervous system, it is recommended to feed it simultaneously with other concentrated feeds, in particular corn, and in limited quantities. The straw of the cowpea plant is a valuable fodder: 100 kg of it

corresponds to 39 feed units with a high content of digestible protein.

1 tonne of green mass of chinoy contains up to 2.8 kg of digestible protein and 21.5 feed units. In addition, 1 kg of green mass contains 76 mg of carotene and all the mineral salts necessary for animals. The green mass of the china plant does not coarsen for a long time and remains tender and juicy, so its shelf life is longer than that of other spring fodder plants.

It is a good honey plant and is one of the best places in crop rotations for other plants. It is also grown as a green manure plant. Its economic value is also determined by its resistance to disease and pest damage. Crops are not treated with pesticides against seed-eaters, and the grown seeds are not subjected to gasification, as they do not contain pests. Chyna belongs to ancient plants. It was grown in Egypt, India, and the Roman Empire as far back as BC. Small-seeded forms originate from Southwest Asia, while large-seeded forms come from the Mediterranean basin. Chinu is grown in India, Iran, and Turkey. The Kharkiv region's varietal sections harvest 4.5 tonnes per hectare of chickpea grain, and according to the Pavlohrad and Synelnykivske varietal sections in the Dnipro region, 4.6 tonnes per hectare. In arid regions, cowpea is more productive (2.5-3.0 t/ha) than other legumes, so it has the greatest prospects in the South-East of Ukraine. When grown for green fodder, the yield of cowpea reaches 25.0-35.0 t/ha, while in arid areas it decreases to 12.0-15.0 t/ha. It easily tolerates a significant decrease in temperature in spring and produces fairly stable yields in dry years. In steppe regions, it is not inferior to peas in terms of yield.

Biological characteristics, varieties. The growth and development phases of the chinchilla plant have some peculiarities related to the nature of stem branching. The rudiments of lateral branches are formed in the axils of two lower and two true leaves

during the formation of the embryo. During the germination phase, in plants with lower and mixed types of branching, the growth of the main and lateral shoots begins almost simultaneously, i.e. the phases of stemming and branching coincide.

Temperature requirements. Chinoy is a fairly cold-resistant plant. Its seeds germinate at a temperature of $+2...3^{\circ}\text{C}$, the optimum germination temperature is $+20^{\circ}\text{C}$. Seedlings of the plant can withstand a short-term drop in temperature to -8°C . Due to its regenerative ability, seedlings damaged by frost grow back and are able to form a crop. During the flowering phase, plants are damaged by frosts of $-1...3^{\circ}\text{C}$. The sum of active temperatures required for ripening is $1500-1800^{\circ}\text{C}$.

Moisture requirements. To germinate, the seed absorbs 100 percent of its weight in water. The transpiration coefficient is 400. It can withstand drought for a long time, and if it rains afterwards, it can produce high yields. During flowering and budding, it is demanding on soil moisture. In terms of drought tolerance, it is superior to peas, lentils and vetch, second only to chickpeas. In wet and cool years, cowpea is affected by rust, forms a large green mass and produces small seeds. In dry years, the growing season is reduced to 70 days.

Soil requirements. The chinoy is undemanding to soils. Various soil types are suitable, except for waterlogged and saline soils. It grows best on chernozems and grey forest soils. Requires neutral to slightly alkaline soil reaction (pH 7-8).

The following varieties of chinook are common in Ukraine: Krasnogradskaya 4, Krasnogradskaya 5, Krasnogradskaya 7, Krasnogradskaya 8.

Agricultural technology. *Place in the crop rotation.* Crops of chinoy plant are placed after winter crops and row crops. The field should be free of weeds, as china grows slowly at the beginning of the growing season and is suppressed by weeds. It is a good place in the crop rotation for cereals and industrial plants.

Soil cultivation. The system of basic and pre-sowing tillage is the same as for other early spring crops.

Fertilisation. The chinoy is not demanding on soil fertility. It responds poorly to nitrogen fertilisation. Chinoy takes out most phosphorus and potassium from the soil. Phosphorus-potassium fertilisers should be applied under autumn ploughing at the rate of 50-60 kg/ha of active ingredient. Before sowing, the seeds must be treated with rhizotorphin. Before sowing, the seeds are treated with Fundazole (2 kg/t). Since the seedlings of the chinchilla plant can withstand a significant decrease in temperature, it is sown simultaneously with the early seed plants. Delayed sowing leads to a sharp decline in yield. The sowing method is conventional row sowing with a row spacing of 15 cm. With wide-row sowing, the yield is lower. The seeding rate is 0.8-1.0 million germinating seeds per 1 ha, which is 160-220 kg/ha for varieties with medium seed size. The seeds are sown to a depth of 7-8 cm.

Crop care. The crops are rolled, which contributes to the friendly emergence of seedlings, especially when soil moisture is insufficient. To protect against weeds and to destroy the crust, the seedlings of the chinamint plant are harrowed across the rows with medium harrows.

Harvesting. The main method of harvesting is separate. Mowing is started when 50-70 per cent of the beans are ripe. Mowing is done at a low cut, as the lower beans of the plants are 18-20 cm high. The beans of cowpea plants crack much less than pea

plants, but they should not be allowed to dry out.

Under favourable conditions, the crop can be harvested by direct combining when 90-95 per cent of the beans are mature. The seeds are stored at a moisture content of 14 per cent.

2.6.7 Chickpeas (*Cicer*)



Chickpea is a valuable food and fodder plant. Its seeds contain up to 30 per cent protein, which is similar in quality to eggs, and 7 per cent fat, and have good taste, so they are widely used as a food product. Varieties with dark coloured seeds are used to feed livestock.

Its protein is very close to ideal in terms of amino acid composition - according to FAO criteria, its nutritional value is not inferior to other types of legumes, including soybeans. In terms of the richness and quality of the natural complex of vitamins and other biologically active compounds, it is one of the most valuable among many products of plant and animal origin. The biological value of the protein is 52-78 per cent, and the digestibility factor is 80-83 per cent. The seed is a good additive to a variety of products, especially baby food. The flour is used to make biscuits and other sweets. It does not contain any anti-nutritional compounds, so there is no need to heat it before feeding it to animals. The stems and leaves of chickpea contain a lot of oxalic, malic and citric acids, so the green mass of this plant is not suitable for livestock feed (only sheep are willing to eat straw).

In symbiosis with nitrogen-fixing bacteria, chickpeas absorb a significant amount of atmospheric nitrogen (100-120 kg/ha) and use hardly available for grain plants, hardly soluble mineral compounds from both the arable horizon and deeper soil layers. After harvesting, each hectare of post-harvest residues contains as much post-harvest organic matter as 15-20 tonnes of humus.

Chickpea seeds contain a large amount of potassium and calcium, which are involved in regulating blood circulation, as well as selenium, which prevents the emergence of many diseases, especially endocrine, anaemia, heart arrhythmia, nervous, etc.

Chickpea is one of the oldest plants in the world. It has long been grown in the republics of Central Asia. The world's sown area is 10.5 million hectares, with gross production of 8 million tonnes. The largest areas of chickpeas are in India (83 per cent of the world's acreage) and Pakistan, and are also grown in Italy, Spain, Turkey, Brazil, etc.

In Ukraine, favourable conditions for chickpea cultivation are provided in Zaporizhzhia, Mykolaiv, Odesa and Kherson regions.

Biological characteristics, varieties. *Requirements to temperature.* Chickpea is a thermophilic and at the same time cold-resistant plant. The minimum temperature for seed germination is +2...4⁰ C, friendly seedlings appear at +6...8⁰ C. It ranks first among legumes in terms of frost resistance. In moderate winters, even late autumn

crops overwinter well in the seedling phase under snow cover, withstanding a short-term drop in air temperature to -25°C . In spring, after the snow melts, the seedlings can withstand frosts down to -16°C , and adult plants do not die at -8°C .

The optimum temperature during the flowering-grain filling period is $+23...25^{\circ}\text{C}$. Chickpea is a fairly heat-resistant plant, since at air temperatures of $+40^{\circ}\text{C}$ its leaves do not droop and do not lose turgor for 7-9 days.

Moisture requirements. Chickpea is a drought-resistant plant with a developed taproot system that can transport water from great depths and uses it sparingly. During germination, the seed absorbs 120-140 per cent of water relative to its weight. The transpiration coefficient is 350. Chickpea tolerates drought better than other seed legumes. It can withstand a lack of water better than waterlogging. Excessively wet weather during flowering reduces seed setting and causes lateral shoots to form. In wet years, the plants are damaged by ascochitosis, which often leads to the death of crops

Soil requirements. The plant is medium-demanding to soil. It grows well on saline soils. Black earth and chestnut soils are the best for it.

As chickpea is more tolerant of drought than other pulses and grows on saline soils, it deserves to be widely cultivated in the southern regions of Ukraine. The growing season lasts from 80 to 170 days.

The following chickpea varieties are zoned in Ukraine: Aleksandrit, Dobrobut, Kolorit, Ornament, Pamyat, Rosanna, Smachnyi, and Stoik.

Agricultural technology. *Place in crop rotation.* In the southern regions, chickpea is mostly sown after winter cereals and row crops. Corn and potatoes are good crop rotations for chickpeas. Chickpea is a valuable place in the crop rotation for winter wheat plants and maize plants. It should be returned to its original place no earlier than after 4-5 years.

Soil cultivation. After stubble cultivation, the field is peeled to a depth of 6-8 cm in crop rotations. After 10-14 days, a second peeling is carried out to a depth of 10-12 cm. Ploughing is carried out at the end of September to a depth of 20-22 cm on clean fields and 25-27 cm on weedy fields.

Fertilisation. With a yield of 2.0 t/ha, chickpea removes 106 kg of nitrogen, 36 kg of phosphorus, 150 kg of potassium and 23 kg of magnesium from 1 ha of soil. However, its biological characteristics allow it to make good use of the aftereffects of mineral and organic fertilisers, fix molecular nitrogen in the air in symbiosis with nitrogen-fixing bacteria, and absorb hard-to-reach forms of phosphorus through mycorrhizal fungi. Chickpea plants enter into a symbiosis with *Rhizobium sisegi bacteria* and absorb up to 150 kg/ha of nitrogen from the atmosphere during the growing season through biological nitrogen fixation, ensuring a seed yield of 2.0-2.5 tonnes/ha without nitrogen fertiliser. After harvesting, up to 30 per cent of the biologically fixed nitrogen remains in post-harvest and root residues and is used by subsequent plants. Organic fertilisers in the amount of 30-50 t/ha should be applied only to the previous plant.

Chickpea responds well to the aftereffects of fertilisers applied to the crop rotation. Therefore, when placing it after a row crop, mineral fertilisers can be omitted. Chickpea plants need more phosphorus than seed plants, and a lack of this element

can limit symbiotic nitrogen fixation, reducing plant productivity. If chickpeas are grown after cereals, it is recommended to apply $P_{60} K_{60}$ for autumn ploughing. The application of starting doses of nitrogen delays or inhibits the development of nodule bacteria and reduces their nitrogenase activity.

Sowing. The legume-rhizobial symbiosis is very sensitive to pesticides, which are undesirable in chickpea cultivation. All pesticides have a negative effect on nodule formation and reduce their nitrogen-fixing activity to varying degrees. The least toxic are Fundazole, Vitavax and Bavistin.

An effective agricultural measure is the treatment of seeds immediately before sowing with chickpea rhizotorphin, combined with Fundazole (2.0-2.5 kg/t). To prevent the development of fungal diseases transmitted by seed, two to three weeks before sowing, the seeds should be treated with Vitavax 200 FF (2.5 l/t) or Lamardor 400 (0.15-0.2 l/t), which have a positive effect on the sowing and productive qualities of chickpea seeds and are the least toxic to nodule bacteria.

Chickpeas are sown in the first days of sowing early cereals. The most preferred sowing method is conventional row sowing, and in dry years, wide-row sowing with a row spacing of 45 cm. The seeding rate of chickpea seeds in the wide-row method is 300-500 thousand, and in the continuous row method - 600-800 thousand grains per hectare. The seeds are sown to a depth of 6-7 cm. If there is insufficient soil moisture, it is increased to 10 cm. Since chickpeas, like peas, do not bring cotyledons to the soil surface during germination, deep sowing does not negatively affect the yield.

Crop care. Chickpea plants are severely inhibited by weeds, especially in the early stages of vegetation. As soil herbicides, we recommend using products with the active ingredient *acetochlor* with a concentration of 90 per cent (Harness New, c.e., Trophy, c.e., Etalon c.e. with an application rate of 2.0 l/ha), which kill annual cereals and some dicotyledonous weeds. These preparations are applied before or immediately after sowing without or with shallow incorporation in dry soil. The disadvantages of this class of products are their short duration of action, weak effect on dicotyledonous weeds and negative effect on the development of nodule bacteria.

The most effective products against dicotyledonous weeds are herbicides with the active ingredient *imazethapyr* (Pivot, 10 per cent w.c., Captain, 10 per cent w.c.), which are suitable for application directly under legumes. Herbicides in this group have an enhanced effect on annual cereal and dicotyledonous weeds. They can be applied both before and after sowing, but before emergence at doses of 0.5-0.7 l/ha (preferably with shallow incorporation). The maximum dose of these products almost completely destroys all weeds. The active ingredient has a long-lasting effect; thus, wheat and barley can be sown no earlier than four months after application, corn - in a year, and all other plants - in two. However, there is also an aftereffect on the main plant, chickpea, especially in conditions of high humidity. Chickpea plants may show yellowing, stunting, and various chlorosis. When normal weather conditions occur, all negative signs of the herbicide's effect on chickpea plants usually disappear.

In recent years, experience has been gained in using the herbicide Fabian, which contains two active ingredients, imazethapyr and chlorimuronethyl, for chickpea. The herbicide kills a wide range of annual and perennial cereal and broadleaf weeds, including ragweed, dodder and dodder.

The active ingredients of Fabian penetrate the plant through the roots or leaves within a few hours, move through the phloem and xylem and accumulate at the growth points. They inhibit the processes of protein synthesis, disrupt the division and growth of weed meristem cells. As a result, weed growth stops, leaves turn yellow, and roots die.

In chickpea, this herbicide is recommended to be applied before or after sowing, but always before the plant emerges. Its use on young plants leads to significant damage. Thanks to its two components and lower concentration of imazethapyr than Pivot and its analogues, Fabian causes less damage to subsequent plants. After chickpea harvesting, these fields can be used for winter wheat or barley, and the following year for spring crops and corn. During the growing season, the crops are treated with insurance herbicides Select (1.4-1.8 l/ha), Targa Super (1.5-2.0 l/ha), Panther (1.7-2.0 l/ha), Fusilade Forte (1.5-2.0 l/ha) against annual and perennial cereal weeds. The crust is destroyed with conventional harrows, and during emergence - with rotary hoes. On wide-row crops, 2-3 cultivations are additionally carried out in the aisles. The first one is carried out to a depth of 5-6 cm with a protective strip of 8-10 cm, the second one - after 8-10 days to a depth of 6-8 cm and, if necessary, the third one - before closing the rows. Inter-row cultivation, in addition to destroying weeds and soil crust after rains, helps to loosen the soil, improves air exchange in it, which has a positive effect on the development of nodules.

Chickpea has no specific pests. However, in some years, especially when sown after vegetable crops or in fields adjacent to them, severe damage by various species of moths is observed. During flight and egg-laying, which coincides with the flowering and bean formation phases, one- or two-time insecticide treatments are effective. The following products have proven themselves well: Connect 112.5 BS, hp (0.4-0.5 l/ha), Actelik 500 ES, hp (1.0 l/ha), Arrivo, 25 percent hp (0.3-0.4 l/ha), Volaton 500, 50 percent hp. (0.8-1.0 l/ha), Decis, 25 per cent h.e. (0.3 l/ha), Sumiton, 50 per cent h.e. (0.6-1.2 l/ha), Fury, 10 per cent h.e. (0.07-0.10 l/ha), Sherpa, 25 per cent h.e. (0.2-0.3 l/ha) and others.

More than forty diseases are found on chickpea. However, only two diseases are widespread in southern Ukraine: ascochitosis and, especially, fusarium. The latter causes wilting of seedlings, adult plants and seed decay. Fusarium wilt is most common in wet and cool springs. The disease is usually fire blight. When plants are affected, yellowing of the leaves and their wilting is observed. When the roots are broken, black dots or streaks of blood vessels clogged with fungal mycelium are visible. The infection persists in the soil, on plant residues and is transmitted through seeds. In case of conditions favourable for the development of the disease and the first symptoms of damage, it is recommended to treat the crops with a product manufactured by Bayer Coronet (0.5-0.6 l/ha with the addition of adherent Mero (0.4 l/ha) or, in the absence of this product, other products with the active ingredient *tebuconazole*.

Harvesting. The chickpeas ripen quite amicably, the beans do not crack, the seeds do not crumble, and the plants do not lodge. Harvesting begins when most of the beans are yellow. Chickpea varieties with high pods can be harvested by direct harvesting. Threshing is carried out with seed combines, reducing the number of drum revolutions to 400-500 per minute and lowering the under-drum.

When standing on a stump, harvesting should be done in the morning to prevent the beans from falling off.

2.6.8 Fodder beans (*Faba vulgaris*)



Fodder beans are characterised by their high fodder quality: 100 kg of seeds corresponds to 129 feed units, and each feed unit contains 220 g of digestible protein, while the same amount of green mass corresponds to 16 feed units and 2.1 kg of digestible protein. The seed contains 25-35 per cent protein, 50-55 per cent starch, 3-6 per cent fibre, and 2.6-4.1 per cent ash. Beans are also grown as a food plant, but in our country they are mainly grown for livestock feed, mainly for the production of compound feed.

Fodder beans exceed other legumes in terms of grain and green mass yields in western Ukraine in rainy years.

In areas with sufficient moisture, high yields of green mass with a high digestible protein content are harvested from intercropping fodder beans and maize plants, which are used for green fodder and silage.

Beans are a good place in the crop rotation of winter and spring cereal plants. They are used as a backdrop plant for growing vegetable plants and as a green manure in horticulture. Beans are also grown as a green manure plant on heavy clay soils. Beans are among the most ancient plants grown in Egypt, Greece, and the Roman Empire. Beans have also been cultivated in our country for a long time: back in the days of Prince Vladimir in Kievan Rus, they were grown as a vegetable plant. Nowadays, the largest areas are in Spain, Italy, Egypt, Morocco and Brazil. The global area of fodder beans is about 8 million hectares, with a gross harvest of 3.5 million tonnes and a yield of 1.5 tonnes per hectare. In Ukraine, pulses are grown on about 12 thousand hectares.

Biological characteristics, varieties. *The* phenophases of fodder beans are the same as those of other legumes with unlimited growth, except for the tillering (branching) phase, which does not appear at the optimum plant density. Fodder beans are undemanding to heat, their seeds germinate at temperatures of +4...6°C. Seedlings can tolerate short-term frosts down to -4°C. The most favourable temperature for fruit formation is +15...20°C. At temperatures above +30°C, growth processes are inhibited.

Moisture requirements. Beans are demanding on moisture, especially in the first period of development (before flowering), so the plant is most promising in areas with sufficient moisture. For germination, the seed requires 110-120 per cent water by weight. The seed germinates more slowly than pea, bean and lentil seeds, due to the presence of a thick seed coat that is poorly permeable to water and air. The transpiration coefficient is 800.

When there is a moisture deficit in the soil, the beans grow slowly, shed their leaves, and the yield decreases sharply. Plants can hardly withstand waterlogging.

Fodder beans are a plant that is quite sensitive to prolonged drought. Despite the

fact that they have a well-developed root system, they do not tolerate dry and hot weather, plants wither quickly, and produce fewer beans with a small number of grains.

Light requirements. They are long-day plants, and when grown in northern regions, the growing season is shortened. Depending on the growing conditions, the growing season lasts from 90 to 130 days.

Soil requirements. Fodder beans are characterised by high requirements for easily soluble nutrients in the soil. They prefer deep, connected soils with a large amount of organic matter and good water retention. Thanks to their well-developed root system (root length 80-120 cm), beans are able to absorb hardly soluble phosphorus and calcium compounds from the lower soil horizons and carry them to the upper horizons, where they become available to other plants. They absorb twice as much nitrogen from the soil, 1.5 times as much phosphorus as barley and winter wheat, and 2.5 times as much potassium as peas and seed plants. Soils unsuitable for pulses are acidic, waterlogged and with a water table of 50-60 cm. Such soils inhibit the activity of nodule bacteria, the root system dies off, and plant growth stops, which leads to a decrease in yield.

The following varieties of fodder beans are zoned in Ukraine: Bilum, Vizit, Orion, Prykarpatsky 4, Yantarni. All of these varieties are small-seeded and belong to the mid-season group.

Agricultural technology. The best place in the crop rotation for fodder beans is potatoes, beets, corn and other row crops that leave the field free of weeds. At the same time, pulses are a good place in crop rotations for spring cereals.

Do not grow fodder beans after legumes and cereals, or legume seeds. They should not be re-sown on the same field until 4-5 years later, otherwise they will be damaged by root rot and other diseases and pests.

Tillage. Tillage for fodder beans is no different from tillage for peas and other legumes. Pre-sowing cultivation is carried out in one or two traces to the depth of seed placement (6-8 cm) with simultaneous harrowing. It should be borne in mind that fodder beans respond positively to deep ploughing - 25-27 cm.

Harrowing is carried out in early spring with heavy harrows. If the field is to be sown as soon as possible, harrowing is not carried out, but pre-sowing cultivation is carried out immediately to a depth of 10-12 cm. On heavy soils, two cultivations are carried out: the first to a depth of 6-8 cm, and the second to a depth of 10-12 cm.

Fertilisation. Fodder beans require 60-70 kg of nitrogen, 15-21 kg of phosphorus, 25-28 kg of potassium, and 22-28 kg of calcium to produce 1 tonne of grain and the corresponding amount of straw. The greatest amount of nutrients is supplied to the plant during the phases of intensive stem growth and bean formation. It is recommended to apply manure for autumn ploughing (20-30 t/ha), and phosphorus-potassium fertilisers for autumn ploughing or spring cultivation at the rate of 45-60 kg/ha of active ingredient. Nitrogen mineral fertilisers applied for cultivation (15-20 kg/ha of active ingredient) also have a positive effect on the bean yield. Fodder beans should be sown simultaneously with early seed plants. Delayed sowing leads to a sharp decrease in yield. Early crops are less damaged by aphids and ripen faster. To protect against bacterial and fungal diseases, seeds are treated with Fundazole 15-20 days before sowing at the rate of 2-3 kg of the product per 1 tonne of seeds.

Fodder beans are sown using wide-row and conventional row methods. With the wide-row method of sowing, the row spacing is 45 cm, and the distance between plants in a row is 10-12 cm. The seeds are sown to a depth of 5-8 cm. In the Forest-Steppe, the optimal seeding rate for wide-row sowing is 350-400 thousand hectares, and in Polissya - 450-500 thousand hectares. The sowing rate for small-seeded varieties with wide-row sowing is 150 kg/ha, and with row sowing - 250 kg/ha. When growing beans with corn, they are sown in separate rows, with four corn plants after two rows of beans.

Crop care consists of loosening the soil and killing weeds. Harrowing is required twice: the first time before germination and the second time after germination in the 3-4 leaf stage.

On wide-row crops, 2-3 inter-row cultivations are carried out to a depth of 4-6 cm. During the last loosening, the plants are hilled. Inter-row cultivation should be stopped before the budding phase. On weedy fields, against annual dicotyledonous and cereal weeds, soil herbicides Dual Gold (1.3 l/ha) or Gezagard (3.0 l/ha) are applied for pre-sowing cultivation.

To protect against bruchid and aphids, the crops are sprayed twice with the same preparations as peas (the first time during flowering and the second time a week later). Ronilan fungicide (1.5 litres/ha) is recommended to protect crops from diseases.

Harvesting. The seeds of fodder beans ripen unevenly, so they are harvested separately when 25 per cent of the lower beans are brown. Start mowing in swaths when the lower beans are black and the seeds are hard.

To ensure simultaneous ripening on seed crops, use Reglon Super desiccant (4 l/ha). Crops are sprayed when the lower beans turn yellow 8-10 days before harvest.

2.6.9 Lupine (*Lupinus*)



Lupine is a valuable fodder plant. Its seeds contain 38-52 per cent protein, 25-40 per cent carbohydrates, and 5-20 per cent fat. Lupine began to be used for fodder in the 1930s after the development of alkaloid-free varieties. These include varieties whose seeds contain no more than 0.0025 per cent of alkaloids. Protein concentrates are used to make artificial wool. Technologies for using lupine as a food product are being developed. For example, some types of lupine (e.g., the fickle lupine) contain up to 20 per cent of fat, which can be used both for technical purposes and in the food industry. There are pilot technologies for baking confectionery, candy production, etc. In terms of digestible protein content, it exceeds peas by 1.6-1.7 times, corn by almost 4.5 times (341 vs. 195 and 78 g/kg, respectively); carotene in the green mass of lupine is 10 times higher than in fodder beans (200 vs. 20 mg/kg); in 1 kg of straw - 0.32 k.i. and 23 g of digestible protein, while wheat straw contains 0.20 k.e. and 8 g of protein. Up to 300 kg or more of nitrogen is fixed from the air per 1 ha of lupine, which is equivalent to 36-40 t/ha of manure. Lupine has a well-developed root system that absorbs phosphorus from poorly soluble compounds. Therefore, it grows well on poor sandy soils and is used

to improve them.

In Ukraine, lupine is grown mainly on poor soils in Polissya (yellow and narrow-leaved lupine). White lupine is grown in the Forest-Steppe and Polissya. The total area under lupine cultivation in Ukraine is about 60 thousand hectares, and the average yield is 1.0-1.4 tonnes per hectare.

In Ukraine, fodder lupine is represented by yellow lupine, which can produce grain yields of 2.0-2.5 t/ha and green mass of 60-80 t/ha, white lupine with yields of 4.0-5.0 and 55-70 t/ha, respectively, and narrow-leaved lupine with yields of 2.5-3.5 and 60-70 t/ha. Among the varieties of fodder lupine, there are alkaloid-free, or so-called "sweet", seeds with an alkaloid content of less than 0.0025 per cent (they can even be eaten), and low-alkaloid seeds with an alkaloid content of 0.1 to 0.2 per cent. The seeds of green manure or "bitter" lupins have an alkaloid content of 1-2 per cent or more. However, as a purely green manure plant, bitter lupins have lost their importance and have been replaced by fodder lupins, which are both high-protein livestock feed (matured seeds or green mass) and improve soil fertility. Protein harvest from 1 tonne of fodder lupine grain is equivalent to 4.5 tonnes of barley grain or 5-6 tonnes of corn grain. Lupine originates from the Mediterranean basin, where it was grown for over 2-3 thousand years BC. Perennial lupine originates from North America. In Ukraine, lupine began to be grown in the early 20th century for green fertiliser.

Biological features, varieties. The lupine genus includes more than 250 species. In Ukraine, narrow-leaved, yellow, white, variable and perennial lupins are grown.

The phenophases of lupine differ slightly from those of other legumes. Lupine forms a rosette of leaves, and stem branching precedes flowering (blue lupine) or begins after flowering of the apical tassel (white lupine). Lupine goes through the following stages of growth and development: seed germination, germination, formation of the first finger leaf, branching, budding, flowering, bean formation, seed filling and maturation.

Temperature requirements. Lupine is a plant that is not very warm. The optimum temperature for germination of seeds of narrow-leaved lupine is $+9...12^{\circ}\text{C}$ (minimum $+2...4^{\circ}\text{C}$), yellow $+10...14^{\circ}\text{C}$ (minimum $+3...5^{\circ}\text{C}$), white $+15...16^{\circ}\text{C}$ (minimum $+4...6^{\circ}\text{C}$). Seedlings of yellow lupine can withstand frosts down to $-2...3^{\circ}\text{C}$, and narrow-leaved lupine - down to -5°C . White lupine dies at sub-zero temperatures.

Moisture requirements. All lupine varieties are moisture-demanding and are long-day plants. The critical periods in relation to moisture supply for the plant are the period of seed germination and the period of formation of generative organs (from the budding phase to the formation of shiny beans). The transpiration coefficient is 600-700.

Light requirements. Lupine is a light-loving and fairly cold-resistant plant. It absorbs almost twice as much solar energy as winter wheat, and its ability to maintain a high temperature in its tissues allows it to carry out photosynthesis even in the cold. Compared to other legumes, lupine is not picky about soil fertility, but light, permeable soils are the most suitable. White lupine is the most demanding in terms of soil fertility, while yellow lupine is the least demanding. It grows on acidic soils, but preferably at pH 5-6. Carbonate, swampy and saline soils are unsuitable for lupine. Lupine varieties

are divided into *fodder*, *food* and *green manure* varieties. The Register of Varieties includes 10 varieties of white lupine (Volodymyr, Veresnevyi, Garant, Diet, Kozeletskyi, Lybid, Makarivskyi, Serpnevyi, Tuman, Shchedryi 50), 6 varieties of yellow lupine (Burshtyn, Kruglyk, Obriy, Prypiatskyi, Prohresvyvyi, Chernihivets) and 3 varieties of narrow-leaved lupine (Zirkovyi for green manure, Pelican and Flamingo for universal use).

Modern lupine varieties are divided into three groups according to their alkaloid content: alkaloid-free - the alkaloid content does not exceed 0.025 per cent; low-alkaloid - 0.025-0.1 per cent; alkaloid - more than 0.1 per cent. Varieties of the first two groups are considered fodder (sweet), their vegetative mass and seeds can be fed to animals without reservation. Alkaloid (bitter) lupins are fed in small quantities only in a mixture with other feeds.

Agricultural technology. *Place in crop rotation.* Lupine is grown in crop rotations as the main plant, as well as after mowing, after harvesting and in mixtures. As a main plant, it is grown for seeds, green fodder and silage. For green fodder and silage, lupine is placed in fallow fields before sowing winter crops. For seeds, lupine should be sown in weed-free fields after winter and spring grain breads, potato plants, corn plants, sugar beet and other non-legume tilled plants. It can be sown on the same field no earlier than 4-5 years later. It should be noted that on very poor soils, only 2-3 plants are forced to grow together: for example, lupine - rye - oats.

Fodder lupine is one of the best green manure, so it can be grown in post-harvest, post-mowing crops, as well as in mixtures with other plants. During the growing season, it absorbs 130-230 kg/ha of nitrogen from the air and can leave 50-150 kg/ha in the soil for the next plants in the crop rotation. Lupins can be grown in mixed crops with wheat and rye. By winter, they form 6.0-7.0 t/ha of green mass, which acts as a backdrop in winter and decomposes in spring and serves as fertiliser. It is not advisable to place it after cereals, whose cultivation techniques involved the use of long-acting herbicides and may have a negative effect on lupine plants, as well as after legumes, perennial cereals and next to cruciferous and perennial legumes due to the threat of migration of pathogens and pests. Return to the field in a crop rotation not earlier than in 2-3 years, for varieties not resistant to *Fusarium* - in 5-6 years.

Soil cultivation. The main purpose of pre-sowing tillage is to loosen the soil to a fine cloddy state and create a dense bed at the depth of seed placement. Pre-sowing cultivation of light sandy and sandy loam soils includes one or two harrowing with heavy harrows, and on more cohesive soils - closing moisture by harrowing and pre-sowing cultivation to a depth of 6-8 cm with harrowing. If there is insufficient moisture in the arable layer, spring levelling of the soil should be avoided, as it causes mixing of the dried top layer with the wetter one. In this case, it is advisable to sow as soon as possible after the conventional spring tillage, which is cultivation to the depth of seed placement.

Fertilisation. For the formation of 1 tonne of grain and the corresponding amount of by-products, lupine requires 60 kg of nitrogen, 17 kg of phosphorus and 33 kg of K_2O . The nitrogen requirement of fodder lupine is met by 65-70 per cent through symbiotic nitrogen fixation by plants, and the rest is met by soil nitrogen. Lupine has a deeply penetrating root system, which makes it possible to use nutrients not only from

the topsoil but also from the subsoil. In addition, with the help of root secretions, plants are able to convert hardly soluble phosphorus and potassium compounds into an accessible form, so it is not advisable to apply phosphorus and potassium fertilisers on soils with a high and very high content of mobile forms of these elements ($P_2O_5 > 10-15$, $K_2O > 15-20$ mg/100 g of soil). At very low, low, medium and high content of these elements, phosphorus and potassium fertilisers are effective in a ratio of 1:2 ($P_{30-45} K_{60-90}$ kg/ha per year). Nitrogen mineral fertilisers at a dose of 20-30 kg/ha per year should be applied only to white lupine. Molybdenum and boron are essential trace elements that activate the process of symbiotic nitrogen fixation. If their content in the soil is low (less than 0.3 mg/kg of soil), it is advisable to use fertilisers containing these elements.

Sowing. High-quality seeds with a germination rate of 90-95 per cent are used for sowing. 2 weeks before sowing, the seeds are treated with Fundazole, Vitavax or Tigam (3-4 kg/t of seeds) to prevent ascochitosis, fusarium and anthracnose. On the day of sowing, the seeds are inoculated with preparations based on active strains of nodule bacteria. If necessary, they are simultaneously treated with microelements, using a 0.1 per cent solution instead of water to dilute nitragin. Sowing of narrow-leaved lupine for seeds begins simultaneously with sowing of early spring plants. The main requirement is that the soil must be ripe, and its temperature at a depth of 10 cm must exceed $+5^{\circ}C$. Under these conditions, flower buds are laid earlier, the stem is formed shorter, but with a more productive central cluster, the plants ripen more amicably, and crops are less damaged by pests and diseases. In years with an early spring, the best time to sow lupins for seeds is after the early spring plants, in years with a late spring - simultaneously with the early spring plants. On fields free of weeds, lupins are sown using the usual row method with a seeding rate of 1.2-1.4 (160-180 kg/ha) for yellow and narrow-leaved lupins and 1.0-1.2 (230-260 kg/ha) million germinating seeds for white lupins. On seed crops, weeded fields, as well as on more cohesive, floating soils, it is more advisable to sow lupins in a wide-row method with a row spacing of 45 cm and a seeding rate of 1.0-1.2 million seeds per ha for yellow and narrow-leaved lupins, and 0.8-1.0 million seeds per ha for white lupins. Sowing depth of yellow and narrow-leaved lupine seeds on light soils is 3-4 cm, on more cohesive soils - 2-3 cm, white - 4-5 and 3-4 cm, respectively.

Crop care. Crop care includes protection against weeds, pests, diseases and inter-row cultivation.

Along with the low competitiveness of lupine plants to weeds, it is characterised by a high sensitivity to herbicides. This biological peculiarity is the main reason why the list of products approved for use on lupine crops does not include herbicides for weed control during the growing season. Currently, only two soil herbicides are approved and recommended for pre-sowing cultivation - treflan and triflurex (1.5-3.0 l/ha).

To control weeds and improve the air-water properties of the soil in wide-row crops, it is recommended to carry out inter-row loosening: the first - in the phase of 3-4 lupine leaves, the second - 10-15 days after the first, the third - 8-10 days after the second, gradually reducing the depth of cultivation.

It is impossible to produce high-quality seed without pest protection. If the

ecological threshold of harmfulness is exceeded by lupine weevil, stem fly, aphids (15 pcs./m²), the crops are treated with insecticides Bi-58 Novy (0.5-1.0 l/ha) or STEFESIN (0.2 l/ha) at the end of budding and beginning of flowering.

The spread of diseases such as anthracnose, brown spot, phomosis and others in lupine crops is prevented by pre-sowing treatment with chemical treatments approved for use on the plant, biofungicides (mycosan, AGATE 25-K), which do not inhibit the development of nodule bacteria, and spraying the crops with Rovral FLO, hp, (3 l/ha) during the budding - bean setting period.

Harvesting. Lupine ripens unevenly for seeds. The beans often crack when ripe, so it is advisable to harvest them separately when 3/4 of the beans turn brown. To accelerate the ripening and hanging of plants, 2 weeks before physiological ripeness, which is determined by the light yellow colour of the seed embryo root, desiccation or defoliation of crops with a solution of Reglon (2.5 l/ha), ammonium nitrate (100-120 kg/ha) is used. Such crops are harvested by direct combining. After threshing, the grains are cleaned of impurities, weeds, chaff and dried if necessary. At a moisture content of more than 14 per cent, the seeds are dried, but the temperature of the coolant should not exceed 35-45° C and the moisture loss in one pass should not exceed 4 per cent. Intensive heating causes excessive amounts of water vapour to accumulate in the seeds, under the pressure of which the seed coat breaks, which facilitates the penetration of infection under the coat and leads to a decrease in seed quality.

Conclusions to Section 2

1. Grain crops are critically important as they are the primary staple food for a large portion of the world's population, providing more than half of the global calorie intake. They are also vital for livestock feed, and their starchy content makes them a source for various products like cooking oils, alcohol, and other industrial goods. Furthermore, they are a significant source of carbohydrates for energy, and some grains are rich in fiber, vitamins, and proteins, especially when combined with legumes. Grains like rice, wheat, and corn are staple foods for billions, providing the majority of daily caloric intake in many parts of the world. They are a key source of carbohydrates, which provide energy. They also offer essential nutrients like vitamins and dietary fiber, although some nutrients are lost during milling. For many populations, grains are the primary source of protein, often combined with legumes (like beans, lentils, or soy) to form a complete protein diet.

2. A large portion of grain production is used to feed livestock, supporting the meat and dairy industries. Grains are used to produce a wide range of industrial products, including cooking oils, biofuels, and alcoholic beverages like beer and sake. Their durability and ease of transport make grains highly suited for global trade, making them a fundamental component of the global economy. The cultivation of grains allowed for the development of settled agricultural societies and the growth of human civilizations. The small, dry nature of grain seeds makes them easy to handle, transport, and store for long periods, which is crucial for food security.

3. Cereal crops form the basis of human nutrition primarily due to their high carbohydrate content, providing essential energy. They also supply significant amounts of protein, fiber, vitamins (like B vitamins and vitamin E), and minerals (including magnesium, zinc, iron, and phosphorus). The specific nutritional value of a cereal crop depends on its processing, as refining often removes nutrient-rich outer layers like bran.

4. Cereals are rich in carbohydrates, which are the body's main source of energy. They provide a significant amount of protein, though the quality and essential amino acid balance can vary. Cereal grains contain fats, with oats and maize being particularly high in this component. Whole grains are an important source of dietary fiber, which is vital for digestion. They are a good source of B vitamins (thiamine, riboflavin, niacin, pyridoxine, biotin, folic acid) and vitamin E. Cereals contribute essential minerals like phosphorus, calcium, magnesium, potassium, iron, and zinc.

5. Whole grains are nutritionally superior because they contain all parts of the grain, including the bran, which is rich in fiber, vitamins, and minerals. The refining process removes the bran and germ, stripping away a large portion of the fiber, vitamins, and minerals. This is why the nutritional value of refined cereals is lower. Cereals like rice, wheat, and maize are staple foods for a large portion of the world's population. The consumption of whole grains is associated with a reduced risk of chronic diseases such as type II diabetes, cardiovascular diseases, and certain types of cancer. Cereal crops play a critical role in global food security, but for them to truly combat malnutrition, their nutritional quality needs to be improved and maintained.

Questions for discussion and self-assessment to Section 2

6. *Plant science as a scientific discipline and branch of agricultural production.*
7. *Contribution of outstanding scientists to the development of Plant science as a scientific discipline.*
8. *Production and botanical-biological grouping of field crops.*
9. *Theory of winter hardiness of winter cereals.*
10. *Seed science as a scientific discipline.*
11. *Field germination of seeds and ways to improve it.*
12. *Measures implemented on farms for the cultivation of environmentally friendly products.*
13. *Technology for growing winter wheat in the steppe zone of Ukraine.*
14. *Characteristics of strong and valuable wheat. The importance of technological measures in improving the quality of winter wheat grain.*
15. *Fertilization system for winter wheat grown using intensive technology.*
16. *Causes of thinning and death of winter wheat during wintering, measures to prevent them.*
17. *Winter rye. Economic importance, areas of distribution, and biological characteristics.*
18. *Technology for growing winter rye.*
19. *Winter barley. Economic importance, areas of distribution, and biological characteristics.*
20. *Technology for growing winter barley.*
21. *Economic importance, areas of distribution, and biological characteristics of hard and soft spring wheat.*
22. *Technology for growing spring wheat.*
23. *Spring barley. Economic importance, areas of distribution, and biological characteristics.*
24. *Technology for growing spring barley.*
25. *Requirements for malting barley and features of its cultivation.*
26. *Oats. Economic importance*
27. *Oat cultivation technology.*
28. *Corn. Economic importance, distribution areas, and biological characteristics.*
29. *Corn cultivation technology in the steppe zone of Ukraine.*
30. *Significance and technology of growing mixed crops of corn and grain legumes for silage.*
31. *Millet. Economic importance, distribution areas, biological characteristics.*
32. *Millet cultivation technology.*
33. *Sorghum. Areas of distribution, botanical characteristics, and biological features.*
34. *Technology for growing sorghum for grain.*
35. *Technology for growing sorghum for silage.*
36. *Rice. Economic importance, areas of distribution, biological features.*

37. *Technology of rice cultivation.*
38. *Buckwheat. Significance, areas of distribution, biological characteristics.*
39. *Technology of buckwheat cultivation.*
40. *Justify the reasons for low and unstable buckwheat yields.*
41. *The most effective methods of sowing winter and spring crops in different regions of Ukraine, their scientific justification.*
42. *The importance of grain legumes.*
43. *Peas. Significance, distribution areas, biological characteristics.*
44. *Pea cultivation technology.*
45. *Types of lupins and their biological characteristics.*
46. *White lupine cultivation technology.*
47. *The role of grain legumes in improving soil fertility.*
48. *Morphological characteristics of grain legumes.*
49. *Significance and biological characteristics of soybeans.*
50. *Soybean cultivation technology.*

3 INDUSTRIAL PLANTS

Industrial plants are agricultural plants that are grown to produce raw materials for various industries (food, textile, soap, paint, pharmaceutical, chemical, etc.). This is a large group of field plants that includes many families, so there is no common botanical, biological and ecological characteristic. According to their intended use, industrial plants are divided into groups (some representatives of the group found in Ukraine are given in brackets): *starch-bearing* (potatoes, which are usually not classified as technical plants but are considered in the group of tuberous plants), *sugar-bearing* (sugar beet, stevia), *oil-bearing* (sunflower, rapeseed, flaxseed or oil flax, camelina, castor oil), *essential oil* plants (coriander plants, rose, peppermint, clary sage), *spinning* (flax, hemp, cotton), *medicinal* (valerian officinalis, echinacea purpurea, ginseng), *aromatic and narcotic* (hops, tobacco, terry).

Some industrial crops have been cultivated in Ukraine for centuries (e.g. flax, hemp plants), some since the nineteenth century - sugar beet, sunflower, hops, some (cotton, tiffon) only recently. A new area of use of industrial plants is the production of various types of biofuels: biodiesel, bioethanol, biogas and solid fuels.

3.1 TUBEROUS CROPS

The most important and widespread tuberous plant in the world's crop production, including in our country, is the potato. Jerusalem artichoke is grown in small areas. In other countries of the world, sweet potatoes, cassava, yams, taro and other plants are common.

Sweet potatoes are common in Africa, India, China, Japan, the USA, South America, Central Asia, and the Caucasus. It is a perennial plant with creeping stems 5 m long. It forms tubers with white flesh, weighing from 0.5 to 5 kg or more. It is used as a food and fodder plant. The yield of tubers is 9.0-10.0 t/ha.

Cassava is grown in India, Africa, Central and South America, and Indonesia. It is a perennial shrubby plant that belongs to the Euphorbiaceae botanical family. Spindle-shaped tubers weighing up to 1.5 kg are formed as a thickening of the lateral roots. It is used for food purposes.

Yams are common in Africa, Asia, Central and North America. It is an annual herbaceous plant from the botanical family Dioscorea. Tubers weighing up to 5.0 kg are formed in the form of root thickenings. The taste resembles the tubers of potato plants. They are used in boiled form as potatoes. Dried tubers are used to make flour.

Taro is common in Africa, Asia, and Indonesia. It is a perennial herbaceous plant from the botanical family Aroidaceae. Tubers weighing up to 4 kg are formed at the ends of rhizomes. They are eaten boiled, fried, and used to make waffles, cookies, and cakes.

3.1.1 Potatoes (*Solanom tuberosum L.*)



Potatoes are one of the most important agricultural crops. It is one of the most important crops in global agriculture, alongside rice, wheat and corn. It is a plant of universal use. Potatoes are an important food, fodder and industrial plant. The tubers of potato plants are a real chemical laboratory and contain 25 percent dry matter, including 14-22

percent starch, 1.4-3.1 percent protein, 1 percent gluten, 0.2-0.3 percent fat and 0.8-1 percent ash elements. Potatoes are an important source of anti-scurvy vitamin C and vitamins A, B, B₁₂, B, D, which increase the body's resistance to diseases of the nervous and circulatory systems. The tubers contain a number of important organic acid enzymes (citric, oxalic, malic) and trace elements (manganese, nickel, copper, cobalt, iodine, etc.). They are also rich in pectin substances, amino acids, lipids, etc.

Potato tubers are also used as valuable fodder for farm animals in raw and steamed form. Green tops silage and industrial processing waste are also of fodder value. In terms of digestibility of organic matter (83-97 percent), it, like fodder roots, ranks among the top vegetable fodder. The feeding value of 100 kg of raw tubers is estimated at 29.5 feed units and 2 kg of digestible protein, silage - 8.5, dried cakes - 95.5, dried bard - 52 feed units. With a yield of 12.0-15.0 t/ha of tubers, the yield of feed units can exceed 5.5-6 thousand. In medicine, the potato diet is recommended as a diuretic, fresh potato juice is used for scurvy, scrofula, constipation, gastritis, and in the treatment of stomach ulcers. Raw potatoes are applied to burns. In cosmetic practice, it is included in nourishing masks. Inhaling the steam of freshly cooked potato plants helps with upper respiratory tract catarrh. Potatoes are a valuable raw material for the processing industry. Tubers are used to make alcohol, starch, molasses, glucose, dextrin and other products. 1 tonne of tubers containing 17.6 per cent starch produces 170 kg of starch and 1000 kg of cake or 112 litres of alcohol and 1500 litres of bard. Thanks to the starch, high quality protein and vitamins contained in the tubers of potato plants and their high taste, they are a very useful product for human consumption. Potatoes are rightly called the second bread. In European cuisine, there are more than 200 dishes made from potato plants and their products. Modern methods of processing potato plants into food and semi-finished products open up new opportunities for its use.

Remember: the peel and flesh of greened potato tubers contain a toxic substance called solanine (0.005-0.01 per cent), which partially decomposes during cooking. Therefore, tubers that turn green and sprout under daylight or artificial light are unsuitable for human consumption and feeding to animals without thorough boiling. Recently, a special substance has been discovered in potato skin, flowers, leaves and stems - glycoalkaloids, which are similar in structure to digitalis glycosides. In moderate doses, these compounds cause a steady and long-term reduction in blood

pressure, increase the amplitude and reduce the heart rate, have anti-inflammatory, analgesic and anti-allergic effects, and have a positive effect on the course of burn shock. As a row crop, potatoes with high agricultural technology help to reduce weediness of fields and are a good place in crop rotation for cereals and other plants, and early varieties are also suitable for winter crops. The homeland of potato plants is South America (Chile, Peru, Bolivia), where it was grown 2 thousand years BC, from where it gradually spread to Italy, France, Holland and other European countries. Peter the Great brought potatoes to from the Netherlands (1710-1725). It began to be grown intensively in in 1765. Today, potatoes are grown on all continents in most countries of the world on an area of more than 20 million hectares. The largest sown areas are in European countries - up to 13 million hectares. In the CIS, potatoes are grown on 6.0-6.5 million hectares. The global production of potato plants is 300 million tonnes. Its main producers are the United States and Canada in the Americas, China and India in Asia, and , Belarus, Poland and Germany in Europe.

Per capita consumption of potato plants in different countries ranges from 40 to 175 kg per year, including 175 kg in Belarus, 138 kg in Ukraine, 127 kg in , 99 kg in the UK, 105 kg in Japan, 80 kg in France, 60 kg in the US and 65 kg in Canada. In Ukraine, potatoes are grown on an area of 1.5-1.6 million hectares. The largest areas are concentrated in Polissya (about 60 per cent) and in the Forest-Steppe (up to 30 per cent). The average yield of potato plants in favourable years is 12.0-13.0 tonnes per hectare of tubers. Advanced farms in the Chernihiv region produce 25.0-30.0 tonnes per hectare of tubers or more. The Vlada farm in the Mlyniv district of Rivne region, using modern zonal cultivation techniques, annually harvests 35-40 t/ha.

Biological characteristics, varieties. Potato plants develop in four stages: germination, budding, flowering and ripening. The duration of each phase depends on the characteristics of the variety and growing conditions. For example, mid-season potato varieties germinate in 15-20 days, 17-24 days from germination to budding, 14-18 days from budding to full flowering, and 45-48 days from flowering to tops dying. In early-ripening varieties, each period is shorter, in late-ripening varieties - several days longer.

Temperature requirements. Potatoes are thermophilic plants. Tubers begin to germinate when the soil temperature at a depth of 10-12 cm is at least $+3...5^{\circ}\text{C}$. However, the emergence of seedlings at this temperature is delayed for up to 30-35 days and they are affected by diseases. Normal germination of tubers occurs at a temperature of $+7...8^{\circ}\text{C}$. The higher the soil temperature, the earlier the seedlings appear. The optimum temperature for tuber germination is $+18...20^{\circ}\text{C}$, at which seedlings appear 10-12 days after planting. Potatoes provide maximum yield growth at an average daily temperature of $+17...18^{\circ}\text{C}$. With sufficient light and soil moisture, the formation and growth of tubers and the accumulation of starch in them are better at a soil temperature of $+16...17^{\circ}\text{C}$, and the aboveground mass (stems, leaves) - at $+18...22^{\circ}\text{C}$. The most favourable temperature for photosynthesis is $+22...25^{\circ}\text{C}$. At temperatures above $+30^{\circ}\text{C}$, assimilation processes, tuber growth and starch accumulation in them stop. High temperatures not only inhibit tuber growth, but also cause degeneration of potato plants, which is the main reason for the limited cultivation of potato plants in southern arid regions.

Potatoes are sensitive to light frosts. Seedlings die when temperatures drop to $-2...3^{\circ}\text{C}$. However, the tubers in the soil remain viable and have the ability to germinate and form new seedlings. During autumn frosts, when the soil temperature drops to -2°C , the tubers freeze and lose their ability to germinate. The sum of temperatures above $+10^{\circ}\text{C}$ during the growing season required for the full development of potato plants for early and mid-early varieties is $1000-1400^{\circ}\text{C}$, and for late-ripening varieties - $1400-1600^{\circ}\text{C}$.

Moisture requirements. Potatoes are very demanding on moisture, as they form a powerful aboveground mass with an underdeveloped root system. The transpiration coefficient of potato plants is 400-550, but it can vary from 170 to 660, which indicates its considerable plasticity and adaptability to environmental conditions. On fertile soils with sufficient nutrients, potatoes use water sparingly. The best conditions for the growth and formation of a high yield of tubers are created at a soil moisture content of 70-80 per cent of HB in the area where the root system is located during flowering and tuber formation, and 60-65 per cent during the accumulation of starch in tubers.

As potato plants grow, the need for moisture increases. The critical period for it is the flowering phase, when the leaf surface reaches its maximum size. Lack of moisture in the soil at this time leads to a 17-20 per cent reduction in tuber yield. The lowest moisture requirements are observed in the initial period, when seedlings and sprouts are formed at the expense of the water of the mother tuber.

Potatoes are better able than other plants to use water from the air through their leaves, which makes them less susceptible to short-term droughts. However, a guaranteed high yield of potato plants can only be obtained if there is at least 300 mm of rainfall during the growing season. Therefore, in areas of insufficient moisture, special care should be taken to preserve and accumulate moisture in the soil. Under these conditions, the moisture deficit can only be compensated for by irrigation.

At the same time, potatoes do not tolerate excessive soil moisture, which negatively affects their growth and development. Under conditions of excessive moisture, when soil moisture exceeds 85 per cent of the HB, premature plant death is observed, tuber growth stops, they rot, and their yield and quality deteriorate sharply.

Light requirements. According to the modern classification, potato plant varieties are classified as short-day plants. Although a short day is not mandatory for potatoes, the tuberisation period is reduced in short-day conditions. However, when potato plants are grown in areas with long daylight hours, more intense flowering, better development of vegetative organs and higher tuber yields are observed.

Like any other row crop, potatoes are demanding of light. When shaded, excessively thickened or heavily weeded, the plants turn yellow, stretch out, hardly bloom, and photosynthesis, metabolism and soil nutrition are disrupted, leading to late tuber formation and reduced yields.

The direction of the rows has a significant impact on the yield and quality of tubers. According to research, potato plants receive better light throughout the day if the rows are placed in the southeast, northeast or northwest directions compared to the west-east direction.

Nutrient requirements. Potatoes consume the greatest amount of nutrients during the intensive growth of the aboveground mass and at the beginning of tuberisation

(flowering phase). At the end of the growing season, the use of nutrients by plants gradually decreases and stops altogether at the beginning of leaf drying. During the flowering period, potatoes use about 60 per cent of nitrogen, 45-50 per cent of phosphorus and more than 50 per cent of potassium.

With an average yield of 18.0 tonnes per hectare of tubers and 8.0 tonnes per hectare of tops, potatoes remove about 95-105 kg of nitrogen, 40-50 kg of phosphorus, and 110-120 kg of potassium from the soil. In terms of one tonne of tubers, this amounts to 5.6 kg of nitrogen, 2.2 kg of phosphorus and 6.4 kg of potassium.

Soil requirements. The root system of potato plants is characterised by an increased respiration rate, especially during the period of tuber formation. The formation of 1 g of dry matter requires 7-12 mg of oxygen per hour. In order to provide sufficient oxygen, the soil must be sufficiently loose. On loose soil with a bulk density of 1.1-1.2 g/cm³, the root system is better supplied with oxygen and has a high absorption capacity. On compacted, moisture-saturated soils, roots and tubers rot and die as a result of oxygen starvation. In addition, stolons develop poorly on compacted soils, and small, often deformed tubers are formed.

For the normal development of tubers, the soil must be loose, fertile, aerated and permeable. Sufficiently fertilised sandy loam and loamy soils and light chernozems are the most suitable for potato plants. When organic fertilisers are applied, potatoes can also be grown on light sandy soils. Heavy clay soils are not very suitable for potato plants. On such soils, potatoes suffer from diseases and produce small tubers with a low starch content. Potatoes also produce poorly on saline soils. Potatoes grow and develop better when the soil solution is slightly acidic (pH 5-6). It grows poorly on acidic and alkaline soils (pH below 4.5 and above 8).

Degeneration of potato plants. Prolonged vegetative propagation of potato plants leads to their degeneration, which is characterised by premature bud awakening in the eyes, the formation of long shoots, the development of small tubers affected by viral and other diseases, and a decrease in plant productivity. The degeneration is caused by unfavourable environmental conditions during the growth and development of potato plants and viral diseases.

The environmental causes of degeneration include high temperatures and lack of moisture in the soil during tuberisation, as well as unfavourable plant nutrition. At temperatures above +25⁰ C, the composition of plant proteins changes, and the buds germinate prematurely with the formation of long and thin shoots. Under such conditions, potato plants have low productivity and form small tubers. Environmental degeneration occurs most often in the southern regions. Viral degeneration of potato plants is observed in different climatic conditions. This degeneration is caused by viruses X, S, Y, M, L, R and others. External signs of the virus disease are curling, wrinkling and mottling of leaves, small tubers, etc. It has been established that viruses are transmitted by aphids. Viral disease depends on the characteristics of the variety, soil, temperature, and agricultural practices.

Degeneration of potato plants can also occur as a result of planting physiologically old tubers, late planting, and poor agricultural practices. In the southern regions, the combined effect of unfavourable environmental conditions and viral diseases on plants increases the degeneration of potato plants.

The main measures to prevent degeneration of potato plants are the cultivation of varieties resistant to viruses and other causes of degeneration, the cultivation of elite plants not affected by viruses using the meristem plant method, careful control over the reproduction of promising clones, etc. Depending on the method of use, potato varieties are divided into 4 groups: table, fodder, technical and universal. About 60 per cent of the sown area is occupied by table varieties, which are characterised by high taste, a favourable ratio of protein and starch and a high content of vitamin C in tubers, which are round and oval in shape with superficial eyes. These are usually early- and mid-season varieties. Technical varieties are often late-season, contain the highest starch content (18-25 per cent) in tubers and are characterised by good keeping quality. Fodder varieties are characterised by high protein content (up to 2 per cent or more) and high yields.

Tubers of universal varieties have good taste and high starch content. Depending on the needs, they are used as table, technical or fodder. According to the ripening time, the varieties are divided into early ripening (50-60 days), medium early (60-80 days), medium ripening (80-100 days), medium late (110-120 days) and late ripening (120-150 days).

The following potato varieties are zoned in Ukraine: *early ripening* - Asterix, Borodyanskaya pink, Bonsedar, Vesta, Vineta, Vitara, Garth, Dnepryanka, Zov, Impala, Kobza, Cardena, Karatop, Mriya, Melody, Nemishayevskaya 100, Povnen, Presto, Ferry, Rosa, Rosalind, Serpanok, Tiras, Chernihivskaya early, etc. *medium early* - Caesar, Fantasia, Solara, Slavyanskaya, Satina, Sante, Sekura, Polyana, Pekurovskaya, Malinskaya white, Malich, Kupava, Zabava, Delikat, Goldila, Vodograi, etc. *medium-ripening* - Bagryana, Virinea, Vera, Volya, Gornaya, Dara, Cinderella, Zakhidnyi, Zoryanaya, Karalina, Kurazh, Leleka, Lybid, Olvia, Slava, Santana, Ukrainskaya rosnaya, Sycamore, etc.; *medium-late* - Chervona Ruta, Teterev, Saturna, Oksamit 99, Dubravka, Dzvon, etc.; *late-ripening* - Drevlyanka, Bernadette, etc.

Agricultural technology. *Place in the crop rotation.* The best places in the potato crop rotation are winter seed plants after perennial grasses and fallow land, legumes, corn for silage, flax, annual and perennial grasses. In Polissya, potatoes are grown after lupine for green manure for post-harvest sowing, and in the Forest-Steppe - after winter wheat plants in a link with seed legumes, corn and sugar beet plants, provided there is sufficient moisture. In the arid regions of the Steppe, high yields of potato plants are obtained in irrigated vegetable crop rotations, in floodplains, and in low-lying areas. In vegetable crop rotations, potatoes are grown after many plants, except for nightshades, which share many common pests and diseases.

Potatoes are one of the few plants that, with high cultivation practices, can produce high yields when re-grown on the same field as last year. Therefore, in specialised crop rotations, where 35-50 per cent of the area is allocated to potatoes, they are grown again under high agronomic standards. Potatoes, in turn, are a good place in crop rotations for early spring crops (wheat, barley, oats), legumes, oilseeds and spinning plants. Often potatoes are grown as a greenhouse plant, using early varieties for this purpose.

Soil cultivation. Methods of soil cultivation depend on soil and climatic

conditions, soil type, place in the crop rotation, fertilisation system, etc. After cereals and legumes, the main tillage involves stubble peeling and deep ploughing. Stubble cultivation is carried out with disc harrows to a depth of 6-8 cm simultaneously or after harvesting in the crop rotation. Ploughing is carried out 2-3 weeks after peeling. In fields after non-stubble crops, ploughing is carried out immediately after harvesting. On sandy soils where fertilisers are applied in spring, instead of autumn ploughing, two stubble peelings are carried out: the first one is immediately after harvesting the place in the crop rotation to a depth of 5-6 cm, the second one - after 20-30 days to a depth of 10-12 cm with ploughshares. Deep ploughing is carried out in the spring with the simultaneous application of organic fertilisers.

According to scientific institutions and best practices in Polissya and Northern Forest-Steppe, replacing autumn ploughing with spring ploughing has virtually no effect on the yield of potato plants if spring ploughing is carried out without delay and in a short time.

The depth of ploughing for potatoes depends on the depth of the topsoil. On light soddy-podzolic soils with a shallow topsoil, it should be deepened by 3-5 cm with mandatory fertilisation. In spring, harrowing is carried out in 1-2 traces. To create a loosened layer, cultivate to a depth of 14-16 cm. On flooded soils, spring ploughing of the fallow is practiced, and in years with low rainfall, ploughing with ploughs without skimmers. In the case of high humidity and prolonged spring, in addition to ploughing before planting tubers, the soil is loosened by chisel cultivators or ploughs without shelves by 16-18 cm. A new, progressive way of preparing the soil is to plant potato plants in pre-cut ridges. Due to the faster soil warming up in the ridges, potato plants can be planted earlier. The ridges increase the root layer of the soil, which contributes to better plant nutrition and development.

Fertilisation. Numerous studies have shown that on almost all types of soils common in the areas where potato plants are grown, potatoes absorb the most nitrogen from the soil (on deep and ordinary black soils - phosphorus). The most demanding plants for nutrients are during the budding - flowering period.

Organic fertilisers are applied to potatoes. Organic fertilisers provide the greatest growth on lightly textured sod-podzolic soils. The best organic fertiliser for potato plants is semi-rotted manure. In Polissia, 50-60 t/ha of semi-rotted manure or peat compost is applied directly to potatoes, and in the Forest-Steppe, 40 t/ha is applied to the crop rotation. When applying liquid manure, its rate is increased by 1.5-2 times. The best time to apply organic fertilisers is in autumn for autumn ploughing. Green fertilisers such as lupine, rapeseed, and winter rye are also used as organic fertilisers, which are ploughed into the soil together with phosphorus and potash fertilisers in autumn.

The effectiveness of mineral fertilisers depends on the type and degree of soil vegetation, weather conditions, and cultivation practices. Increasing the doses of nitrogen and phosphorus fertilisers to 60-90 kg/ha and potash fertilisers to 90-135 kg/ha (active ingredient) in the non-chernozem zone provides significant yield increases. The maximum yield increases from mineral fertilisers are obtained on sod-podzolic and grey podzolic soils.

More efficient and economical combined use of organic and mineral fertilisers.

Mineral fertilisers provide potatoes with nutrients in the first half of the growing season, while organic fertilisers provide them with nutrients in the second half, when they are mineralised. Against the background of organic fertilisers, depending on soil fertility, full mineral fertiliser is applied at the rate of: on black soil - N P K₆₀₋₉₀ 60-90 60-90 ; on sod-podzolic, grey forest, light chestnut soils - N P K₉₀₋₁₂₀ 60-90 90-120 . On drained peat soils, only phosphorus-potassium fertilisers are used at the rate of P K₆₀₋₉₀ 90-120 . Phosphorus and potash fertilisers are applied for autumn ploughing, and nitrogen fertilisers are applied in spring for cultivation. Fertilisers are also applied to the rows when planting potato plants with potato planters. The best phosphorus fertiliser for potato plants is superphosphate, and on acidic sod-podzolic soils, phosphate rock. Nitrogen fertilisers for potatoes include ammonium nitrate, ammonium sulphate, urea and ammonia water. Potash fertilisers should be chlorine-free or concentrated with a low chlorine content. These fertilisers include potassium sulphate, potassium magnesium, wood ash, and potassium salt. It is better not to use potassium chloride and raw potash fertilisers for potatoes.

Microfertilisers (manganese, boron, copper) for potatoes are effective on sandy and sandy loamy sod-podzolic soils. It should be noted that the greatest yield increases are obtained on soils poor in micronutrients. Microfertilisers are applied in different ways: together with mineral fertilisers during ploughing or foliar feeding, spraying the planting material with a solution of appropriate microfertilisers at the rate of 50 litres of solution per 2.5-3 tonnes of tubers.

Liming the soil, as already mentioned, helps to increase yields and improve the quality of tubers. Limestone fertilisers should be applied under the previous plant. Applying high rates of lime directly to potatoes causes the development of actinomycetes, which results in scabbed tubers and worsens potassium nutrition. If limestone fertilisers were applied under the previous plant, they may not be applied directly under the potatoes or 0.5 doses are applied according to hydrolytic acidity for ploughing in autumn, winter on snow, and spring during pre-sowing tillage.

The timing and methods of fertilising potatoes depend on the soil and climatic conditions, types and forms of fertiliser. On chernozem soils, full mineral fertiliser applied in autumn provides the same yield as when applied in spring. In the western regions and on sod-podzolic sandy loam soils in the non-black earth zone, phosphorus and potash fertilisers can be applied in autumn or spring, and nitrogen fertilisers in spring. On light soils, as well as on soils with a high groundwater table, where deep soil freezing is possible, it is advisable to apply not only nitrogen but also phosphorus and potassium fertilisers in autumn and winter and in spring.

Preparing tubers for planting. For planting, use healthy, non-degenerate tubers. Before storing them, remove any diseased or damaged tubers. In the spring, the tubers are inspected and sorted again. Planting material should be typical for the variety, free from mechanical damage and disease. It is not recommended to plant spindle-shaped tubers with pale colour and thread-like seedlings, i.e. with signs of degeneration. For planting, it is more advisable to use tubers that are medium in size (60-80 g), but small (30-50 g) and large (over 90 g) tubers are also planted. Tubers of different sizes should be planted separately. Large tubers are cut into pieces weighing 20-30 g with 3-4 eyes. Cut the tubers the day before or on the day of planting. Before planting, the cut tubers

are treated with Fundazole (0.5-1.0 kg/t) and Vitavax (2 kg/t).

Germination of tubers before planting accelerates the emergence of seedlings, promotes better growth and development of the aboveground mass, roots, stolons and tubers. Pre-planting germination is effective in areas with a short frost-free period, at late planting dates on peat soils. Tubers are germinated in the light or in the dark, on racks or in boxes in special rooms (vernalisers) adapted for this purpose, sometimes covered with plastic wrap. Tubers for germination are placed in 2-3 layers, and the boxes are stacked in stacks of 10. Blocks of fluorescent lamps are placed on shelves between the stacks of boxes. The room is maintained at a temperature of +12...15°C and a humidity of 80-90 per cent. For uniform lighting, the tubers are periodically turned over. In addition, tubers are also germinated in a humid environment (in sawdust, peat, humus), in plastic bags or sleeves, in storage and piles using generators for heating, etc. Tubers of early-ripening varieties are germinated 35-45 days before planting, and mid-ripening varieties - 45-60 days before planting.

Planting. When planted too early in unheated soil, tubers do not germinate for a long time and are damaged by diseases, which leads to thinning of the plants and a decrease in yield. Delayed planting also negatively affects the yield of potato plants.

Potato plants are planted when the soil warms up to a temperature of +6...7°C at a depth of 10-12 cm. On light soils, where the soil warms up more quickly, potatoes are planted in the early stages - simultaneously with sowing early cereal plants. First of all, sprouted tubers of early-ripening varieties are planted, followed by seed and marketable potatoes of later ripening varieties.

In areas where there is a lot of rainfall and stagnant water, ridge planting is used. The most common method of planting potato plants is the ridge method, in which tubers are worked into the soil to a depth of 4-6 cm and then a ridge is poured. The distance from the top of the ridge to the surface of the tubers is 15-16 cm. On ridged crops, potatoes can be cared for before emergence. The row spacing when planting potato plants is 70 cm with tubers placed in a row at a distance of 25-35 cm. Sometimes planting with a row spacing of 90 cm is used.

The depth of planting on light soils is 12-14 cm, on heavy moist clay and loamy soils, as well as on lowland soils - 7-8 cm, in areas of sufficient moisture on chernozem soils - 10-12 cm, in areas of insufficient moisture and in the southern and southeastern regions - 12-15 cm. The average density of planting with tubers weighing 50-80 g in areas of sufficient moisture (Polissya, Northern Forest-Steppe) is 55-60 thousand/ha, seed - 65-75 thousand/ha; in the zone of unstable moisture (Southern Forest-Steppe) - 50 and 55 thousand/ha, respectively; in the Steppe - 45 and 50 thousand/ha; under irrigation - 55 and 60 thousand/ha. Potatoes are planted more densely (by 10 per cent) on more fertile soils, when growing early varieties and using small tubers. Depending on the size of the tubers, 3.5-4.5 tonnes are planted per hectare. Care of potato *plants* begins with harrowing, which is carried out 2-3 times before and 1-2 times after emergence. On ridge and semi-ridge crops, on the 6-8th day after planting, profile, rotary and mesh harrows, cultivators with arrow tines and razor tines are used.

After emergence, inter-row loosening is carried out: the first to a depth of 12-14 cm, and the subsequent ones to a depth of 10-12 cm. If there is insufficient soil moisture, the loosening depth is reduced to 6-8 cm.

During budding, potato plants are hilled by 8-10 cm. In conditions of insufficient moisture, shallow loosening is carried out instead of hilling. Hilling is most effective immediately after rain.

Weed control is of great importance in the potato care system. After harvesting, continuous-acting herbicides (Roundup, etc.) are used in the stubble crop rotation when weeds are growing intensively. The following herbicides are applied to potato crops before germination: Gesagard (3.0-4.0 kg/ha), Dominator (2 litres/ha), Zenkor (0.5-1.5 kg/ha), Stomp (5 litres/ha), Hurricane Forte (1.5 litres/ha). During the growing season of potato plants, when weeds are in the 3-4 leaf stage, we apply insurance herbicides Panther (1.5-2.0 l/ha), Targa (2.0-4.0 l/ha), Titus (50 g/ha), Shogun (0.6-1.2 l/ha), Fusilade super (1.0-3.0 l/ha). For protection against the Colorado potato beetle, Decis (0.2-0.5 l/ha), Karate (0.1-0.2 l/ha), Aktara (0.06-0.08 g/ha), Bankol (0.2-0.3 kg/ha), Confidor (0.2-0.25 l/ha), Mospilan (0.02-0.025 kg/ha), Fury (0.07 l/ha) are used. Crops are treated twice: the first time after early emergence of potato plants during the period of mass emergence from the soil and settlement of beetles, the second time after 10-15 days, when the second generation larvae appear en masse. Against late blight, the first spraying of crops is carried out during the budding period - at the beginning of flowering (according to the data of the disease and pest forecasting centre or plant protection station). Crops are treated again when black spots appear on the plants. Then the fields are sprayed every 8-10 days if the disease spreads. Acrobat (2.0 kg/ha), Ridomil (0.8-1.0 kg/ha), Tatta (3.0 litres/ha), Champion (2.5-3.0 kg/ha) are used.

Harvesting. The signs of full tuberisation of potato plants are drying tops, drying stolons and easy detachment of tubers from them. 3-4 days before harvesting, on heavy soils, the row spacing is loosened to a depth of 14-16 cm to improve the performance of potato harvesters. Depending on the variety and use of the tubers, potatoes are harvested at different times. Early varieties used for food are harvested before they are fully ripe.

Potato harvesting should begin during the period of potato tops dying off so that it can be completed at an air temperature of +7...10°C. First, seed potatoes are harvested, and then food potatoes. 3-4 days before harvesting, tops of potato plants are mowed on food crops and 10-12 days before harvesting on seed crops with a KIR-1.5B tops harvester. Potatoes are harvested by combine harvesters and potato diggers in a direct, separate, streaming or combined way. In this method, the tubers are first dug up by windrowers and placed in windrows of two, four or six rows. After drying, the tubers are picked up by combines. The remaining rows are dug up by a combine harvester.

In direct harvesting, the tubers dug up by the combine are separated from the soil and tops and piled in a hopper. In the separate harvesting method, the tubers dug from several rows (2, 4, 6) are placed in a windrow for subsequent pick-up by combines. In the combined method, tubers from 2 or 4 rows are piled by diggers between the rows of two unexcavated rows, after which these rows are harvested by direct combining. The most efficient harvesting method is in-line harvesting, which uses a system of topshearers, a potato harvester, and a sorting station of the KSP-15B type. To improve the performance of the harvesters, the row spacing is loosened to a depth of 14-16 cm 2-3 days before harvesting. There are 2-3 harvesters working in each field. The potatoes are unloaded from the bins into trucks and transported to a sorting facility,

where they are dried and sorted. In the flow-through harvesting method, tubers are stored for some time in piles on the field under a layer of straw. After removing disease-affected tubers, it is advisable to keep seed potatoes in the light for 10-12 days until they turn slightly green. The greened tubers accumulate the alkaloid solanine (0.3-0.4 per cent), which protects the tubers from disease.

Potatoes are stored in specialised potato stores and kagats. In potato storage facilities, a favourable storage regime for tubers is created by active ventilation. The temperature should be $+2...4^{\circ}\text{C}$, and the relative humidity should be 85-90 per cent.

Methods of improving seed potato plants. When growing seed potato plants, the same set of agronomic measures is mainly used as when growing high yields of commercial potato plants. However, specialised measures are also used for this purpose. To obtain high-quality seed material, potato plants are planted in the summer, grown on peat bogs, and harvested with unripe tubers.

During summer planting, tuber formation occurs in more favourable conditions than during spring planting. When potato plants are planted in late June and early July, tuber formation occurs in mild weather, when it rains and daylight hours are reduced. For summer planting, seed material is imported from closed northern regions. Freshly harvested tubers from spring plantings are also used for planting. Planting density is 60-65 thousand per hectare. During the summer-autumn growing season, potatoes are watered 4-5 times after emergence at a watering rate of $450\text{-}500\text{ m}^3/\text{ha}$ and disease-affected plants are removed. Potatoes are harvested in the second decade of October. Summer planting is particularly effective in the Ukrainian Steppe.

Features of growing potato plants under irrigation. Irrigation of potato plants is especially effective in arid southern regions. Under irrigation conditions, the yield of tubers is almost doubled. Potatoes are planted under irrigation by the ridge method, the planting density is increased to 55-60 thousand bushes per 1 ha. The rate of organic and mineral fertilisers is increased by 30-40 per cent. Tubers are planted to a depth of 8-10 cm. The need for watering is determined by the condition of the plants (wilting of leaves in the daytime) and soil moisture. During the period of flowering and tuber formation, soil moisture should be at the level of 75-80 percent HB. Potatoes are watered 3-5 times with an irrigation rate of $450\text{-}500\text{ m}^3/\text{ha}$ of water. Stop watering when the bulk of the tubers are formed. After each irrigation, inter-row cultivation is carried out. During the budding period, potatoes are hilled. Watering is more effective if it is combined with vegetative fertilisation with mineral fertilisers, especially during the tuberisation period.

3.2 ROOT CROPS

Fodder roots include fodder beetroot, carrots, rutabagas and turnips, which are grown to produce juicy fodder. Succulent fodder contains a lot of carbohydrates, vitamins and minerals that are easily absorbed by the animal body.

Fodder roots are primarily an important source of easily digestible carbohydrates, the content of which in fodder beetroots, carrots and rutabagas is about 9 per cent, and in turnips - up to 7 per cent, and the digestibility coefficient reaches 96-98 per cent. The protein content is low, at around 1.1-1.5 per cent, but it is characterised by a rich amino acid composition and good digestibility. Root vegetables also contain

a significant amount of minerals (1-1.5 per cent) and vitamins. Carrot roots are particularly rich in vitamins. It contains all the vitamins known so far. Of all root vegetables, carrots contain the most carotene (provitamin A). It contains 700-1400 mg of carotene per 1 feed unit.

In addition to root crops, tops are also used for fodder, which yields 20-25 c/ha of fodder units with a root crop yield of 500-600 c/ha. Fodder roots produce high yields and feed unit yields. For example, fodder beetroot yields 800 c/ha of roots and 150 c/ha of tops, producing 120-130 c/ha of fodder units. The nutritional value of fodder roots is characterised by the data given in Table 3.1.

As row crops, root crops leave fields free of weeds and provide a good place in the crop rotation for the following plants. Fodder beetroot and carrots are grown in all zones, while rutabagas and turnips, being moisture-loving and low in heat, are most common in the Northern Forest-Steppe and Polissya.

Table 3.1
Number of feed units and digestible protein per 100 kg of plants

Plants	Root vegetables		Gypsy	
	feed units	digestible protein, kg	feed units	digestible protein, kg
Fodder beetroot	11,5	0,3	9,3	0,7
Carrots	13,3	0,4	16,5	1,5
Rutabaga	12,5	0,4	10,2	0,8
Turnips	9,0	0,4	11,3	0,9

3.2.1 Sugar beet (*Beta vulgaris* L.)



Sugar beet is the main source of large-scale sugar production in Ukraine and many other temperate countries. Sugar is extremely important economically as a food product and raw material for industry. Sugar is produced in 116 countries: 71 from sugar cane, 34 from sugar beet, and 11 from both sugar cane and sugar beet. While at the beginning of the twentieth

century more than half of the total amount of sugar was produced from sugar beet, after the Second World War, sugar production from sugar beet and sugar cane reached a ratio of 30:70. In recent years, the share of sugar produced from sugar beet has decreased to 23-25 per cent. Sugar beet is also an important factor in strengthening the fodder base and increasing crop production. Thanks to favourable soil and climatic conditions, Ukraine has always been a leader in terms of sugar beet planting and sugar production. The country needs almost 2 million tonnes of sugar annually to meet its domestic needs alone. Root crops contain 17-19 per cent of sugar, and under favourable

growing conditions, high-sugar varieties and hybrids contain up to 20 per cent. Sugar is mainly represented by the carbohydrate *sucrose* ($C_{12}H_{22}O_{11}$). It is crystallised from plant sap and occurs naturally in its pure form. Sucrose consists of glucose and fructose molecules and is hydrolysed to these constituent elements by enzymes in the human body. The chemical composition of root vegetables can be characterised by the following indicators: water content 75 per cent, dry matter 25 per cent, of which sugars are 17.5 per cent and non-sugars 7.5 per cent. The content of certain substances depends on soil and climatic conditions and technology. For example, dry matter can range from 16 per cent to 26 per cent, and sugar from 8 per cent to 23 per cent. Root crops also contain 2 per cent fibre, 1.5 per cent nitrogenous substances and 0.7 per cent ash.

The value of sugar beet is not limited to sugar production. It is also used as a fodder plant. With a sugar beet yield of 50.0 t/ha, an additional 2.8 t/ha of pulp, 1.8 t/ha of molasses and 36.0 t/ha of silage from the tops are produced, which can be equated to the yield of winter wheat plants of 8.3 t/ha.

Sugar beet roots are significantly superior to other root crops in terms of their fodder properties: 100 kg contains 26 feed units, 1.2 kg of digestible protein, 0.5 kg of calcium and 0.5 kg of phosphorus. However, sugar beet is only 40 per cent digestible by cattle, while fodder beet is 100 per cent. Therefore, it is not advisable to feed them to animals. The weight of the tops is 35-50 per cent or more of the weight of the roots, and they are used for green fodder and silage. It contains 26.5 per cent dry matter, including 2.5-3.5 per cent protein, 0.8 per cent fat, and many vitamins. 100 kg of tops corresponds to 18-20 feed units. Although the fodder properties of sugar beet tops are not bad, their use for livestock feed is increasingly losing its economic importance. For example, in Germany, less than 10 per cent of farms currently use it for this purpose. Beet tops are a valuable organic fertiliser. Ploughed up beet tops are a good slow release fertiliser for subsequent plants, especially cereals. 10 tonnes contains about 31 kg N, 57 kg K_2O and 9 kg Mg, with a variation of up to 50 per cent. A tops yield of 40.0-50.0 t/ha equals 30 t/ha of manure. Beetroot processing produces many other products: pulp, molasses (or molasses), and defecate. *Molasses* contains up to 60 per cent sugar and is close to grain in terms of feed value: 100 kg of it corresponds to 77 feed units and 4.5 kg of digestible protein. It is used to produce mixed fodder, processed into alcohol, bioethanol, glycerin, yeast, citric acid and other substances for the chemical, perfume and food industries. The yield of raw *pulp* is 80 per cent, pressed pulp is 40 per cent, and molasses is 4.5-5.5 per cent of the processed root crops. 100 kg of fresh pulp contains 8 feed units and 0.9 kg of digestible protein, and 100 kg of dry pulp contains 85 feed units and 3.9 kg of digestible protein. Waste from sugar beet processing - *defecate* - is used to reduce soil acidity. Defecate is a limestone fertiliser containing 60-75 per cent $CaCO_3$, 10-15 per cent organic matter, 0.2-0.7 per cent N, 0.2-0.9 per cent P_{2O_5} and 0.3-1.1 per cent K_2O . Application of defecate increases sugar beet yield by 2.0-4.0 t/ha and sugar yield by 0.2-0.4 per cent.

Sugar beet is of great agronomic importance. This plant requires deep soil cultivation, fertilisation, and careful crop maintenance, so it is a valuable crop in the rotation of many agricultural plants.

The history of the sugar beet plant is not that old. The homeland of sugar beet is the Mediterranean (West Asia), where it was cultivated around 2000-2500 BC.

According to scientists, it is probably the only plant created by man. The biennial sugar beet plant is believed to have originated from a wild annual form that still grows on the coasts of the Mediterranean, Caspian and Black Seas, in the Transcaucasus and Asia Minor. Leafy forms of beetroot were cultivated 1500-2000 years before Christ, and root forms were known in Central Asia 500-800 years before Christ. Root beet cultivation began in Kievan Rus in the X-XI centuries, and in Western Europe in the XIII-XIV centuries.

Leafy forms (chard) were the first to be introduced into the plant, and later root forms. The appearance of root sugar beet dates back to the beginning of the 18th century; its original form was white garden beet. The widespread development of sugar beet production in Ukraine began in 1840, when a powerful sugar factory was built in the village of Smila. Sugar beet was originally grown by seedlings, and sowing with seeds was introduced in the mid-nineteenth century. Among sugar-bearing plants, sugar beet is second only to sugar cane in terms of area under cultivation. Over the past 14 years, its area has been declining. The global area under sugar beet cultivation is more than 9 million hectares. The main crops are concentrated in Europe (37.1 per cent of the world's), Asia (17.4 per cent) and North America (7.7 per cent). Among the countries, the largest sugar beet areas are in - 1.25 million hectares, Germany - 0.57 million hectares, the USA - 0.56 million hectares, and France - 0.46 million hectares.

The global sugar beet harvest totals 264 million tonnes. produces the most sugar beet roots - 31.1 million tonnes, France - 29.9 million tonnes, Germany - 23.8 million tonnes, and the USA - 24.6 million tonnes. In Ukraine, the current production of root crops is 12.3 million tonnes.

At the end of the twentieth century, beet acreage in Ukraine was between 1.6-1.7 million hectares. In recent years, they have decreased significantly. For 2013, the projected area under sugar beet is 450 thousand hectares, gross harvest of root crops is 12.0-14.0 million tonnes, and sugar production is 1.5-1.7 million tonnes. The largest areas of sugar beet are concentrated in Poltava, Cherkasy, Kyiv, Vinnytsia, Khmelnytsky, Kharkiv and Ternopil regions. Sugar beet is a high-yielding plant. The average global yield of the root crop is about 36.0 tonnes per hectare. Among the countries, the highest yields are in France - 65.0 t/ha, Italy - 49.7, the UK - 54.8, the USA - 44.0, and Germany - 58.3 t/ha. According to the State Statistics Committee of Ukraine, the average yield of sugar beet roots in 2012 was 41.1 t/ha.

Biological characteristics, hybrids. The relation of sugar beet to the main factors of life - moisture, heat, light, soil, and nutrient content in the soil - is determined by its biological characteristics. The formation of a large mass of organic matter, including sugar, is possible with a sufficiently long growing season, good lighting and favourable temperature conditions, and sufficient soil moisture content.

Requirements to moisture. Sugar beet was developed in regions with high relative humidity, so it is adversely affected by a sharply continental climate. Plants develop poorly in the absence of precipitation in March and April. The period of emergence should be warm with moderate rain, the first half of summer should be cool and rainy, and then moderately dry and warm weather should prevail.

Water is a crucial factor in growing high yields of sugar beet. It is necessary for seed germination (160-170 per cent of its weight), cooling of plant tissues through

transpiration, ensuring the turgid state of plants, opening of stomata, photosynthesis and other biological processes.

Sugar beet is a water-efficient plant that is relatively drought-resistant. Their transpiration coefficient is about 400. They have a well-developed root system, which makes it possible to use moisture from deep soil layers; a long growing season ensures the use of precipitation in the second half of summer; anatomical and physiological features of their structure ensure photosynthesis during dry periods at high temperatures, when other plants become depressed. However, sugar beet consumes a lot of water and deeply dries the soil. With a root weight of 400-500 g, one plant consumes 30-35 litres of water during the growing season, and 1-2 litres of water during one hot July day. For the formation of 1 g of raw root mass from the soil, 70-80 cm³ is used, and 1 g of sugar requires 450-500 cm³ of water. Only to ensure transpiration at a yield of 40-50 t/ha of root crops, plants absorb 4000-5000 m³ of water from the soil. Optimal soil moisture for the growth and development of sugar beet ranges from 50 to 90 per cent of HB.

Requirements to heat and light. The energy basis of crop production is solar insolation, which determines the amount of photosynthetically active radiation (PAR) during the growing season. PAR is the part of solar radiation in the wavelength range of 0.38-0.71 microns that is used in the process of photosynthesis by plants. The amount of PAR is approximately 52 per cent of the total (direct and scattered) radiation that reaches the Earth's surface. Beetroot leaves use blue-violet (0.40-0.48 microns) rays most intensively, and orange-red (0.65-0.69 microns) rays for vegetative mass growth.

Solar radiation resources for sugar beet are estimated by the average long-term sums of total solar radiation during the growing season with temperatures above +5⁰ C. The heat supply should be at least 80 per cent.

In terms of importance for the accumulation of sugar in root crops in the second half of the growing season, in areas of sufficient moisture, the first place should be given to lighting, and the second to air temperature. In areas of unstable and, especially, insufficient moisture, moisture takes the first place. Seed germination, plant growth and sugar beet productivity directly depend on the thermal regime. The heat demand of sugar beet during the period from sowing to technical maturity is determined by the sum of active temperatures of 2340⁰ C. In the sugar beet growing regions of Ukraine, the sum of average daily air temperatures above 5⁰ C from the beginning of the growing season to the mass harvesting of sugar beet is 2400-2800⁰ C.

The most favourable temperature for germination of sugar beet seeds is about 20⁰ C. The duration of the germination period depends on the soil temperature. Thus, at soil temperatures of +1...2⁰ C, seeds germinate within 45-60 days, +3...4⁰ C - 25-30, +6...7⁰ C - 10-15, +9...10⁰ C - 8-10 and +11...12⁰ C - 3-4 days.

Beetroot seedlings can tolerate short-term frosts on the soil surface of -3...5⁰ C, and sometimes up to -6...7⁰ C. Root crops dug up in autumn are damaged by frosts of -2⁰ C.

Sugar beet is most productive when the temperature of the root layer of the soil is about +30⁰ C during the day and +10⁰ C at night. Soils on which sugar beet is grown must have a sufficiently high absorption capacity. The soil absorption complex of such

soils is saturated with calcium, which leads to favourable physical, chemical and biological properties of the soil. The optimum amount of exchangeable calcium in the soil for sugar beet is 60-70 per cent of the absorption capacity, while exchangeable magnesium and potassium are 10-15 and 3.5 per cent, respectively. Such soils create the most favourable water, air and thermal conditions. Humus substances retain plant nutrients in the soil, promote their rational use, reduce unproductive losses and prevent environmental pollution.

Humus ensures a continuous supply of soil carbon dioxide to the surface air layer, which improves photosynthesis and the accumulation of sugar in root crops. In a fertile, well-structured soil, the solid phase accounts for 50 per cent of the total volume. The most agronomically valuable are structural aggregates with a size of 1.0-0.25 mm. Soil density is of great importance for sugar beet. It is determined by the volume mass of the soil in its natural (undisturbed) structure in g/cm^3 and is considered loose - up to 1.1; dense - 1.15-1.35, very dense - more than 1.35 g/cm^3 . The most favourable conditions are created when the total soil porosity is 53-58 per cent, the density is 1.1-1.2 g/cm^3 , and the air capacity is about 15 per cent.

Requirements to nutrients. Beetroot is characterised by increased requirements for soil nutrients. To produce 10.0 tonnes of crop (roots and tops) on black soil in areas of sufficient moisture, they take out 50-60 kg of nitrogen, 15-20 kg of phosphorus, and 55-75 kg of potassium from the soil. Sugar beet also removes a lot of calcium, magnesium, sulphur, manganese, boron and other elements from the soil. The optimum amount of exchangeable calcium in the soil for sugar beet is 60-70 per cent of the absorption capacity, while exchangeable magnesium and potassium are 10-15 per cent and 3.5 per cent, respectively.

To obtain high yields of sugar beet roots with high sugar content and good technological qualities, it is necessary to provide moderate nitrogen nutrition during seed germination and in the early stages of plant growth, the optimal level of nutrition with all mineral elements during the period of intensive formation of the leaf apparatus and increased nutrition with phosphorus and potassium, with somewhat limited nitrogen nutrition at the end of the growing season. At the end of the growing season, the need for nitrogen can be met by its recycling from older leaves.

Beetroot consumes the maximum amount of nutrients in July and August (the period of the highest dry matter growth).

The State Register of Plant Varieties Suitable for Distribution in Ukraine includes more than 160 varieties and hybrids of sugar beet. The share of population varieties is insignificant, and they occupy less and less area in production each year.

Sugar beet breeding is aimed at creating hybrids that provide high yields and high sugar yields. Varieties are offered in the following classifications:

E - productive type, sugar yield is provided by a high yield of root crops.

N - normal type, the sugar yield is realised by both yield and sugar content.

Z - sugar type, the sugar yield is realised due to the high sugar content.

ZZ is the highest sugar type, which ensures high sugar yields due to its particularly high sugar content in root crops

Z and *ZZ* types are more profitable in regions with long distances to sugar factories, due to lower transport costs. In addition, they require less nutrients per unit of sugar yield

and are much more profitable when harvested early.

Compared to varieties, hybrids are more demanding on environmental conditions, requiring enhanced care, optimally high supply of nutrients, moisture and other life factors.

For sowing, inlaid or teased seeds are used mainly of new generation hybrids of domestic (Ukrainian CS 70, Yaltushkivsky CS 72, Ivanivsky CS 33, Bilotserkivsky CS 57, KV Ros, KV Bar, KV Zbruch, KV Roy, KV Yaltushkiv, Bila Tserkva CS 90, Shevchenkivskyi, Ivanivsko-Veselopodilskyi CS 84, Slovianskyi CS 94, Vesto, Vorskla, Umanskyi CS 97) and foreign selection - Crocodile, Alyona, Boruta, Silenta, Vincent, Mosaic, Libero, Nastya, Corrida, Bakara, Slatka, etc.

Agricultural technology. *Place in the crop rotation.* Sugar beet is very picky about its place in the crop rotation. In the zone of sufficient moisture in beet farms, 10-plant crop rotations with the following plant rotation were widespread: 1) annual plants for green fodder and silage; 2) winter wheat; 3) sugar beet; 4) spring seed crops with under-sowing of perennial grasses; 5) perennial grasses; 6) winter wheat; 7) sugar beet, 8) peas; 9) winter wheat; 10) sugar beet, corn for seed.

In the zone of unstable moisture, the highest yields of sugar beet are obtained after winter wheat plants on occupied fallow land, pea plants and perennial grasses.

In a zone of insufficient moisture, the correct rotation of plants in the crop rotation is of particular importance as a factor in regulating the water regime of the soil.

Repeated sowing of sugar beet is particularly undesirable. Repeated sowing of beetroot on the same field causes "beetroot" soil, which is caused by the accumulation of specific pests and diseases (nematodes, aphids, rot, cercospora, perenospora, etc.). Continuous cultivation leads to a decrease in yield and sugar content, even with manure and full mineral fertilisation. In a crop rotation, sugar beet can be grown on the same field no earlier than in the 4th year. If the soil is infested with nematodes, it can be grown in 5 years, and in case of severe infestation - in 6-7 years. *Soil cultivation.* Sugar beet forms the bulk of the crop in the soil and is demanding on the condition of the arable horizon. Therefore, timely and high-quality soil cultivation is extremely important for the formation of a high yield of root crops. It is important to incorporate crop residues, straw, and fertilisers in a high-quality manner. The most common methods of basic tillage are improved and semi-steam tillage.

Improved cultivation involves double stubble peeling. The first one is carried out with disc stubble harrows (LDG-10) in two tracks at an angle of 30-45° to a depth of 5-6 cm. If straw is used as an organic fertiliser and when the soil is dry, it is better to use heavy disc harrows (BDT-3, BDT-7, BDV-6.3) for the first stubble hulling. This accelerates the decomposition of straw, reduces moisture evaporation, provokes germination of weed seeds, and destroys or suppresses vegetative weeds.

In 10-12 days after the first one, the second peeling is carried out with ploughshare peelers (PPL-5-25, PPL-10-25) to a depth of 12-14 cm in an aggregate with heavy harrows. If weeds appear after peeling, they are destroyed by surface cultivation by harrowing, cultivation, etc. After applying organic and mineral (phosphorus and potassium) fertilisers, the soil is ploughed to a depth of 28-30 cm in late September - early October with PLN-5-35 and PLP-6-35 ploughs. To improve the quality of autumn tillage, it is better to use two-tiered ploughs PYA-3-35; PNYA-4-40,

PN-4-40.

Sugar beet reacts very negatively to spring ploughing. The soil should never be ploughed if it is waterlogged. This creates a plough sole, the soil floats and becomes compacted, and the plants can only absorb nutrients and moisture from the topsoil. The root system hardly absorbs them from the subsoil.

On heavy soils, the topsoil is cultivated to a depth of 37-40 cm with the help of soil deepeners. Improved tillage is most effective in areas of unstable and insufficient moisture.

Semi-steam tillage is recommended in areas with sufficient moisture and higher weed infestation. It consists of stubble cultivation to a depth of 5-6 cm with disc harrows in 2 traces. After applying organic and mineral fertilisers, the field is ploughed to a depth of 28-30 cm with ploughs with skimmers in combination with heavy harrows (BZTS-1.0), and in dry conditions - with ZKKSH-6 rollers, no later than the first decade of August. In case of weed infestation with rhizome weeds (wheatgrass, couch grass, pigweed), they are first peeled with ploughshares to a depth of 12-14 cm to bring the rhizomes to the surface, then cut with disc harrows, which are used to cultivate in 2-3 traces. Ploughing is carried out when weeds grow back.

As the weeds sprout, the ploughed field is worked several times with harrows or cultivators to destroy new waves of sprouted weeds. In the second half of October, the field should be loosened to a depth of 16-20 cm with ploughs without shelves or flat cutters. Ammonia water can be applied at the same time. Semi-steam cultivation reduces weed infestation by 30-50 per cent and increases soil moisture reserves by 20-30 mm. It is important to carry out late autumn slotting to a depth of 45-50 cm using the ShP-3-70 slotter. With late ploughing, weed seeds do not have time to germinate and sprout only in spring, weeding out beet crops.

Spring tillage. The quality of sugar beet sowing and seed germination depend to a large extent on timely and high-quality spring tillage. It consists of loosening the top layer of soil, levelling it, and, in the area of sufficient moisture, additional layer-by-layer deep loosening. Such loosening is also required on fields with soils prone to flooding. The spring tillage system also includes pre-sowing cultivation.

On fields that have been well prepared and levelled in autumn, only pre-sowing cultivation is carried out in spring.

Early spring loosening and levelling of the soil. The purpose of early spring loosening and levelling is to loosen the surface soil layer to a fine lumpy state, prevent moisture loss, level the field surface and create favourable conditions for pre-sowing tillage, sowing and crop care.

Early spring loosening should be carried out during the period of physical ripeness of the soil, when its moisture content is 3-4 per cent higher than the lower limit of plasticity and the soil is not smeared and crushed without sticking to the working bodies of tillage tools. The duration of this condition of the topsoil is no more than one to two days. A one-day delay in moisture closure leads to unproductive losses of 60-120 tonnes/ha of water. The thickness of the loosened soil layer should be 2.5-3 cm. In the loosened layer, the content of lumps with a diameter of more than 20 mm should not exceed 20 percent, including 50 mm in diameter - no more than 5 percent of the sample weight. Early spring loosening is carried out with wide-coverage units

equipped with tooth harrow couplings pulled by caterpillar tractors that do not form deep ruts. Depending on the type of soil and the density of the top layer, two rows of harrows are attached to the hitch: heavy or medium harrows are placed in the first row; medium sowing or district harrows are placed in the second row. Soils with a heavy mechanical composition, as well as those that have floated and become excessively compacted, are cultivated with a machine with heavy tooth harrows in the first row and medium harrows in the second row. For cultivation of medium-compacted soils, medium harrows are placed in the first row and sowing harrows in the second row. For cultivating loose soils, sowing harrows are placed in the first row and harrows in the second row.

Levelling the soil surface in conditions of high humidity is carried out 1-4 hours after early spring loosening, depending on weather conditions, as the loosened soil dries, using a unit consisting of a train and harrows. Harrows are used in the first row and harrows in the second row. In conditions of low humidity and high air temperature, the field is levelled without preliminary loosening with tine harrows. Early spring loosening and levelling of the soil is effective only when it is carried out in a complex and without delay. In the system of technological measures of intensive tillage, early spring loosening and levelling of the soil are combined into one complex operation. To carry out these works and apply soil herbicides, complex units are used that perform all operations in one pass.

In Germany, in most cases, after the autumn levelling of the fields, no special levelling is carried out in the spring. Usually, they limit themselves to one pre-sowing cultivation with combined machines, for example, the Lemken Compactor.

Pre-sowing soil cultivation. The purpose of pre-sowing tillage is to loosen the surface layer to a fine crumbly state to a given depth, create a solid seedbed, and destroy weed seedlings and germination (Table 3.2).

Table 3.2

Agronomic requirements for pre-sowing tillage

Indicator.	Requirements and tolerances
Terms of work execution	Cultivation begins when the average daily soil temperature at a depth of 8-10 cm reaches +5-6° C and is carried out simultaneously with sowing
Duration of work in one field	One to two calendar days for which the group mode of operation of machines is used
Depth of loosened soil layer after passing the machine	For seed placement depth (2.5-4.0±0.5 cm)
Looseness of the soil	In the treated layer, the content of lumps larger than 20 mm should not exceed 10 per cent of the total sample weight
Cutting back weeds	The working bodies of the tools should cut at least 98 per cent of the weeds
Time gap between pre-sowing tillage and sowing of sugar beet	Time required for 2-3 passes of the sowing unit

Pre-sowing soil cultivation is an integral part of a single technological process - sowing sugar beet - and should be carried out without any time gap, with the first pass preceding the sowing by two or three passes of the sowing unit.

Failure to comply with the agronomic requirements for pre-sowing tillage leads to drying out of the loosened layer, which worsens the conditions for germination of beet seeds. The simultaneous performance of early spring and pre-sowing operations is carried out using multi-operational units, and a harrow-cultivator is also used for pre-sowing.

Modern tillage tools allow us to prepare the soil for sowing sugar beet in 1-2 passes. Pre-sowing tillage with Europak combined machines prevents soil over-compaction caused by multiple passes of single-function machines. Combined units perform more than four operations in one pass - levelling, crumbling clods, loosening, and compacting the seedbed. This is an important element of energy saving and a prerequisite for high-quality sowing. *Fertilisation.* Fertilisers in combination with other agronomic measures are the most effective factor in intensifying sugar beet cultivation. The average increase in root crop yields per 1 kg of nitrogen is 35.7 kg, 1 kg of phosphorus is 37.5 kg, and 1 kg of potassium is 18.8 kg.

The fertilisation system for sugar beet includes basic fertilisation, which is applied in autumn for deep tillage; row fertilisation, which is applied during sowing in the area close to the germinating seed; and fertilisation during the growing season (top dressing). The main fertiliser application includes organic and mineral fertilisers; mineral micro- and macro-fertilisers are applied to the rows during sowing, and mineral and liquid organic fertilisers are fertilised. The highest productivity of sugar beet is ensured by the application of organic and mineral fertilisers. Organic fertilisers used for sugar beet are mainly semi-rotted bedding manure, which is obtained after 4-5 months of storage in manure storage facilities or piles. From 1 tonne of such manure, 5 kg of nitrogen, 2.5 kg of phosphorus and 6 kg of potassium are applied to the soil. It is recommended to apply manure in autumn directly under sugar beet or under a place in the crop rotation (for deep ploughing without a gap between spreading and ploughing) at the rate of 40-50 t/ha in the zone of sufficient moisture, 30-40 t/ha in the zone of unstable moisture and 30-35 t/ha in the zone of insufficient moisture. When growing beets using Ukrainian intensive technology, manure rates are increased to 30-60 t/ha, depending on moisture conditions.

Mineral fertiliser rates are calculated for the planned yield. The approximate norms of mineral fertilisers recommended by the Sugar Beet Institute and its network of research and breeding stations for different moisture zones and soil types are designed to produce root crop yields of 35.0-50.0 t/ha. In the zone of sufficient moisture on typical, leached chernozems, mineral fertilisers should be applied at the rate of N P K₁₆₀₁₇₀₁₆₀, on dark grey forest soils and podzolic chernozems - N P K₁₇₀₁₆₀₂₀₀, on grey forest soils - N P K₁₈₀₁₅₀₂₀₀; in the zone of unstable moisture - respectively N P K₁₂₀₁₅₀₁₅₀, N P K₁₄₀₁₄₀₁₉₀, N P K₁₆₀₁₃₀₁₇₀; in the zone of insufficient moisture - respectively N P K₁₁₀₁₄₀₁₀₀, N P K₁₃₀₁₂₀₁₅₀, N P K₁₄₀₁₂₀₁₅₀.

The vast majority of the recommended or calculated rate of mineral fertilisers (70-90 per cent) is applied in the main fertilisation. In the rows, mineral fertilisers are applied in all zones at a dose of N P K₁₀₁₅₋₂₀₁₀₋₁₅. In the zone of sufficient moisture, it

is advisable to fertilise sugar beet in the 2-4 leaf stage with a dose of N P K₃₀₃₀₄₀. In this zone, some mineral fertilisers, especially nitrogen fertilisers, can be applied for pre-sowing cultivation, provided that the fertilisers are not applied for deep ploughing. However, it should be borne in mind that spring fertilisation is less effective than using them in the main fertilisation. Foliar fertilisation is also effective for sugar beet crops and is used in all zones. Urea (25-30 kg/ha) or a combination of urea (25 kg/ha) and potassium chloride (20 kg/ha) is used for foliar fertilisation. Root crop yields increase by 4.0-6.0 t/ha and sugar content by 0.5-0.8 per cent. It is most effective to carry out this fertilisation before the sugar beet leaves close in the rows.

Boron, copper, manganese, zinc, molybdenum and cobalt micronutrient fertilisers are also used for sugar beet. Boron fertilisers in the form of boric acid or magnesium borate are applied to the rows at the rate of 0.4-0.6 kg of boron per hectare. They are especially effective on sod-podzolic and grey forest soils. Copper micronutrient fertilisers are used mainly on drained peatland soils in the form of copper sulphate or pyrite butts. Manganese fertilisers increase sugar beet yields on carbonate, leached and saline soils. For deep ploughing, apply 100-170 kg/ha of manganese slag, or for foliar feeding, 250-300 litres/ha of a 0.1 per cent solution of manganese sulphate. Liming increases the vital activity of microorganisms, which accelerate the mineralisation of organic matter and improve the soil's nutritional regime. On acidic soils, limestone ameliorants are applied to sugar beet in the form of defecate, raw limestone, dolomite, chalk, etc. The dose of lime (t/ha), depending on the calcium carbonate content, is determined by multiplying the hydrolytic acidity of the soil by a factor of 0.5. In the beet rotation, lime fertilisers are applied under winter crops (a place in the sugar beet rotation) or directly under sugar beet - once per crop rotation.

In order to improve the conditions for the development of sugar beet plants, it is necessary to carry out gypsumisation on saline soils that occur in the beet sowing zone. The average dose of gypsum on saline soils on the left bank is 3-4 t/ha, on salt marshes - 6-10 t/ha, and in the south - 2-3 and 5-6 t/ha, respectively. *Sowing.* Seeds are currently sold in sowing units. One sowing unit contains $100,000 \pm 2$ per cent of seeds. At seed plants, seeds are calibrated by their size (diameter and thickness) into two fractions: 3.5-4.5 mm and 4.5-5.5 mm. To ensure high field germination, uniformity of plant placement, it is necessary to use seeds with laboratory germination and levelling of at least 90 percent, and moisture content of no more than 14.5 percent. To prepare high-quality seeds (which is an indispensable requirement of modern intensive technologies for growing factory sugar beet), they must be ground during the factory preparation process. This is especially true for the seeds of hybrid World Cup, as well as all seeds grown without planting. At the same time, the seed fraction with a diameter of more than 4.5 mm is practically not obtained, because the seed, due to the removal of the most fragile part of the pericarp, goes into a smaller fraction or into waste as a multi-sprouted seed. Improvement and adoption of modern technologies for post-harvest and factory processing and preparation of seeds largely solves the problem of their uniformity within each seed fraction. The last stage of seed preparation at seed plants is seed *treatment* or more modern methods - *inlay, pelleting or capsulation*.

Seed treatment involves applying a layer of insecticides and fungicides to the surface of the seed to protect it from pests and diseases. Such seeds are sold at relatively

low prices.

Another measure to improve the sowing qualities of seeds is more effective than dressing: *inlay*, i.e. applying a thin film to the seed, which, in addition to the film-forming agent, includes fungicides, insecticides, and sometimes substances that stimulate germination. In addition, a variety of dyes are used for branding. Except for a certain increase in flowability, inlay does not change the physical properties of the seed. Its main effect is to stimulate and protect the seed. Seed germination is stimulated, which increases its field germination, accelerates emergence and optimises seedling friendliness. The addition of effective pesticides to the inlay film, which protect seedlings and seedlings from diseases and pests, ensures the preservation of a given plant density in the initial period of their life, which is difficult to overestimate from the point of view of the effectiveness of the entire intensive sugar beet cultivation technique in general. Compared to pelleted seeds, such seeds require less moisture for germination, so it is advisable to use them on farms where moisture reserves in the topsoil are limited and insufficient for pelleted seeds to germinate in spring.

When growing sugar beet by sowing reduced seed rates or sowing at the final plant density, the most effective is the use of pelleted or encapsulated seeds. The technology of seed *pelleting* and *capsulation* is more complex and energy-intensive, but it allows to obtain better quality seeds, mainly due to high uniformity in size, more reliable layer-by-layer fixation of the components of protective and stimulating substances. The spherical shape of the pellet *seed* allows to sow it with a given interval at the final plant density. Reliable and safe fixation of chemical protective and stimulating agents around the seed in separate shells improves seedling nutrition and seedling protection from pests and diseases. The dragee is hydrophilic and does not require high soil moisture (Fig. 3.1). However, in dry conditions, or with low crop production, you should not use pelleted seeds. It is better to sow "bare" inlaid seeds.

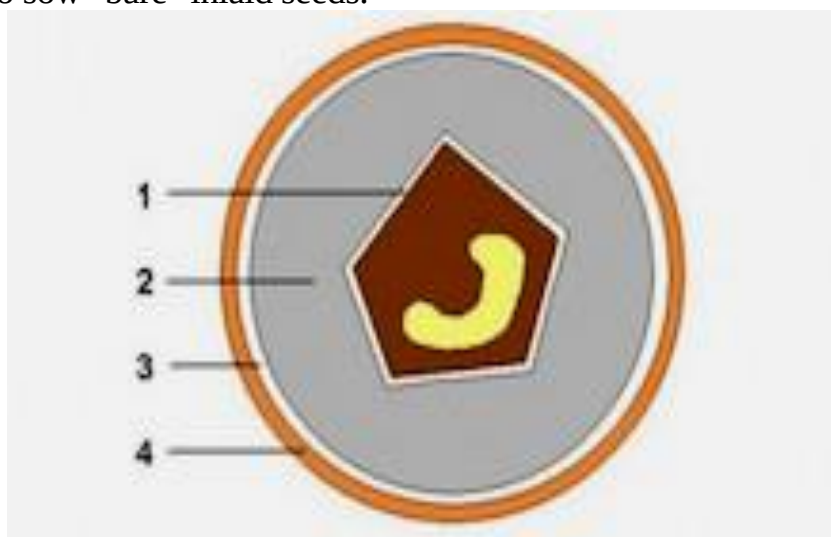


Fig. 3.1 Structure of sugar beet seed pellets:

1. Fungicide on the seed with the embryo; 2. Special teasing mass; 3. Fungicide and insecticide; 4. Protective coloured coat

Capsulated seeds differ from pelleted seeds in that a shell (capsule) is created around the seed, which contains nutrients, stimulants and a composition of insecticides.

Compared to pelletised seeds, the germination of pelletised seeds requires less moisture, which allows them to be used in conditions of less moisture in the topsoil. Pelleting as a special measure to increase the uniformity of sugar beet seed fractions, improve the whole range of its physical properties (size, shape, flowability, ballistics) and, most importantly, firstly, the accuracy and fixity of its sowing, and then the friendliness of seedlings, stimulate initial growth and protect seedlings from pests and diseases, has become widespread in the world beet industry. The material used for pelleting is of high quality, which contributes to fast and friendly germination without negative consequences. In order to disinfect seeds from pathogens, provide a protective effect against soil and ground pests in the early stages of plant development (from sowing to the first pair of true leaves), seeds are treated with protective and stimulating compositions, which include both fungicidal preparations (TMTD (8 l/t) and Tachigaren (6-15 kg/t), and such preparations as Gaucho (128.6 g/1 p.o.), Poncho), Poncho Beta FS 453.3 (0.075-0.15 l/1 b.p.), Force 200 SS (35 ml/1 b.p.) and Cruiser 350 FS (10.0-15.0 l/t), which effectively protect seeds and seedlings from a complex of underground and ground pests in the initial periods of sugar beet growth. The *sowing dates* are determined by the biological properties of sugar beet (the need for heat, moisture, and the length of the growing season), as well as soil, climatic and agronomic conditions, and the peculiarities of meteorological phenomena.

Given that modern sugar beet hybrids are resistant to blossom and can withstand relatively low temperatures during seed germination and early vegetation, they should be sown in early spring, immediately after the end of sowing early spring plants. Sowing of sugar beet should be started when the soil moisture content is 22-23 per cent of the RH and the soil is well crumbled, and its average daily temperature at a depth of 8-10 cm reaches 5-6⁰ C. A delay in sowing by only 5-6 days, compared to the optimal time, leads to a shortfall of 3.0-4.0 t/ha of root crops. On irrigated fields in areas of sufficient moisture, the depth of seeding is 2-3 cm, unstable and insufficient - 3-4 cm. On heavy floating soils, the seeding depth should be no more than 2-3 cm.

The main condition for setting the seeding depth is that the seed must be embedded in a moist soil layer. Peeled seeds, which require more moisture for germination, are also sown slightly deeper. The best sowing depth for pelleted seeds under normal moisture conditions is 2.5-3 cm. When water reserves are limited, the seeding depth is increased to 4 cm. The optimal plant density for the harvesting period on high agro-ecological backgrounds for the zone of sufficient moisture is 100-110 thousand/ha, unstable - 95-100 and insufficient - 90-95 thousand/ha. The mass seeding rate is 3-5 kg/ha. It is necessary to reasonably determine the required number of seedlings, taking into account the method of formation and the plant loss rate from germination to harvest (1.2-1.3) and the expected field germination, taking into account laboratory germination, soil characteristics, its condition in spring, the forecast of pest species and number, pathogenic microflora, etc. Under intensive sugar beet cultivation, two methods of plant density formation are used: sowing to the final density and formation by mechanical means. When sowing to the final plant density, the optimal distribution of seeds in the rows is ensured in order to obtain 6-7 viable, evenly spaced plants along the length of the row. The cultivation of sugar beet at the final plant density is most effective when using pelleted seeds. For sowing sugar beet with row spacing of

45 cm, mechanical and pneumatic seeders of domestic and foreign production are used. The required width of the main row spacing of 45 ± 1 cm is ensured by adjusting and sowing control during sowing.

Crop care. The crop care system includes: continuous tillage before emergence, loosening of the soil between rows and in the row zone (layering), continuous loosening of the soil between rows, protection against weeds, pests and diseases, and plant nutrition.

When sowing to the final density, pre-, post- and inter-row loosening should only be carried out if necessary, as it can lead to a significant reduction in the optimum plant density. It is important to remember that the seed drill requires more water and better air access for germination than normal seeds.

Pre-sowing care. Under optimal conditions of seed germination, sugar beet seedlings appear 8-10 days after sowing, and at low surface soil temperatures - in 20-25 days or more. During this period, a significant number of weed seeds germinate. Depending on the duration of weed seed germination, weediness of the field, and the physical condition of the soil, continuous loosening of the surface soil layer is carried out once or even several times. The purpose of continuous pre-germination loosening is to destroy weed seedlings, prevent soil crusting and root-eating diseases, and improve the conditions for germination of sugar beet seeds. For pre-sowing loosening, mainly wide-coverage machines equipped with tooth harrows are used, as well as cultivators equipped with rotary working bodies with bar rotors without plumes. If it rained after sowing and soil crust formation is possible, pre-sowing loosening should be carried out as soon as it is possible to operate the machines in the field. On very loosened soils, to ensure the required processing depth, the field is pre-rolled with smooth rollers, which are directed at an angle of 5-10° to the direction of the rows. It is not allowed to carry out continuous pre-germination loosening of the soil if the height of the seedlings exceeds 10 mm.

Post-emergence crop care consists of the first loosening of the soil between rows and in the row zone (layering), adjustment (at low seed rates) or formation (at high seed rates) of plant density, continuous loosening of the soil between rows, protection against weeds, pests and diseases, and plant nutrition.

The first loosening of the soil between rows and in the row zone (*layering*) is carried out, if necessary, when the rows of beet seedlings are just visible. To do this, use cultivators equipped with one-sided flat-cutting tines with a working width of 150 mm, two of which are installed for each row spacing and at a cultivation depth of 3-4 cm, as well as rotary batteries moving in the row spacing and row zones.

On heavily weeded fields and with a sufficient number of seedlings (at least 10 plants per 1 hectare), continuous post-germination loosening of the soil is used. The optimal period for this is the first pair of true leaves. If the equilibrium soil density of sugar beet crops is high, a dense crust forms on the soil, or the soil floats after prolonged and heavy rainfall, then inter-row loosening is required. Loosening of the soil between the rows is carried out after the formation of the plant density, combining it with fertilisation. For this purpose, cultivators are equipped with appropriate working bodies. The first ones are equipped with rotary working tools, which allow to reduce the protective zone of the rows to 6-8 cm and loosen the soil in the row zone to a depth

of 2-2.5 cm.

The first inter-row loosening is carried out to a depth of 8-10 cm. If large clods are formed due to increased soil density, the soil is first loosened to a depth of 5-6 cm with one-sided razor tines, two of them for each row spacing, and rotary working tools. Then the soil is loosened to 10-12 cm and the plants are fertilised with mineral fertilisers. To cultivate each row spacing, a chisel, a fertilising knife and rotary working tools are installed. After 10-15 days, depending on the amount and intensity of precipitation, weeds, and soil conditions, it is advisable to loosen the row spacing again to a depth of 12-14 cm, and even deeper on heavy floating soils.

Protection of crops from weeds. Due to their morphological characteristics, sugar beet plants are unable to resist weeds on their own. The amount of reduction in sugar beet yields significantly depends on the period of their joint vegetation with weeds in crops, as well as the species composition of weeds. Perennial weed species (thistles, creeping wheatgrass, field bindweed) and annual dicotyledonous weeds (quinoa, cowpea, bitterroot and others) are particularly harmful. An important factor in the damage is their competition for energy, water, and minerals. During the 80 days of joint vegetation, the weed complex absorbs from the soil the amount of the most available forms of macronutrients (N, P_2O_5 , K_2O), which is sufficient to produce a root crop yield of 45-55 t/ha with the corresponding aboveground mass. Studies have established that with a mixed type of weeds, the permissible weight of weeds on crops in the second half of the growing season should not exceed 100-200 g/m².

The weediness of crops is influenced by many factors, namely, the amount of potential weed infestation of fields, rotation of plants in the crop rotation, methods of basic tillage for the place in the crop rotation and sugar beet, and the species composition of weeds. In general, the basis for obtaining high yields of agricultural plants and, in particular, sugar beet is agrotechnical measures. Herbicides are an important and effective tool for protecting crops from weeds, and their use requires strict compliance with regulations.

Perennial weeds pose a serious problem in the fields, and their number must be controlled in crops in the rotation of sugar beet or after harvesting. When the perennial plants grow back, continuous-acting herbicides are used against them in the stubble. Against creeping wheatgrass (4-6 leaf stage), it is enough to spray Roundup herbicide (3-4 l/ha), against different types of thistles - 4-5 l/ha of Roundup or its analogues according to the regulations for their use (the beginning of the formation of the generative shoot in thistles). If the fields are weeded with thistles and dicotyledonous annual species, it is recommended to add 2,4-D amine salt (2.5 l/ha), Diallyl super (1.5 l/ha) or Dicamba forte (1.2 l/ha) to Roundup to enhance its effect. Annual weeds, especially dicotyledonous weeds, cause great damage to sugar beet crops. These weeds are characterised by a large species diversity, belong to different botanical families, and seed reserves in the ploughed soil layer reach 2.0-2.5 billion units/ha. A reliable weed protection system is an important part of intensive sugar beet cultivation. The choice of a sugar beet crop protection system depends on the level of potential soil contamination in the fields, the technical equipment of the farm, the level of qualification of specialists and machine operators, the financial capabilities of the farm and the specific soil and climatic conditions. Currently, there are two main systems of

weed control for sugar beet crops: *combined* and *post-emergence*.

The *combined* weed control system is used in fields with a high level of potential weed infestation of the topsoil, as well as in farms with insufficient technical support. The combined system involves the mandatory application of soil herbicides that act in wet soil through the root system and subsequent spraying (usually two, less often three times) of sugar beet seedlings. When using herbicides, it is necessary to take into account the species composition, structure and quantity of seeds of annual weed species in the soil, pH, soil texture, humus content, the level of moisture in the topsoil in spring, and the spectrum of action of the products. The most difficult to control is the complex of dicotyledonous weed species. In the area of sufficient moisture, it is most appropriate to apply Goltix and Pyramin Turbo to the soil. In the area of unstable moisture, use the above-mentioned products or Dual Gold. In the zone of insufficient moisture, apply Dual Gold or Frontier Optima from soil preparations. The effect of Frontier on sugar beet plants is relatively "tough", so it requires an accurate and correct choice of application rates. If the humus content in the soil is up to 3.0 per cent, the application rate of Frontier Optima before sowing beet can be 0.8-1.0 l/ha. If the soil contains more than 3.5 per cent of humus, the dose of Frontier Optima can be increased to 1.2 l/ha.

The timing of soil application of soil herbicides is essential. If the spring is cold and prolonged, it is better to apply soil herbicides before germination, so that the active germination of weed seeds coincides with the period of active action of the herbicides. In a late and mild spring, when the temporal growth is rapid, it is more rational to apply herbicides to the soil before sowing. In the zone of unstable moisture in dry spring, it is advisable to work herbicides into the soil, but if the spring is rainy, this measure is not necessary. In areas of insufficient moisture, incorporation of soil preparations is mandatory, as it increases the effectiveness of herbicides by 15-30 per cent. Most soil herbicides can effectively inhibit the emergence of weeds for 3-4 weeks after application if there is moisture in the soil. After that, the protective effect is significantly reduced. As a result of a decrease in the level of protective effect of soil herbicides, weeds appear on sugar beet crops in the second half of May. In the combined system of controlling weeds, the following herbicides or their compositions should be used before the emergence of sugar beet seedlings (in dry conditions it is better to bury them in the soil): Goltix, 2.5 l/ha; Pyramin Turbo, 2-3 l/ha; Goltix + Pyramin Turbo, 2.0 + 0.5-0.8 l/ha; Pyramin Turbo + Dual Gold, 2.5 + 1.5 l/ha; Dual Gold + Hexilur, 1.2-1.6 + 0.8-1.0 l/ha; Dual Gold + Lenacil Beta, 1.2-1.6 l/ha + 0.8-1.5 kg/ha; Pyramin Turbo + Frontier Optima, 2.0 + 0.8-1.0 l/ha. The application rate of Frontier Optima can be increased up to 1.2 l/ha (only on soils with a humus content of more than 3.5 per cent).

Soil herbicides can significantly reduce weed infestations, but as mentioned above, their duration of action is limited (30-35 days).

During the germination of beetroot (weeds in the cotyledon phase), one or two sprayings with one of the herbicide formulations should be carried out: Betanal Expert (or Betanes) + Caribou, 1.0 + 0.03 l/ha; Betanal Expert (or Betanes), 1.0 l/ha; Betanal Expert (or Betanes) + Pyramin Turbo, 1.0 + 1.5 l/ha; Burefen FD-11, 2.0-2.5 l/ha; Symbethan Duo, 2.0-2.5 l/ha.

When a new wave of weed germination appears (after 7-10 days), spraying is repeated using one of the formulations: Betanal Expert (or Betanes), 1.0-2.0 l/ha; Betanal Expert (or Betanes) + Goltix, 1.0 + 1.5 l/ha; Betanal Expert (or Betanes) + Pyramin Turbo, 1.0 + 2.0 l/ha; Burefen FD-11, 3.0-3.5 l/ha; Symbethan Duo, 3.0-3.5 l/ha; The use of soil preparations reduces the stress of protective measures when sugar beet shoots appear, but cannot replace post-emergence herbicides. Most weed species, especially dicotyledons, have an extended period of seed germination, so it is very difficult to fully control their emergence with soil herbicides. To successfully protect sugar beet crops from weeds, the effect of soil herbicides is enhanced by seedling preparations.

The post-emergence weed control system is advisable in fields with low and medium level of potential clogging of the topsoil in farms with high plant production, with sufficient technical support (there should be enough sprayers to process all sugar beet areas in no more than 3 days), availability of qualified specialists and herbicides in the required quantity. The post-emergence system requires high technological discipline, timeliness and high quality of protective measures, taking into account the species composition of weeds, plant development stages, peculiarities of the effect of the preparations, and weather conditions. The post-emergence system is the most modern and promising and can be used in all soil and climatic zones of beet growing.

Almost simultaneously with the emergence of sugar beet seedlings, the crops are covered with white quinoa, hybrid quinoa, multi-seeded quinoa, bindweed, spreading mustard, wild radish, and field mustard plants. At the same time, or 7-15 days later, late spring weeds germinate en masse: common ragweed, white ragweed, chicken millet, black nightshade, grey mouse and others. For the correct choice of herbicides, the sensitivity of weeds of different species to the action of specific preparations should be taken into account (Table 1.4).

Dicotyledonous weed species should be treated with herbicides in the cotyledon phase, when weeds are most sensitive to their action. When choosing herbicide formulations, it is necessary to take into account the characteristics of weeds and the structure of weed infestation of crops. The most selective and "soft" sugar preparations for beet plants are used: Goltix, Pyramin Turbo, Caribou, Betanal Expert, Betanal Progress OF, Victor and others. Do not spray crops that are heavily damaged by pests or after frost. If soil herbicides were not applied, then two to three consecutive sprayings are carried out in the phase of developed cotyledons in sugar beet plants and weeds. Herbicides of one of the compositions are applied: Betanal Expert (or Betanes), 0.75-1.0 l/ha; Betanal Expert (or Betanes) + Goltix, 0.75 + 0.1 l/ha; Betanal Expert (or Betanes) + Caribou, 0.75-0.03 l/ha; Betanal Expert (or Betanes) + Pyramin Turbo, 0.75 + 2.0 l/ha; Burefen FD-11 + Caribou, 1.5 + 0.03 l/ha; Symbethan Duo + Caribou, 2.6 + 0.03 l/ha; Betanal Progress Am + Pyramin Turbo, 1.5-2.0 + 1.5 l/ha

When a second wave of weeds appears, spraying is repeated with one of the following compositions: Betanal Expert (or Betanes), 0.75-1.0 l/ha; Betanal Expert (or Betanes) + Goltix, 1.0 + 1.0 l/ha; Betanal Expert (or Betanes) + Pyramin Turbo, 1.0 + 2.0 l/ha; Betanal Expert (or Betanes) + Caribou, 1.0 + 0.03 l/ha; Burefen FD-11 + Caribou, 3.0 + 0.03 l/ha; Symbethan Duo + Caribou, 3.0 + 0.03 l/ha.

When spraying seedlings or using in tank mixtures with other herbicides, when

a new wave of weeds appears (after 10-14 days), apply Betanal Expert at the same rates, and the dose of Betanes can be reduced to 0.75 l/ha. The third spraying of seedlings is carried out when a new wave of weeds appears in 10-14 days with the same herbicide rates as in the second treatment. As a rule, during the third and sometimes the second spraying, mass shoots of annual cereals appear on the crops.

Cereal weeds are destroyed by spraying with one of the graminicides (Targa Super, Centurion, Poast Plus, Furore Super, Fusilade Forte, etc.) or in combination with the application of dicotyledonous preparations.

When applying herbicides to sugar beet, it should be remembered that the main task of the agronomist-technologist is not to eliminate weeds in crops by 100 per cent, but to obtain high yields of high-quality sugar beet raw materials. Therefore, it is necessary to strictly adhere to the regulations and timing of herbicide application, as these products in high doses and when used in the cotyledon phase of sugar beet are quite phytotoxic to the plant. Consequently, they can significantly inhibit sugar beet plants, which leads to a decrease in yield and product quality.

The complex of weed control in beet fields, if strictly adhered to, does not produce side effects and is therefore acceptable. Mechanical work after herbicide application can be carried out on the 4thth day. Manual work can be started on the 8thth day after spraying. The optimal rate of working fluid consumption when applying soil preparations is 300-400 l/ha, when spraying seedlings - 180-220 l/ha with a working pressure of 2.0-2.3 atm. Ground spraying is carried out in dry weather, at a wind speed of up to 5 m/s and a temperature not exceeding +24⁰ C.

Pests of sugar beet and measures to protect against them. Many types of pests damage sugar beet in Ukraine. Among them, the most harmful are: common and grey beet weevils, beet fleas, scale insects, beet codling moth, wireworms, beet mining fly and beet leaf aphids.

In some years, sugar beet is damaged by leaf-eating and gnawing moths, meadow butterflies, root beet aphids, copperhead larvae, deadly beetles, mining moths and others.

If there is a strong threat of soil and ground pests, both in winter and in spring and summer, a set of measures should be taken. In particular, seeds treated with protective and stimulating substances containing insecticides and fungicides, or their compositions in accordance with the recommendations of scientific institutions for a particular beet growing area, species composition of phytophages and pathogens and their regional abundance should be used for sowing.

Thus, the application of a composition of systemic insecticides to the seed: Poncho Beta, Cruiser 350 FS, Force Magna and fungicides: Tachigaren 70 per cent w.p., Apron XL, 35 per cent w.c.s., Royal Flo 48 per cent w.c.s., TMTD, Tachigaren + Royal Flo, in the recommended norms provide proper protection of sugar beet seedlings from pests within 30-40 days from the beginning of the plant's vegetation in optimal weather. At high air temperature in the period after sowing sugar beet (above +20⁰ C) and in the absence of precipitation, the period of toxic effect of insecticides will be significantly reduced. To avoid plant loss from wireworm damage, it is advisable to determine the location and condition of these pests. The best time to sow is when wireworms are in the 0-5 cm soil layer, as the toxicity of the treated seeds

ensures almost 100 per cent of their death.

If the number of beet fleas, grey and common beet weevils is above the economic threshold of harmfulness (5-7 individuals of fleas, 1.5-2 individuals of weevils per 1 m.p.) and the threat from them to seedlings, sugar beet crops should be sprayed with insecticides, giving preference to organophosphate compounds, or their mixtures with pyrethroid preparations at half the norms. To do this, it is necessary to have a reserve of insecticides of at least 30 percent of the total crops of this plant (Basudin, 60 percent + Fozalon, 35 percent - 0.8 + 1.5 kg/ha by preparation or Decis 5 percent + Fozalon, 35 percent - 0.2 + 1.5 kg/ha by preparation). In the summer, when an increased threat to developed beet plants is expected from the main specialised (leaf and root aphids, mining flies, nematodes) and polyphagous (leaf-eating and gnawing scoops, meadow butterflies, etc.) pests, careful monitoring of the appearance and growth of these insects is necessary. When they reach the level of economic threshold of harmfulness, it is necessary to take protective measures.

Leaf aphids and mining flies first infest the edges of plantations. Therefore, in June, when 10 per cent of plants are infested with aphids and 30 per cent with mining flies (3 larvae per plant), spray edge strips 45-60 m wide and, only if necessary, treat the entire field with insecticides: Actelic or Lebacid, 50 per cent e.i., Dursban 48 per cent e.i., Buzudin, Diamet 60 per cent e.i. - 0.8 l/ha, Sumiton, 50 per cent e.i. - 0.6-1.2 l/ha, Sherpa, 25 per cent e.i. - 0.48 l/ha (seed flies).

Sugar beet diseases and protection measures. Sugar beet is affected by many diseases caused by fungi, bacteria, viruses, flower plants - parasites, as well as unfavourable soil and climatic conditions and other environmental factors. The most common and damaging diseases of sugar beet are: seedling root eater, scab, dry fusarium, brown and other root rot, late blight, viral diseases, root rot during the growing season, and gray rot during storage. Diseases cause disruption of the normal physiological functions of plants, leading to inhibition of their growth and even death.

Agricultural practices can prevent or significantly reduce seedling diseases. In this case, high overall crop productivity, adherence to scientifically based crop rotations with optimal doses of organic and mineral fertilisers, high-quality primary and pre-sowing tillage, optimal sowing dates and seeding depths are crucial.

An important element of disease protection is the treatment of seeds with protective and stimulating substances at seed plants. An obligatory component of these compositions is a fungicide that allows to completely destroy the activity of soil pathogens. In the area of constant threat of root emergence, the most reliable protection is provided by Tachigaren in a mixture with Apron or Previcur or Sulfocarbathion-K. Treatment of sugar beet seeds with protective and stimulating substances is carried out centrally at seed plants no earlier than six months before sowing, or immediately before sowing. Taking into account the periods of active disease damage and the stages of sugar beet development, a fungicide application programme is developed, which specifies the products recommended for combating individual diseases or their complexes, the doses used and the duration of toxic effects.

The use of sugar beet for processing, for livestock feed, as well as seed production of this plant in the planting method, requires storage of root crops for 150-160 days. At the same time, as many years of experience show, storage of sugar beet

is usually accompanied by weight and sugar losses, often significant. One of the reasons for these losses is the vital activity of microorganisms - fungi and bacteria - that cause root rot, or gray rot. Affected parts or the entire root crop are covered with white, grey, red or pink mould, and the rotten tissue becomes greyish, sometimes almost black, loses its strength and collapses. In some years, 15-20 per cent, sometimes even 30-40 per cent of sugar beet roots die in the sugar beet fields of sugar factories. The following system of measures has been developed to combat gray rot: development and introduction of disease-resistant sugar beet varieties and hybrids; sowing sugar beet after the best crops in the crop rotation, and applying scientifically sound organic and mineral fertiliser rates; timely protection of crops from a complex of pests and diseases; protection of root crops during harvesting, transportation, bagging and storage from mechanical damage, wilting and freezing; creation of optimal conditions in root storages, bagging, trenches - temperature $+1...3^{\circ}\text{C}$, relative humidity - 90-98 per cent.

The protection of the leaf apparatus from diseases, the main of which are cercosporosis, powdery mildew, ramularia, phomosis, downy mildew and rust diseases, is of great importance in sugar beet cultivation. To protect crops from these diseases, modern single- and multi-component products have been developed that protect against a range of pathogens and with one spraying can solve the problem not only with one of the pathogens, but also protect crops from other harmful diseases. Among them are fungicides that contain the active ingredient of the strobilurin group: azoxystrobin (Amistar extra 280 sc, h.e.); pyraclostrobin (Abacus, m.c.e.), picoxystrobin (Acanto plus 28, h.e.); trifloxystrobin (Sphere max). The use of these products in the systems of sugar beet protection against leaf diseases allows to protect sugar beet not only from diseases, but also, due to the so-called "vigor effect", significantly prolong the active photosynthetic activity of sugar beet leaves in the late periods of vegetation (August - September). This allows to significantly increase the yield and sugar content of the roots.

It should be borne in mind that the best effect can be obtained when spraying crops with these fungicides is carried out as a preventive measure at the initial stages of leaf diseases development (third decade of June - first decade of July). In addition to the above-mentioned products, the List of Pesticides and Agrochemicals Permitted for Use in Ukraine contains a sufficient number of original and "generic" fungicide products that successfully control leaf diseases. According to the experience of producers and scientific research, when planning the sugar beet protection system, in order to prevent negative side effects on plants, preference should be given to original products and a very cautious approach should be taken to replacing them with "generic" ones.

The first signs of cercospora appear on the leaves in the form of single light brown spots with a brown border in the phase of leaf closure in the aisles (late June - early July). In most cases, the disease first appears in areas bordering or close to last year's crops.

The factors that accelerate the development of the disease are abrupt changes from moderate and humid weather to hot and dry. Under their influence, sugar beet leaves quickly lose their turgor and become vulnerable to the cercospora pathogen.

Harvesting. In autumn, sugar beet continues to grow intensively and accumulate sugar. Thus, the weight gain of one root crop from 20 August to 20 September averages 96 g, and the sugar content increases by 2.2 per cent during this time. Therefore, harvesting operations should be planned in such a way as to ensure a greater increase in root weight and to complete harvesting and export in time. Mass harvesting of sugar beet in the main sugar beet growing area of Ukraine should be carried out from 20 September to 25 October.

Today, self-propelled foreign-made beet harvesters - Holmer (Germany), Kleine (Germany), Vervat (Netherlands), Moro (France), which allow harvesting both tops and roots in one pass, and trailed beet harvesters - Kleine (Germany), Stoll (Germany) - are used for harvesting. When harvesting the tops, the cutting of root heads into tops and the contamination of the harvested beet raw material with green mass should not exceed the standard tolerances of 5.0 and 3.0 per cent, respectively; total losses of green mass in the tops should not exceed 10 per cent, and the mass of soil in the tops should not exceed 0.5 per cent; the number of root crops knocked out of the soil and their parts remaining in the soil and on its surface should not exceed 1.5 per cent, and severely damaged root crops by weight - not more than 5 per cent.

When loading root crops with combines from field clumps with beet loaders, the completeness of root crops selection should be at least 99 per cent, and the number of severely damaged root crops should not exceed 3 per cent. The total contamination of beet raw materials after the beet loader should not exceed 5 per cent, including tops and other plant residues - no more than 10 per cent.

During harvesting, losses and the quality of the machinery are monitored. For this purpose, 10 m is measured², i.e. six-row harvesting equipment has 6 rows of 3.70 m each. All root crops or their residues are harvested from the soil, weighed and the result is divided by 100. This is how we get the losses in centners per hectare. To accurately determine the losses per hectare, it is necessary to carry out this control at least 5 times per shift for each machine. Losses occur due to surface losses of root crops, under-digging and breaking off of their tails (underground losses). Beetroot losses due to breakage of root tails are shown in the plant in Figure 3.2.

The height of the tops depends not only on the yield and quality of the root crop, but also on the resulting refined sugar yield. The optimal place to cut the tops is 1 cm below the lowest green leaf petioles. The quality of the cutting edge of the topsy-turvy knife is crucial.

The cutting of the tops is also influenced by field germination, as the height of the sugar beet plant heads in sparse crops is different. As a result, the cut of the tops can be either too high, too low or oblique. The distance between the plants in the row also affects the quality. If the spacing is too short, the topsy-turvy knife may jump and not cut at all. Finally, the quality of the cut depends on the varietal properties of the hybrids. The quality of sugar beet depends on the correct cut, because the heads of sugar beet contain twice the amount of harmful substances for processing compared to the entire root crop.

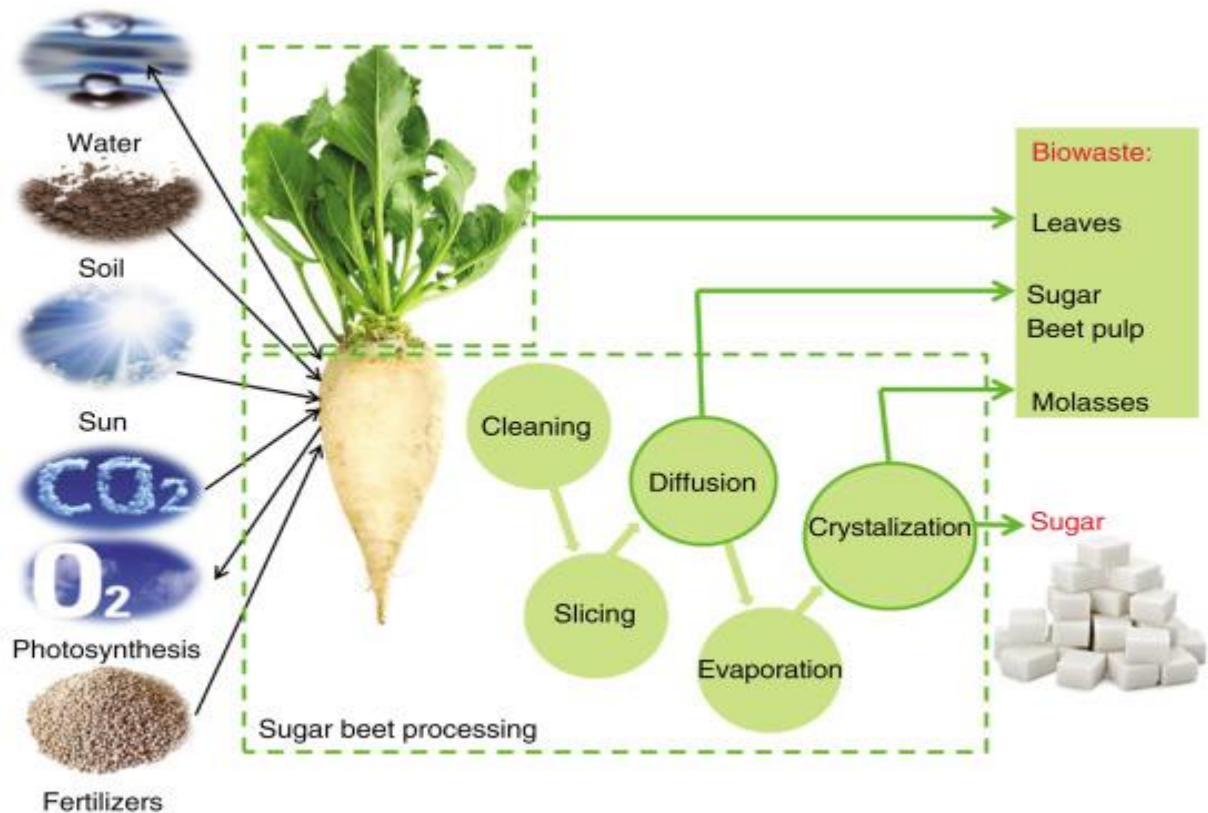


Fig. 3.2. Sugar beet yield losses depending on of underground losses

The main method of sugar beet harvesting is *in-line harvesting*. It ensures minimal labour and money costs, high quality of beet raw materials and less losses and damage to root crops due to direct delivery to the sugar factory and avoidance of temporary storage in field piles. Root crops harvested in a streaming method are better stored in factory sheds. Their weight loss from decay is 1.5-3.0 times less than that of root crops harvested by the transshipment method. However, the use of the streaming method requires more vehicles, higher fuel consumption and wear and tear on vehicles moving alongside the root harvesters at low speed. It also reduces the efficiency of heavy trucks and road trains.

The *transshipment* method of harvesting should be used in case of insufficient availability of trucks and in extreme conditions (very wet or dry, hard soil, high weediness), when the roots are significantly contaminated with soil and plant residues. It should be used only in the amount that allows to transport the stock of root crops created on the day of harvesting to the sugar factory during the day. It should be noted that the transshipment method of harvesting increases the efficiency of heavy-duty vehicles, reduces the contamination of raw materials with soil and plant residues, and increases the possibility of transporting beets in adverse weather conditions.

It should be remembered that the transshipment method of harvesting increases the loss of raw materials and deteriorates their quality due to the increase in the number of damaged root crops during their stacking and temporary storage in field piles.

On the eve of harvesting, an agrotechnical assessment of the plantations is carried out to determine the width of the main and butt rows, plant density, root and top yields, their size and weight, the position of the root heads relative to the soil

surface, and the deviation of the rows from the axial lines.

It is advisable to start harvesting beetroot from fields away from paved roads, earlier sowing dates, as well as from areas damaged by diseases and pests, with uneven plant distribution and large hollow roots, which are most likely to be damaged during harvesting.

Firstly, the beetroot is harvested from the headlands, which should be 21.6 m wide (4 passes of a 12-row seeder). After harvesting the beetroot on the headlands, the field is divided into paddocks with an optimal number of rows of 240, i.e. multiples of the working width of the machines. The width of the inter-paddock aisles should be 12 rows; the boundaries of the paddocks should be along the butt rows. For the passage of transport units, six rows are assembled on each side of the paddock.

Harvesting sugar beet in a *three-phase* process (windrow technology) and a set of less metal-intensive trailed machines for its implementation requires an increase in the amount of energy, which leads to an increase in labour costs, fuel, and crop losses.

3.3 OIL AND ESSENTIAL OIL PLANTS

Oilseeds are plants whose seeds or fruits contain at least 15 per cent fat (lipids). There are more than 340 such plants belonging to different botanical families and they include more than 15,000 varieties and hybrids. The content and quality of vegetable oil in the seeds of different oilseeds vary. Oilseeds are grown on all continents and in many countries. The main producers of oilseeds include the United States and Brazil. Argentina, China, India, and Ukraine. Together, these countries account for more than two-thirds of the world's oilseed production. Soybeans dominate the structure of oilseed production. It accounts for more than half of the world's oilseed production, while rapeseed accounts for 14 per cent, cottonseed for 11 per cent, and sunflower for 9 per cent.

The balance of global fat resources is dominated by vegetable fats, in particular oil. Vegetable oil meets 60-70 per cent of the world's fat demand. About 86 percent of its total production is used for food and feed, and only 14 percent for technical purposes. According to the U.S. Department of Agriculture (USDA), the area under oilseeds has been steadily increasing over the past five years and in 2011/12 marketing year it totalled 227 million hectares. In 2011/2012, the total global production of oilseeds was 441.39 million tonnes, and the global production of vegetable oil was about 100 million tonnes, including 10 million tonnes of sunflower oil (soybean oil is the world leader with 25.8 per cent).

Vegetable oil is of great nutritional and technical importance. The direction of its use primarily depends on the composition of fatty acids, the ratio between saturated, simply unsaturated and multiple unsaturated fatty acids. The oil is used directly as a food product, in the canning, food and confectionery industries, and for the production of various types of margarine. It is a valuable raw material in the production of drying oils, varnishes, paints, stearin, linoleum, and is used in the electrical, leather, metalworking, chemical, soap, textile and other industries. Vegetable oil is the main source for the production of biodiesel, a biofuel.

Regardless of the end use of the oils, the first step in the processing of seeds usually consists of two processes: pressing and extraction. The production of oils

produces oilcake and meal as by-products. Oilcake and meal are a valuable concentrated animal feed, containing 35-40 per cent protein with a high content of essential amino acids.

By its nature, vegetable oil is an ester of triatomic alcohol - glycerol and various fatty acids. Compared to proteins and carbohydrates, vegetable oil has a higher calorie content. 1 g of oil contains 9,500 calories (1 g of protein contains 4,400-5,500 calories, and 1 g of carbohydrates contains 4,000-4,200 calories). Vegetable oils are distinguished by the presence of double and triple bonds, which determine the degree of their saturation. The degree of saturation determines the quality of individual oils and their uses. Oils used for food should contain few free fatty acids.

A significant proportion of vegetable oils dry out and turn into a solid, elastic mass when they absorb air oxygen. The ability of an oil to dry is a valuable indicator of its quality and is determined by the iodine number, i.e. the number of grams of iodine that are consumed to oxidise 100 g of oil. The higher the iodine number, the more capable the oil is of drying. Vegetable oils are divided into three groups according to their ability to dry.

Drying oils (iodine number over 130) include linseed, perilla, and castor oils. They are used mainly for technical purposes. *Semi-drying oils* (iodine number from 85 to 130) - sunflower, rapeseed, mustard, safflower, etc. *Non-drying oils* (iodine number less than 85) - castor, peanut, olive. They are used in medicine and for technical needs.

High-quality edible and technical oils should contain a minimum amount of free fatty acids. An indicator of the free fatty acid content of an oil is the *acid number*, which is determined by the number of milligrams of caustic potash required to neutralise the free fatty acids in 1 g of oil.

Oil with an acid number of more than 2.25 is not suitable for food purposes. The acidity of the oil depends to a large extent on the growing conditions of the oilseed and the maturity of the seeds, the time of harvest and storage conditions. An important indicator of the quality of oil used for soap making is the *saponification number*, which is determined by the number of milligrams of caustic potash required to neutralise free and glycerol-bound fatty acids. For most vegetable oils, the saponification number is 160-200.

The most common oilseeds in Ukraine are sunflower, soybeans, rapeseed, mustard, flaxseed (or oilseed), poppy, camelina, safflower, castor oil, peanuts, sesame, perilla, and lallemantia.

Essential oil plants are cultivated to produce volatile aromatic substances - essential oil. These are various mixtures of organic compounds: carbohydrates, alcohols, phenols, esters, aldehydes, ketones and organic acids. Essential oils have a pleasant smell and are used in the cosmetics, pharmaceutical, food, soap, tobacco and other industries. They are accumulated in various plant organs: in fruits, seeds (coriander plants, caraway plants, anise, fennel); in leaves and stems (mint, lavender plants, sage), in flowers (rose); rhizomes (iris) (Table 3.3).

Table 3.3**Content of essential and fatty oils in different essential oil carriers**

Plant name	Body. oil accumulation	Essential oil, percentage	Fatty oil, percentage
Anis	seed	2,5-4,0	16-22
Coriander plants	also	1,5-2,7	17-28
Cumin plants	also	4,0-7,0	18-22
Mint	leaves and stem	2,5-4,0	-
Nutmeg sage	flowers	0,2-0,35	-
Lavender plants	also	1,0-2,0	-

Essential oil plants such as coriander, cumin, and anise contain a significant amount of fatty oil (14-28 per cent) in addition to essential oil (1-7 per cent). Essential oil is extracted by steam distillation, and fatty oil is extracted by extraction with organic solvents. Essential oil plants, unlike oilseeds, contain volatile oil with a strong, pleasant smell. In Ukraine, the most common essential oil plants are coriander plants, caraway plants, mint, anise, fennel, rose, lavender plants, and sage. In the late 80s of the XX century, the sown area of essential oil plants was almost 33 thousand hectares. In 1998, it decreased to 10 thousand hectares. However, in recent years, there has been a tendency to expand the area under cultivation. There are a large number of rare essential oil plants that are suitable for cultivation in Ukraine. These are anise loquat, lavender, lemon wormwood, lemon catnip, medicinal rosemary, etc.

**3.3.1 SUNFLOWER (*Helianthus*)**

Sunflower is the main oilseed in Ukraine. It accounts for about 65 per cent of oilseeds and 15 per cent of the total sown area. The seeds of modern varieties and hybrids contain 50-55 per cent fat (on a completely dry seed weight) and 16 per cent protein, while the kernel contains 65-67 per cent and 22-24 per cent, respectively. Compared to other oilseeds, sunflower provides the highest oil yield per unit area (750-1000 kg/ha on average in Ukraine). The oil belongs to the group of semi-drying oils (iodine number 112-124), which means it has high taste and advantages over other vegetable fats in terms of nutrition and digestibility.

Sunflower oil is particularly valuable due to its high content of up to 90 per cent *unsaturated fatty acids*: linoleic (55-60 per cent) and oleic (30-35 per cent). The fatty acid composition of oil in sunflower seeds is changed by blocking the work of the desaturase enzyme, which converts oleic acid into linoleic acid. About 65 per cent of the total fatty acids are synthesised in ordinary sunflower oil, while no more than 15 per cent is synthesised in high-oleic sunflower oil. The most biologically useful is linoleic acid, which accelerates the metabolism of cholesterol esters in the body, which

has a positive effect on health.

Sunflower oil is also used to make canned fish and vegetables, as well as in the baking and confectionery industries. After refining (purification from mixtures) and hydrogenation (the oil reacts with hydrogen to form hydrogenated fats; hydrogenation makes fats less prone to rancidity, which extends their shelf life), it is used to make margarine. The oil also contains phosphamides, vitamins (A, D, E, K) and other organic substances that increase its biological value. In terms of calories, one weight unit of oil corresponds to 2-3 units of sugar, 4 units of bread, and 8 units of potato plants. The worst quality sunflower oil is used in the paint and varnish, soap making, and other industries, and is used to produce stearin, linoleum, waterproof fabrics, electrical fittings, etc.

When seeds are processed into oil, pressing produces cake and extraction produces meal, which make up 35 per cent of the seed weight. The cake contains 38-42 per cent digestible protein, 20-22 per cent nitrogen-free extractives, 6-7 per cent fat, 14 per cent fibre, 6-8 per cent ash and mineral salts. In terms of nutritional value, 1 kg of cake corresponds to 1.09 feed units and contains 363 g of digestible protein. The meal contains about 33-34 per cent digestible protein, 3 per cent fat, and 1 kg of it corresponds to 1.02 feed units.

The husk (16-22 per cent of the seed weight) is a valuable raw material for the production of hexose and pentose sugar. Hexose sugar is used to make ethyl alcohol and fodder yeast, while pentose sugar is used to produce furfural, which is used to make plastics, artificial fibre, durable glass and other products.

Sunflower baskets (yield 56-60 per cent of the seed weight) are used for animal feed. They contain 6.2-9.9 per cent protein, 3.5-6.9 per cent fat, 43.9-54.7 per cent BER, and 13.0-17.7 per cent fibre. 1 kg of flour made from dry baskets contains 0.8 feed units and 38-43 g of protein. Baskets are used to produce food pectin, which is used in the confectionery industry. Ash from the dry stems of sunflower plants is a valuable phosphorus-potassium fertiliser (it contains up to 36 per cent potassium oxide and 4 per cent phosphorus). The stalks can be used to make paper. Sunflower is also grown as a fodder plant, either as a pure crop or in mixtures with other fodder plants. The yield of green mass when growing tall sunflower varieties reaches 40.0-50.0 tonnes per hectare. Silage from sunflower plants harvested in the flowering phase is not inferior in nutritional value to silage from corn plants. 1 kg of it contains 0.13-0.16 feed units, 10-15 g of protein, 0.4 g of calcium, 0.28 g of phosphorus and 25.8 mg of carotene. Sunflower is an important honey plant. From 1 hectare of its crops, the honey yield reaches 40 kg. The yellow petals of the reed flowers have medicinal value. Sunflowers are also sown to create a backdrop on steam fields for snow retention. With a yield of 2.5 tonnes per hectare, 1,200 kg of oil, 800 kg of cake (300 kg of protein), 500 kg of husk (70 kg of yeast), 1,500 kg of baskets (equivalent to hay), and 35-40 kg of honey can be produced from 1 hectare. To produce 1 tonne of sunflower oil, 1 hectare is required, and 1 tonne of animal fat requires 8-10 hectares of arable land.

Sunflower plants are native to the southwestern part of North America, where wild species of the genus *Nelianthus*, including close relatives of the cultivated sunflower, still occur. The indigenous population used its seeds for food purposes and also made flour for baking bread. Today, soybeans are the most common oilseed plant

in the Americas. As an oilseed, sunflower has been grown for about 150 years, mainly in temperate regions with rich black soil, warm summers, and sufficient rainfall. However, a significant part of its crops is also concentrated in areas with hot climates and insufficient moisture.

The sunflower was introduced to Europe by the Spaniards in 1510, when they called it the Peruvian chrysanthemum. It was introduced to Ukraine in the 18th century. For a long time, it was grown as an ornamental plant, and only occasionally for its seeds. In the mid-nineteenth century, sunflower oil was first produced. Since then, it has been widely cultivated.

Sunflower accounts for 8 per cent of global oilseed production, or 27 million hectares. The main areas under sunflower are concentrated in Europe (60 per cent) and Asia (20 per cent), and among the countries: - 6.5 million hectares, Ukraine - 5.2 million hectares, Argentina - 3.4 million hectares, India - 2.2 million hectares, and the United States - 1.4 million hectares. According to the forecasts of the US Department of Agriculture (USDA), in 2012-2013 marketing year the company expects to produce 36.5 million tonnes of sunflower seeds. The increase in production is a result of higher yields and expansion of planted areas. Thus, the yield is expected to be about 1.4 t/ha, and the area under this plant is about 25 million hectares, which is 2.2 million hectares, or 10 per cent more than in the previous year. In recent years, Ukraine has been experiencing an upward trend in sunflower seed production. While in 2005 the harvest of this plant was 4.7 million tonnes, in 2012 it increased to 8.4 million tonnes. This was facilitated by the expansion of the sown area to 5.2 million hectares in 2012. Along with the expansion of the area, the yield is also increasing, which in 2011 was 1.84 t/ha (compared to 1.28 t/ha in 2005). Ukraine's share in global sunflower oil trade is estimated at 57 per cent, which confirms its sole leadership in foreign sales of this product. For comparison, exports over 1 million tonnes or 11 per cent of global sales, while Argentina exports over 1 million tonnes (17 per cent). In total, Ukraine exports sunflower oil to 88 countries, including India, which buys up to 27 per cent of its foreign commodity stock, the EU - 22 per cent, Turkey - 12 per cent, Egypt - 8 per cent, and - 6 per cent.

Biological characteristics, varieties and hybrids. *Requirements to temperature.* Sunflower is a thermophilic plant in terms of heat. Its seeds begin to germinate at $+4...6^{\circ}\text{C}$, but seedlings appear at this temperature on the 18th-20th day. The optimum germination temperature is $+20^{\circ}\text{C}$. Seedlings at this temperature appear on the 6-7th day. The sum of active temperatures from sowing to germination is $140-160^{\circ}\text{C}$. Sunflower seedlings can withstand frosts down to -8°C , but this delays and weakens plant growth and development. In the flowering phase and in the following period, the most favourable temperature is $+25...27^{\circ}\text{C}$. Temperatures above $+30^{\circ}\text{C}$ inhibit plant growth, and at $+40^{\circ}\text{C}$, photosynthesis processes stop. The sum of effective temperatures during the growing season is $1600-1800^{\circ}\text{C}$ for early ripening and $2000-2300^{\circ}\text{C}$ for late ripening varieties.

Moisture requirements. Sunflower is a drought-resistant plant. However, the requirements for soil moisture are quite high. Water consumption per plant during the growing season exceeds 200 litres. The transpiration coefficient is higher than that of many other plants and is 450-570. However, with a well-developed root system that

penetrates the soil to a depth of 3-3.5 m, sunflower meets the need for water from deep soil layers. The moisture supply of sunflower plants during the flowering and seed filling phases is crucial for high yields. If there is a lack of moisture during this period, yields are sharply reduced due to significant hollow seeding, incomplete seed filling and reduced seed size in the basket. Therefore, when growing sunflower plants in arid conditions, it is important to accumulate moisture in the soil through snow retention, irrigation, etc. Sunflower is very demanding on light. In shaded and cloudy weather, the growth and development of plants is weakened, and small leaves and small baskets are formed, which negatively affects the yield. Sunflower is a short-day plant. In the north, the growing season is extended.

Soil requirements. Sunflower is very demanding on soil fertility. The best soils are sandy loam and loamy chernozems and chestnut soils with a neutral or slightly acidic soil solution reaction (pH 6.0-6.8). Heavy, structureless soils, as well as light sandy, saline and very acidic soils, are not suitable for sunflower plants.

Nutrient requirements. Sunflower uses nutrients from the soil better than other plants, and takes out more of them per unit of yield. For example, to form 1 tonne of seeds, it takes up 65 kg of nitrogen, 27 kg of phosphorus and 150 kg of potassium. The nutrients are used unevenly by phase. Sunflower consumes the most nitrogen from the beginning of the basket formation to the end of flowering, phosphorus from germination to flowering and potassium from basket formation to ripening.

During the vegetation period, sunflower goes through the following phases: germination, first pair of true leaves, formation of the head, flowering, and ripening. The duration of the interphase periods for the most common mid-season sunflower variety group is: from sowing to germination 14-16 days, from germination to the beginning of the basket formation 37-43 days, from the beginning of the basket formation to flowering 27-30 days, and from flowering to ripening 44-50 days. The total length of the growing season of this group of varieties is 120-140 days. In early maturing varieties, the interphase periods are reduced. The length of the growing season of varieties and hybrids, depending on their early maturity, ranges from 80 to 140 days. According to the length of the growing season, sunflower varieties and hybrids are divided into early or ultra-early (80-100 days), early (100-120), medium early (110-130) and medium early (120-140 days). Abroad, sunflower hybrids are divided into maturity groups based on the length of the flowering-ripening period. The State Register of Varieties includes more than 120 hybrids and varieties of domestic and foreign breeding.

Early ripening varieties: Odesskyi 149, Kharkivskyi 49, Aeneas, Ranok, Chumak, Tisa, PR62A91; *early ripening varieties:* ES Biba, ES Karamba, Dunai, Zaporizkyi 26, Nakhodka, Natil, NK Brio, Sanluka, Svitoch, Kharkivskyi 7, PR63A40, PR63A90, Kazio, Savinka; *medium early* - Alamo, Arena, Krasotka, Odesskyi 123, Kharkivskyi 58, PR64A44, PR64A63, ES Bambina; *medium ripe* - Kharkivskyi 3, Zaporizkyi Kondyternyi, PR64A58, PR64A83, PR64A89, PR64E83, ES Aramis, *high oleic* - NC Ferty, Tutti, NC Kamen.

Agricultural technology. *Place in the crop rotation.* When placing sunflower plants in crop rotation fields, it should be borne in mind that it is affected by the parasitic weed sunflower broomrape (*Orobancha cumana* Wallr.). Seeds of broomrape

in the soil remain viable for 6-8 years, and under favourable conditions - 10-13 years. In addition to sunflower plants, broomrape affects safflower, perilla, tobacco, terry, and tomatoes. Therefore, sunflowers should be grown on the same field no earlier than 7-8 or even 8-10 years later. To control broomrape in crop rotation fields, weeds must be systematically destroyed, especially those on which it can parasitise (bluestem, wormwood, wild lettuce, and dodder). The best crop rotations for sunflower plants are winter wheat, corn, and legumes. It is inappropriate to sow sunflower after perennial grasses, Sudanese grass, sugar beet, pea plants, rapeseed plants, soybean plants, and in the Steppe - after barley plants and oat plants.

Due to the fact that sunflower dries out the soil deeply and leaves a lot of residue, it is one of the worst crops to be replaced in a crop rotation. The fields where sunflower was grown are left under clean steam, which helps to restore moisture reserves in the soil.

Soil cultivation. The method and timing of soil preparation for sunflower is chosen differentially, depending on the place in the crop rotation and the availability of appropriate technical means, using one of three known technologies: classical (traditional), minimal or zero (No-Till). The best method of basic soil cultivation in sunflower growing areas is *improved autumn* tillage.

After cereal plants infested with annual weeds, two stubble cultivations are carried out with disc stubble cultivators LDG-10, LDG-15 - the first to a depth of 6-8 cm, the second - after 10-12 days to a depth of 8-10 cm. On fields infested with thistles and other root and sprout weeds, the first peeling is carried out with disc tools to a depth of 6-8 cm, and the second, as weeds appear, with ploughshares PPL-10-25 or cultivators-plane cutters KPSH-5, KPSH-9 to a depth of 10-12 cm. An effective way to control weed infestation with root and sprout weeds is to combine autumn tillage with the use of 2,4-D amine salt herbicides mixed with ammonium nitrate (8-10 kg/ha). They are applied after weeds grow back on the ploughed field. This method ensures the death of 94 per cent of sow thistle and 96 per cent of field bindweed.

When placing sunflower plants after corn plants before ploughing, the soil is disced with BDT-7, BDV-6.3 disc harrows in two directions to crush nutrient residues. In late September - early October, ploughing is carried out to a depth of 27-30 cm, and on soils that are not prone to compaction and sticking, and in the absence of perennial weeds - to 22-25 cm.

In areas of sufficient moisture, semi-steam tillage is used. In this method, firstly, ploughing and ploughing are carried out with ploughs with skimmers in the harrow unit. Subsequently, as the soil moistens and weeds germinate, cultivation is carried out with simultaneous harrowing. To combat wind erosion, especially in the Steppe, where dust storms are common, flat-cut tillage is recommended, which involves cultivating the field with a BIG-3 needle harrow to a depth of 6-8 cm, and when weeds appear, with a KPP-22 cultivator to a depth of 10-12 cm. After the weeds regrow, the soil is loosened with a KPG-250 flat cutter to a depth of 25-27 cm.

Spring and pre-sowing tillage consists of early moisture closure and 1-2 cultivations. Pre-sowing cultivation is carried out to the depth of seed placement.

The herbicidal period in sunflower is 40-50 days (it lasts from germination to the phase of head formation). The biological basis of the long herbicidal period is the

slow growth of the plant at the beginning of the growing season, and the technological basis is the wide-row sowing method, which creates favourable conditions for the germination of weed seeds. The peculiarity of growing sunflower plants is that all the main actions to protect crops from weeds must be carried out before the plant germinates, which involves the use of soil hybrids, and only in the case of cereal weeds can graminicides be used. For pre-sowing cultivation, soil herbicides such as Harness New (2-2.5 l/ha), Stomp 330 (3-5 l/ha), Treflan (2-5 l/ha), Trophy (2-2.5 l/ha), Frontier Optima (0.8-1.4 l/ha), Dual Gold (1.2-1.6 l/ha), and Gezagrado (2-4 l/ha) are applied; against dicots - Goal (0.8-1.0 l/ha).

The effectiveness of soil herbicides is highly dependent on a number of factors. For example, the rate of herbicide use depends on the absorption properties of the soil and the number of weeds - the more weeds, the higher the rate. Even if the herbicide is applied on light soils and the level of weeds is several times higher than the threshold of harmfulness, the maximum consumption rates should be applied, and vice versa - if the level of weeds is low, the rate of the product should be reduced. The soil on which the herbicide is applied should be fine-clodded so that the product evenly covers the entire surface of the field with a protective screen and does not fall on clods from under which weeds can safely germinate.

The choice of herbicide depends on the type of cultivation and the expected yield. Under extensive cultivation techniques, a mixture of Trophy 90 ES, c.e. and Gezagrado 500 FW, h.p. is used to protect against annual cereal and dicotyledonous weeds, but it should be remembered that the consumption rate of Trophy should not be exceeded, as this can lead to phytotoxicity. The main signs of phytotoxicity of acetochlorines on sunflower plants are poor development of the lateral root system, deformation of the plant, and stunting.

Fertilisation. Mineral fertilisers have a significant impact on seed quality and the fatty acid composition of oil, especially in high oleic hybrids. Nitrogen mineral fertilisers contribute to yield growth, but their excess causes a decrease in fat content and increases the content of linoleic acid by up to 10 per cent, which is undesirable when growing high oleic sunflower. Phosphorus and potassium fertilisers increase the oil content of seeds and the content of oleic acid. Therefore, it is necessary to apply balanced rates of nutrients, taking into account their content in the soil. The sunflower fertilisation system consists of basic and line fertilisation ($N_{15} P_{20}$). Organic fertilisers are best applied on-site in a crop rotation at a rate of 30-40 t/ha. In the Steppe and Forest-Steppe regions of Ukraine, the highest yields are obtained on chernozem and dark chestnut soils when nitrogen-phosphorus fertilisers are applied. If the soil is low in nutrients (less than 5 mg per 100 g of soil), 60 kg of nitrogen and 90 kg of phosphorus are applied per hectare, if the soil is medium in nutrients (5-10 mg per 100 g of soil), $N_{45-60} P_{90}$ is applied, and if the soil is high in nutrients (more than 10 mg per 100 g of soil), $N_{20-30} P_{30}$ is applied. Fertiliser rates should be specified in each specific field. On less fertile soils, it is recommended to apply full mineral fertiliser at the rate of $N_{60} P_{40-60} K_{40-60}$. Sunflower is sensitive to the lack of microelements such as boron and magnesium, and therefore microfertilisers should be used on soils where there is a deficiency of these elements.

Sowing. Seeds are prepared for sowing immediately after harvesting the seed

crops. They are cleaned, dried, sorted and then stored. Seeds weighing 1000 seeds for 80-90 g varieties and at least 50 g for hybrids are used for sowing, with a purity of 98.0-99.9 per cent, a shelling rate of 96.0-99.0 per cent and a germination rate of 87.0-92.0 per cent.

The full potential of any hybrid and obtaining uniform and healthy seedlings is impossible without reliable protection, the first step to which should be the protection of seeds and seedlings from diseases (seed mould, Fusarium root rot, white rot, downy mildew) and pests. For this purpose, the seeds are treated with special preparations, i.e., seed treatment agents, among which Maxim XL 035 FS, d.c. (6 l/t) is the basic one. This preparation contains 25 g/l of fludioxonil and 10 g/l of metalaxyl-M, which not only provides reliable protection against a range of diseases (seed mould, fusarium root rot, downy mildew, etc.), but also does not have a negative effect on the germination energy of seeds during the year after treatment. In case of a high threat of downy mildew damage to seedlings, the amount of Metalaxyl-M should be increased by adding Apron XL 350 ES, c.s. (3 l/t). In this mixture, the consumption rate of Maxima can be reduced to 3 l/t. Sunflower seedlings can be damaged by a whole range of pests (wireworms, weevils, aphids, copperheads, etc.). Therefore, to protect against pests in the early stages of organogenesis, the seeds must be treated with Cruiser 350 FS, t.c.s. (6-10 l/t), Cosmos (4 l/t), Gaucho (10.5 kg/t), which provide protection for seedlings and young seedlings for 40-45 days. In addition, Cruiser produces the so-called "vigor effect", i.e. it has a stimulating effect on the root system, as a result of which plants develop more actively, seedlings are more uniform and better tolerate drought. If the number of soil pests is too high, Force 200 CS, s.c. (2 l/t) should be added to Cruiser. The peculiarity of this product is that due to its fumigation properties, a protective gas sphere is formed around the seeds and young roots, getting into which the pests die without damaging the plants. Force can also be used in a special granular formulation. In this case, the product should be applied to the soil during sowing at a rate of 6 kg/ha.

Sunflower is sown in a dotted pattern with row spacing of 70 cm, with precision seeders to a depth of 6-8 cm for varieties and 4-6 cm for hybrids. Both early and late sowing dates cause undesirable results. In case of early sowing, the period before emergence extends for 3-4 weeks, and seedlings are unfriendly and sparse. With late sowing, the topsoil is often dry, which also has a negative impact on germination. Early sowing (simultaneously with early spring plants) is preferred in the Northern Forest-Steppe. This is because late sowing in conditions of sufficient moisture increases the development of vegetative mass to the detriment of generative organs. The optimal sowing date is when the soil warms up to +6...8⁰ C at a depth of 4-6 cm. Each individual sunflower field needs to be sown in 1-2 days, and sowing is completed within 4-6 days on the farm.

The seeding rate depends on the recommended plant density. The optimum pre-harvest plant density is 30-35 thousand/ha in the Southern Steppe, 45-50 thousand/ha in the Central and Northern Steppe, and 55-60 thousand/ha in the Forest-Steppe. Early maturing and undersized varieties and hybrids do not reduce yields when thickened to 80 thousand/ha.

A sunflower is an annual plant with a large, daisy-like flower head that follows

the sun and is known for its edible seeds and bright yellow petals. The scientific name for the common sunflower is *Helianthus annuus*, derived from the Greek words for "sun" and "flower". Sunflowers are grown for ornamental purposes, for their oil-rich seeds, and as a source of animal feed. Heliotropism: Young sunflowers exhibit heliotropism, meaning they turn to face the sun as it moves across the sky. Flower head: The large "flower" is actually a collection of many smaller flowers called florets. Varieties: Cultivated varieties can have single large flower heads or multiple smaller ones, and come in various colors, including yellow, red, orange, and maroon.

Sunflowers can range from small dwarf varieties to giant ones that grow up to 16 feet tall. Uses The seeds are a source of edible oil and are eaten as a snack. They are also used for livestock and bird feed. Their bright, cheerful appearance makes them a popular choice for gardens and as cut flowers. The leaves can be used as animal fodder.

Sunflowers symbolize adoration and loyalty, and are often associated with happiness. It is the state flower of Kansas, which is sometimes called the "Sunflower State". In Ukraine, sunflowers are a national symbol of peace and resilience. They were also planted after the Chernobyl disaster to help remove toxins from the soil.

Crop care. During crop care, you should ensure effective protection against weeds, pests and diseases, maintain the optimum plant density, create favourable conditions for their growth and development, which will ensure the formation of a high yield of sunflower seeds. If the seed layer is loose and the weather is windy, the field should be rolled after sowing. This will improve the germination of sunflower seeds, and, what is especially important for herbicide-free technologies, weed seeds. After 5-6 days, in the "white thread" phase of weeds, pre-emergence harrowing is carried out with sowing or medium tooth harrows across or diagonally across the field. It is important that the harrow tines do not go deeper than 3-4 cm into the soil and do not damage the sunflower seedlings. When sowing in colder soil and sunflower germination is slow, harrow twice before germination.

The optimal time for post-emergence harrowing is when the sunflower has 1-3 pairs of true leaves. The machine's driving speed should not exceed 4 km/h. This operation should not be carried out before 11 a.m., as the plants are severely damaged due to high turgor. If these conditions are met, the damage to sunflower plants does not exceed 10 per cent, and weed control reaches 80-90 per cent. In sunflower crops, post-emergence herbicides Furore Super (0.8-2.0 l/ha), Select 120 (0.4-1.4 l/ha), Fusilade Forte (0.5-2 l/ha), Shogun 100 (0.6-1.2 l/ha), Aramo 45 (1-2 l/ha) can be used.

During the growing season, two inter-row loosening operations are usually carried out with KRN-4.2, KRN-5.6A, and KRN-8.4 cultivators. Inter-row loosening is especially effective in fields weeded with pink and yellow thistles. In the Steppe, it is best to carry out loosening to the same depth - 6-8 cm. In the Forest-Steppe, the last loosening is recommended to be carried out with chisel-shaped tines to a depth of 10-12 cm at an increased speed of the machine. A powerful mulching layer of soil is created, which prevents moisture evaporation and destroys vegetative weeds. Due to the increased speed, weeds in the protective zone of the row are crushed, and the upper horizontal layer of the root system of sunflower plants is cut, which stimulates the development of the root system in deeper horizons. This reduces the risk of plant depression in the event of drought.

The yield of sunflower plants increases when beehives are placed on its crops. In addition, bee pollination reduces self-pollination of flowers in baskets, hollow seeds, etc. Apiaries are placed on crops at the rate of 1-2 bee colonies per hectare.

The introduction of the *Clearfield* system is an innovative trend in sunflower cultivation. In English, *clearfield* means "clean field". This system fully justifies its name, as it allows us to produce almost clean crops even on heavily weeded fields. The Clearfield system was first applied to sunflower plants in 2003 in the US and Turkey, and in recent years it has become widespread worldwide.

With *Clearfield*, the modern high-performance hybrids used in the system have the opportunity to realise their full yield potential. This should be based primarily on the developmental stage of the weeds. It is desirable that dicotyledonous weeds do not outgrow the six-leaf stage, and cereals do not outgrow the four-leaf stage. And in the presence of broomrape, Euro-Lightning herbicide (1.0-1.2 l/ha) should be applied at the 8-10 leaf stage.

It should be noted that high temperatures, low air humidity, and other unfavourable environmental factors for sunflower can lead to mild phytotoxicity, such as yellowing of the leaves. After the weather conditions return to normal, this phenomenon quickly disappears without any negative impact on yield formation. After applying Euro-Lightning herbicide, it is very important to take into account crop rotation restrictions.

Clearfield hybrids: NK Fortimi, **NK** Neoma, Sanai, Tristan, ES Amis, ES Primis, ES Florimis, ES Artimis, ES Aramis, ES Bellamis, Mas 80, Mas 91, Mas 87, Mas 92, Mas 95.

DuPont offers the *Express Sun* system, a unique hybrid-herbicide technology for effective control of annual and perennial weeds during the growing season. This technology is based on the use of the post-emergence herbicide Express 75 v.g. The main advantages of this product include, first of all, its high efficiency against a wide range of dicotyledonous weeds, including malicious and difficult-to-eradicate ones (thistles, ragweed, etc.). Other advantages of using this product include flexibility and a wide time interval of herbicide application: from 2 to 8 leaves of the plant. Pioneer offers the following sunflower hybrids for this technology: PR64E83, PR64E71, P63LE10, P64LE19.

To control sunflower broomrape (especially with *Clearfield* and *Express Sun* technologies) in the following crop rotation, it is recommended to use Granstar Gold, Kalibr, Ellay Super, Laren Pro herbicides on grain plants in tank mixtures with herbicides based on fluroxypyr, dicamba, 2,4-D, 2M-4X. In corn crops, it is recommended to use DuPont Tusk herbicide 307-385 g/ha + surfactant Trend 90, 200 ml/ha, as well as Titus, Basis, Harmony in tank mixtures with hormonal herbicides (2,4-D, dicamba). It is necessary to ensure spatial isolation of 1500 m for the areas intended for seed sowing or sunflower hybridisation from sunflower crops tolerant to Express and Euro-lightning.

Protection against diseases and pests. Sunflower plant diseases can cause significant yield losses (20-30 percent or more). Therefore, it is recommended to use insecticides recommended for use on sunflower crops (Table 3.4).

Table 3.4

**Fungicides for sunflower plant protection
from diseases**

Name of the drug, of the active substance, firms	Norma introduction l, kg/ha	Harmful organism, against processed	Method, processing time, limitations
Acanto Plus 28 hp (picoxystrobin, 200 g/l, ciproconazole, 80 g/l), DuPont	0,5-1,0	white and grey rot, phomopsis, phomosis, rust, downy mildew, septoria, alternaria	spraying during the growing season no more than 2 times no later than 30 days before harvesting
Derosal, c.s. (carbendazim, 500 g/l), Bayer Crop Science	1,5	white and grey rot, phomosis, fake mealy dew	
ColfugoSuper, v.s. (carbendazim, 200 g/l), f. Agro-Kemi Kft.	2,0	phomopsis	
Corbel, c.e. (fenpropimorph, 750 g/l), f. BASF	0,8	phomopsis	
Tanos, v.g. (cimoxanil, 250 g/kg, famaxadone, 250 g/kg), DuPont	0,4-0,6	Alternaria, phomopsis, phomosis, downy mildew, septoria, white and grey rot	

To protect against pests, sunflower crops are treated (if the harmfulness threshold is exceeded) with recommended insecticides (Table 3.5).

Harvesting. In 35-40 days after flowering, the accumulation of fat in the seeds is completed in the yellow ripeness phase. Then the water physically evaporates from the achene and the phase of full ripeness begins. In practice, three phases of ripeness are identified by the change in the colour of the baskets: yellow - leaves and baskets are lemon yellow, the moisture content of the basket is 85-88 percent, the seeds are 30-40 percent; brown - the baskets are dark brown, their moisture content is 40-50 percent, the seeds are 10-12 percent; full - the moisture content of the baskets is 18-20 percent, the seeds are 7-10 percent.

Harvesting of sunflower plants begins at an average seed moisture content of 12-14 per cent, when 80-90 per cent of the plants have yellow-brown, brown and dry baskets, and 10-20 per cent have only yellow baskets. Optimal conditions for harvesting are at a seed moisture content of 9-11 per cent. Provided that the farm has drying equipment and a large area of sunflower plants, you can start harvesting at a seed moisture content of 20-22 per cent. It should be borne in mind that seeds with a moisture content of no more than 7-8 per cent are suitable for long-term storage. At higher moisture content, the seeds oxidise and the oil becomes unfit for human consumption.

Table 3.5**Insecticides for plant protection of sunflower from pests**

Drug name, active ingredient, manufacturer	Norma contribution l, kg/ha	A harmful organism, against processed	Method, processing time, limitations
Decis f-Lux, k.e. (deltamethrin, 25 g/l), Bayer Crop Science	0,3	meadow butterfly	spraying during the growing season no more than 2 times no later than 30 days before harvesting.
Dimilin, z.p. (Diflubenzuron, 250 g/kg), Crompton	0,09	locust complex	spraying in the phase of 12-18 leaves in sunflower plants no more than 1 time no later than 25 days before harvesting.
Mospilan, r.p. (acetamiprid, 200 g/l), Nippon Soda Co. Ltd.	0,05-0,075	locusts	spraying of crops no more than 1 time no later than 40 days before harvesting.
Coragen, c.s. (chlorantraniliprole, 200 g/l), Dupont	0,15-0,175	scoop complex, sunflower moth, meadow butterfly	spraying of crops no more than 2 treatments per season (sequentially, within one generation of the pest).
Fufanon 570, c.e. (malathion, 570 g/l), Keminova	0,6	bedbugs, aphids	spraying crops no more than 2 times no later than 20 days before harvesting.

The optimal harvesting time for sunflower is 5-6 days. If sunflowers are harvested at full ripeness, then on the fifth day, losses from seed shattering increase by 2 times, and on the 15th day by 12 times. In other words, harvesting in the early stages leads to an increase in energy consumption for drying, and leaving sunflower plants on the stump until the full ripeness stage is accompanied by seed losses. Therefore, to accelerate harvesting and simultaneous ripening, crops are treated with *desiccants*: Reglon Super (2-3 l/ha), Reglon Air (2 l/ha), Basta 150 SL (2.0-2.5 l/ha), Dominator (3 l/ha), Glyphogan (3 l/ha), Roundup (3 l/ha). Reglon Air is a contact desiccant with a high content of active ingredient and an optimised system of adjuvants. Specially designed for desiccation by air, it ensures harvesting with the least losses. Desiccation is an essential part of agricultural practices for many crops, including sunflower. It is necessary to carry out desiccation on sunflower crops to accelerate the ripening and

drying of plants on the root, to obtain dry seeds that will allow harvesting to begin 8-10 days earlier. In production, there are four main cases when desiccants should be used: wet, cool weather; uneven ripening of crops; severe disease infestation (especially grey and white rot); and high weed infestation. Also, desiccants should be used on high backgrounds and under irrigation, when the length of the growing season in sunflower can significantly change. They are applied at a seed moisture content of 25-30 per cent. The desiccants work best at an average daily air temperature of 13-14⁰ C. In this case, the plants stop growing, ripen at the same time, and harvesting is accelerated by 7-8 days. Disease incidence is reduced, combine productivity, seed quality and yield are increased, oil yield per hectare is increased, and energy costs are reduced. After treatment with Reglon, harvesting begins in 5-6 days at a seed moisture content of 12-14 per cent, when 75-85 per cent of the baskets turn brown. When sprayed with Roundup or Glyphogan, harvesting takes 11 days.

The heap is immediately cleaned on ZAV-20 and ZAV-40 seed cleaning units. The seeds of sunflower plants are dried to 12 per cent, and those to be stored to 6-7 per cent. Commercial sunflower seeds must meet the requirements of DSTU 4694-2006 "Sunflower. Oilseeds. Technical specifications". Depending on the quality criteria, the grown products are divided into the highest, first or second class.

3.3.2 Winter rape (*Brassica napus*)



Winter rape is the most widespread oilseed plant in the cabbage family. Among the cabbage (cruciferous) plants, it is the most highly oil-rich plant. Its seeds contain 45-50 per cent of semi-drying (iodine number 94-112) edible and technical oil. Rapeseed oil contains 60-70 per cent oleic acid, and since the 1980s it has been widely used for the food industry, whereas before 1974 it was mainly used for technical purposes. This is due to the high content of erucic acid, which is harmful to the body (up to 40-45 per cent). However, at the end of the century, varieties of rapeseed plants with a low content of erucic acid (0-5 per cent) were developed, which significantly improved its nutritional quality and brought

it closer to sunflower oil. According to the European standard, edible oil from modern erucic acid-free rapeseed varieties (00) should contain only traces of unsaturated acids - erucic and eicosene acids, 5-8 per cent saturated acids, 60-65 per cent monounsaturated acids and 30-35 per cent polyunsaturated acids.

Processing of rapeseed plants yields 55-57 kg of oil cake from 100 kg of seeds, in addition to 38-41 kg of oil, which contains 32-34 per cent of protein with a well-balanced amino acid composition and 10-18 per cent of fat, or meal (34-38 per cent) of protein and only 2-5 per cent of fat. The protein contains essential amino acids that

are vital for animals, such as lysine, methionine, ziotine, tryptophan and threopine. 100 kg of cake contains 90 k.e. 1 kg of rapeseed meal contains 413 g of digestible protein. A tonne of meal or cake allows you to balance 8-10 tonnes of seed fodder in terms of protein, while increasing the content of digestible protein per 1 k.o. from 80 to 110 g.

From 1 hectare of rapeseed, up to 1.0 tonnes of oil and 0.5-0.6 tonnes of protein feed are produced. For comparison, 1 hectare of such a valuable plant as soybeans produces only 0.2 tonnes of oil and 0.7 tonnes of protein feed.

Winter rape is also valued as a fodder plant because it is grown for its green mass, for silage and haylage. 100 kg of its green mass corresponds to 16 feed units, and one feed unit contains 190 g of digestible protein, or 2 times more than the green mass of a corn plant. The green mass contains vitamins A and C and is highly digestible.

Rapeseed is a valuable honey plant. It produces up to 100 kg of honey per hectare. It clears the field early, dries the soil out little, and is therefore one of the best crops to be used in crop rotations for winter and spring cereals. Winter rape is grown as a winter intermediate and post-harvest fodder and green manure plant.

Rapeseed is a valuable crop rotation, especially for cereals. Its growing season lasts for 10 months, and during this time, rapeseed plants protect the soil from the negative effects of heavy rains and overheating by sunlight, as well as from unproductive evaporation of water from the soil. Unlike sunflower plants, it dries the soil out less, improves its agrophysical properties and phytosanitary condition, and releases the field early. Ploughing up rapeseed residues is equivalent to applying 15-20 t/ha of organic fertiliser and can increase grain yields by 0.5-1.0 t/ha. A well-developed taproot system penetrates deep into the soil, improves its structure, and loosens it, which is especially important when using heavy tractors. The root system is able to absorb nutrients from deeper soil layers, where they are inaccessible to most plants. Ploughing up the root system, stubble and chopped straw allows for a partial return of organic matter to the soil. After its mineralisation, the soil receives 60-65 kg/ha of nitrogen, 32-36 kg/ha of phosphorus and 55-60 kg/ha of potassium.

Rapeseed is native to the Mediterranean, and from there it spread to Asia. It has been known in plants since 4,000 BC. In Europe, rapeseed has been grown since the 16th century, and in Ukraine since the 17th century.

The global area under rapeseed reaches 24 million hectares with an average yield of 1.5-1.8 t/ha. Global production of this crop is forecast at 59.9 million tonnes in 2013. In the 2013-2014 marketing year, the global supply of rapeseed will amount to 66.4 million tonnes. The largest producers of rapeseed in the world today are the EU (21.6 million tonnes), China (13.5 million tonnes), Canada (11.8 million tonnes), India (7.2 million tonnes), and Australia (1.9 million tonnes). Ukraine shares the 5th-6th place with Australia in the production of rapeseed.

According to the State Statistics Committee of Ukraine, the area under rapeseed in 2012 was 547,000 hectares, or 35 per cent less than the previous year. The harvest was 1.2 million tonnes. Ukraine is dominated by winter rapeseed production. Its share in the area structure is 85-90 per cent. The yield of winter rapeseed is 2.2 t/ha, while the yield of spring rapeseed is 1.6 t/ha. The largest producing regions of winter

rapeseed are Cherkasy (123 thsd tonnes), Lviv (122 thsd tonnes), Vinnytsia (115 thsd tonnes) regions, and Chernihiv (18.6 thsd tonnes) and Sumy (17.9 thsd tonnes) regions.

Biological characteristics, varieties. Rapeseed (*Brassica napus oleifera* DC.) belongs to the botanical family *Brassicaceae*. Two forms of rapeseed are common in production: *winter* and *spring* (or *kola*). Winter rapeseed looks similar to common rape (switchgrass), but the colour of switchgrass is grassy green and the leaves are covered with stiff hairs.

Temperature requirements. Rapeseed is an oilseed plant that is not demanding of heat. Rapeseed seeds begin to germinate at a temperature of $+1^{\circ}\text{C}$, but germination requires a temperature of $+14\ldots 17^{\circ}\text{C}$ by day 3-4. The sum of effective air temperatures above $+10^{\circ}\text{C}$ for obtaining friendly germination of winter rape plants is $60\text{--}90^{\circ}\text{C}$, and the guaranteed seed production is 2400°C .

Plants vegetate at $+5\ldots 6^{\circ}\text{C}$ and continue autumn vegetation even in the event of night frosts. For autumn vegetation, a sufficient amount of active (above $+5^{\circ}\text{C}$) temperatures should be $750\text{--}800^{\circ}\text{C}$. Growth and development of winter rape plants in autumn, plant architecture at the end of the autumn growing season have a significant impact on the winter hardiness of plants and overwintering of crops. Plants with a developed rosette of 6-8 true leaves overwinter best, which is achieved by the optimal sowing date and recommended plant density.

Rapeseed plants are hardened in two phases. The first phase takes place in autumn for 14-20 days at temperatures ranging from $+5^{\circ}\text{C}$ to $+7^{\circ}\text{C}$ and stops with the onset of sub-zero temperatures. During this time, high-energy substances, including soluble sugars, accumulate in the leaves. They then flow to the root collar and growth point. The main thing in wintering is to increase the resistance of biocolloids to coagulation, which is provided by protective substances: sugars, pentoses, amino acids and other compounds with a low freezing point. The second phase lasts only 5-7 days at temperatures of $-5\ldots 7^{\circ}\text{C}$. As a result of the outflow of free water from the cells, resistance to low temperatures increases in plants. The root collar is the most vulnerable to low temperatures.

Plants with a rosette of 6-10 true leaves, a root collar diameter of at least 8 mm and a growth point height of no more than 2-3 cm overwinter best.

Seedlings of winter rape plants at late sowing dates with 3-4 leaves do not undergo hardening and die at temperatures of $-6\ldots 8^{\circ}\text{C}$. With good hardening, rapeseed can tolerate a decrease in temperature at the level of the root collar to $-12\ldots 14^{\circ}\text{C}$, and in the presence of a snow cover of 5-6 cm - to $-23\ldots 25^{\circ}\text{C}$ and even to -30°C . It overwinters best at a plant height of 10-15 cm.

The root collar is most damaged at low temperatures. Freezing can be caused by a sharp and sudden drop in temperature, as well as overgrowth of rapeseed plants in autumn, and most often in spring when cold weather suddenly returns. When the soil is not frozen and the plants are covered with snow, there is a risk of rapeseed crops falling out. The reason for this is the high consumption of reserve substances for respiration and growth processes. If this process lasts for more than 50 days, in addition to falling out, the plants will be severely affected by diseases (mould, phomosis, etc.). Such crops are not able to provide a high level of yield and will require special care (microelements, growth-stimulating fertilisers).

Soil frosts down to -5°C lead to the formation of cracks of varying depths. Small cracks heal, while more severe damage can lead to plant breakage and harbour pathogens.

The resistance of rapeseed plants to frost also depends on soil moisture. If the soil is waterlogged, it can freeze even at temperatures of $-6...8^{\circ}\text{C}$. If the soil is dry, rapeseed can withstand low temperatures of $-18...20^{\circ}\text{C}$ for several days. Rapeseed reacts negatively to sudden fluctuations and prolonged drops in temperature in autumn, when the plants have not yet had time to harden, or in spring, after the plant vegetation has resumed. In case of a long cold winter, or contrastingly changing temperatures in early spring, when the vegetation resumes, winter rape plants freeze out en masse.

All generative organs that determine the yield of winter rape plants are laid down at very early stages of plant development. As early as the rosette stage, when 6-8 leaves have formed, the process of their differentiation takes place. About 70 per cent of the yield of winter rapeseed is determined by its development before the onset of winter dormancy (5-7 days at temperatures below $+2^{\circ}\text{C}$).

Rapeseed undergoes the vernalisation stage in the field in autumn and winter for 45-60 days at average daily temperatures below $+8^{\circ}\text{C}$. During spring sowing, winter rape usually does not undergo the vernalisation stage and does not form flowering shoots, but develops a rosette with large leaves that reaches a height of 60-80 cm. This allows it to be used for livestock feed in various soil and climatic zones of Ukraine, both in its pure form and in mixtures throughout the summer and autumn.

Moisture requirements. Rapeseed is a moisture-loving plant. During the growing season, it consumes 1.5-2 times more moisture than seed plants. The transpiration coefficient is 750. Germination requires 50-60 per cent of water by weight of the seed. Rapeseed is inferior to wheat in terms of winter hardiness, and therefore is sown in areas with mild winters and sufficient snow cover. The lack of moisture in the soil during the stemming - flowering phase leads to weak branching, physiological wilting, bud and flower drop, shortening of the flowering phase, and reduced plant productivity. During flowering, the soil moisture content should be 80 per cent.

Light requirements. Winter rape is a long-day plant. Clear weather during hardening increases the frost resistance of rapeseed plants. During the spring and summer growing season, it grows better with high humidity and low temperatures.

Soil requirements. Of all the oilseed rape plants, rapeseed is the most demanding on soil fertility and responds well to organic and mineral fertilisers. The best soils for it are chernozems, grey and dark grey podzolic soils with a saline acidity of 6.2-6.5, potassium content (mg per 100 g of soil) of 2.0-14.5, phosphorus of 6.0-7.5, magnesium of 5.0-7.0, boron (mg per 1 kg of soil) of 0.25, sulphur of 30-60, and manganese of 10-15. Soils with a pH of less than 6 need liming.

Soils with close groundwater, heavy clay, swampy, saline, acidic and light sandy soils are unsuitable. Rapeseed cannot withstand close groundwater.

Nutrient requirements. Winter oilseed rape uses significantly more nutrients to form 1 tonne of seed than seed plants. The average yield per 1 tonne of seeds is: 60 kg of nitrogen, 24 kg of phosphorus, 47 kg of potassium. To form 1 tonne of main products, rapeseed takes out nitrogen, phosphorus - twice as much, and calcium, magnesium, boron and sulphur - 3-4 times more compared to seed plants.

There are *one-zero "0"* varieties containing no more than 5 per cent of erucic acid from the total fatty acids; *two-zero "00"* varieties characterised by low content of erucic acid and glucosinolates; and *three-zero "000"* varieties with low content of erucic acid, glucosinolates and fibre and light (yellow) seed coat. Zoned varieties and hybrids of winter rape in Ukraine: Alligator, Atlant, Helio, Dangal, Dembo, Gorinsky, for use for seed and feed (low in erucic acid and glucosinolates), Exotic, Elvis, ES Artist, Landar, Lidarjet, Nadezhda, Nelson, Odila, Octane, Omicron, Morning Podillya, Rohan, Black Giant, Sherpa, Yura, PR46W10, PR46W15, PR45D01, PR45D03; for technical needs (with low erucic acid content) - Mytnytskyi 2, Ksaverivskyi, Fedorivskyi improved.

Agricultural technology. *Place in the crop rotation.* The best place in the crop rotation of winter rape plants is black and busy fallow, seed legumes, cereal-legume mixtures for green fodder. It can be grown after clover on one mowing and early potato plants. Due to the specialisation of both large and medium-sized farms, when more than 50 per cent of the sown area is allocated to seed plants, the most common place in the crop rotation is for seeded spiked plants. In this case, the choice should be in favour of cereal plants, which leave the field earlier. For example, rapeseed seedlings are friendlier, and development at the initial stages of growth is faster after winter barley plants than after spring barley. This significant advantage should be taken into account, especially in years with dry weather conditions during the summer and autumn. It should not be returned to the same field earlier than after 4-5 years, and should not be sown after mustard, cabbage and other plants of the cabbage family. Winter rapeseed is a good place in the crop rotation for winter and spring cereals, maize plants and intermediate fodder and green manure plants. Growing rapeseed and cereal plants in the same crop rotation improves the phytosanitary condition of fields and minimises the infection of cereals with root rot.

Soil cultivation after fallow and early harvested place crops includes tillage, ploughing and half-pair cultivation. When preparing the soil, it is necessary to pay attention to the even distribution of the residues of the crop rotation (straw), as they are usually winter seed crops. If the straw remains on the field, it should be properly chopped and worked into the soil so that it does not interfere with the growth of rapeseed plants. If necessary, apply stubble destructors (Biodestructor, Cellulad, etc.), and take into account the additional amount of nitrogen fertiliser required for the mineralisation process. The soil is crumbled to a depth of 6-8 cm with disc harrows, which should be equipped with modern heavy rollers for soil compaction (in order to provoke the emergence of grain litter).

Ploughing is carried out to a depth of 22-25 cm with ploughs with skimmers in combination with ring-spur rollers and medium harrows. When weeds or soil crust appear, cultivation or harrowing is carried out. After an unpaired place in the crop rotation, the field is ploughed by 20-22 cm and harrowed at the same time. If early potatoes are included in the crop rotation, surface tillage can be limited to. Two weeks after ploughing, the first wave of sprouted weeds is destroyed by surface tillage, and the second wave is destroyed by pre-sowing tillage. Since after cereals, instead of the recommended 3-4 weeks, rapeseed plants often have only 2 weeks to sow, special attention is paid to the quality of ploughing. The plough is combined with a roller and

harrows to accelerate soil subsidence.

For pre-sowing cultivation of rapeseed plants, only combined units are used - RVK-3.6, LC-4, APB-6, KAAP-6, Combi 3900, AG-3, AG-6, Europak, Compactor, Farmet, etc. - which ensure compaction of the topsoil and create its fine lumpy structure. The depth of the loosening tines should correspond to the sowing depth and be no more than 3-4 cm. The combined tools further settle the soil, which compensates for the 1-month interval between ploughing and sowing.

If the technology calls for the use of soil herbicides, they are applied after levelling the field with combine harrows. They are worked into the soil with the help of a harrow coupling. For pre-sowing soil cultivation, it is recommended to apply Butizan 400 (1.75-2.5 l/ha), Butizan Star (1.75-2.5 l/ha), Dual Gold (1.1-1.3 l/ha), Trophy 90 (1.5-2.0 l/ha), Triflurex 480 (1.2-3.0 l/ha). The effective effect of most soil herbicides lasts for 30-40 days after their application and is not able to reliably control seedlings and germination of late spring weeds.

Fertilisation. Under conditions of sufficiently good development, rapeseed uses about 120-140 kg/ha of nitrogen before the stemming phase, and 200-220 kg/ha before flowering. However, it should be borne in mind that rapeseed is the only winter plant that can accumulate nitrates in the same amount in its roots and leaves. Thus, one hectare of well-developed winter rape crops absorbs up to 80 kg of nitrogen before entering winter, while normally developed winter wheat crops absorb only 20 kg. The rate of mineral fertilisers depends on the place in the crop rotation, soil fertility and the programmed yield level and is on average N P K₈₀₋₁₅₀, 60-80, 80-120. The full rate of potassium phosphate fertilisers is applied before ploughing, except for P K₁₀₋₁₅, which is applied to the rows during sowing. It is better to apply nitrogen fertilisers in fractions: part before sowing, if necessary, in the autumn, and the rest in the spring. Before sowing, N₂₅₋₃₀ is applied after cereals, and N₁₀₋₁₅ is used in crop rotations after fallow. Excessive nitrogen nutrition in the autumn worsens the wintering of plants and, as a result, reduces plant yields. Winter rape resumes vegetation at temperatures of +5 °C. The vegetative mass of rapeseed plants grows intensively within 2-3 weeks after the vegetation resumes, and during this period, most nitrogen is required. Therefore, almost 80-90 per cent of nitrogen is applied in the first two weeks of spring growth. On fertile soils, the full dose of nitrogen can be applied in one application. On light soils, the full dose is divided into parts (50:50). The second application is carried out 3-4 weeks after the first - before the start of stem growth. As a rule, the first fertilisation with nitrogen fertiliser N₄₀₋₆₀ is carried out in spring, and the second at the beginning of budding at a dose of N₂₅. In dry conditions, only in spring N₆₀₋₉₀. When choosing nitrogen fertilisers, preference is given to those containing an amide form of nitrogen rather than a nitrate form. Nitrate fertilisers are preferably used on underdeveloped crops if applied after the start of the growing season. In other cases, they provoke rapid growth of the leaf mass and increase the risk of lodging. The third feeding in the middle of flowering promotes pod growth and seed weight. Foliar application of nitrogen is possible in autumn and spring before budding. Rapeseed is less susceptible to burns than seed rape. Urea is used at 12 per cent concentration.

To guarantee a high yield of winter rape plants (4-5 t/ha), in addition to the traditional nitrogen, phosphorus, potassium, and calcium fertilisers, it is necessary to

apply fertilisers containing sulphur, magnesium, boron, manganese, zinc, iron, molybdenum, and other trace elements. It is advisable to use microelements for pre-sowing seed treatment (e.g. Rostok Oliynyi (3 l/t) and in the form of foliar feeding of rapeseed plants together with spraying of crops with pesticides (Kristalon, Rostok, Zeolit).

Sowing. High and high-quality yields of rapeseed plants can only be achieved with timely and high-quality sowing, optimal seeding rates of seed treated with seed treatment agents and adherence to the recommended sowing depth.

To protect against disease and pest damage in the initial stages of growth, the seeds must be treated with fungicidal (Acrobat (2 l/t), Maxim XL (5 l/t), TMTD (3.0 l/t) and insecticidal (Cruiser 350 FS, thp (4.0 l/t), Cruiser OSR, hp (15.0 l/t), Cosmos (4 l/t), Gaucho (10.5 kg/t)), which provide protection of seedlings and young seedlings for 40-45 days. In addition, Cruiser has the so-called "vigor effect", i.e. it has a stimulating effect on the root system, resulting in more active plant development, more uniform seedlings and better drought tolerance.

The time of sowing winter rape plants should be chosen so that by the beginning of winter the plants have formed 6-8 rosette leaves, the height of the plant growth point is no higher than 1.0-1.5 cm above the soil surface, the root system penetrates the soil to a depth of 50-100 cm or more, and the diameter of the root collar is 8-12 mm. This optimal development of winter rape plants is achieved in most cases within 105-110 days from the date of sowing. In practice, in different soil and climatic zones of Ukraine, winter rape is sown 20-25 days before the optimal sowing date for winter wheat. The optimal sowing dates for winter rape are: 15-25 August in the northern regions; 15-30 August in the western regions; 20-30 August in the central regions; 25 August - 5 September in the eastern regions; and 10-20 September in the southern regions.

Recommended sowing dates should be adjusted depending on weather conditions and soil moisture. Therefore, they may vary by 5-10 days earlier or later. If drought is forecast in August, it is advisable to sow earlier. This is a risky measure, because in case of favourable conditions for growth and development in September and October, there is a risk of overgrowth and reduced winter hardiness. Therefore, farms that have decided to take this step should definitely plan to apply growth regulators in the autumn. Compliance with the depth of seeding ensures that the plants sprout together and increase their resistance to diseases and pests. Rapeseed cannot withstand deep seed placement in the soil, as the seedlings, when they break through to the soil surface, are severely depleted, lose their resistance to pathogenic microflora and are intensively affected by blackleg pathogens and die. The depth of seed placement in the soil is differentiated depending on the type, mechanical composition and moisture content of the soil. On light soils, it ranges from 2.5-3.0 cm, while on heavy soils it is 1.5-2.0 cm.

The optimal seeding rate for winter rape plants is 0.6-0.8 million germinating seeds per 1 ha (3.5-5.0 kg/ha) for hybrids and 0.8-1.0 million germinating seeds per 1 ha for varieties. For some foreign-bred rapeseed hybrids, the seeding rate is much lower and ranges from 40-50 germinating seeds per 1m² (0.4-0.5 million germinating seeds per 1 ha). When determining seeding rates, one should take into account the timing of

sowing, the quality of preparation and the presence of moisture in the soil. Thickening of crops with early sowing dates leads to greater competition between plants, which in turn causes overgrowth (plants entering the stemming phase) and a sharp decline in winter hardiness. At the same time, if sowing is delayed, seeding rates should be increased, as the probability of entering winter in the optimal phase decreases, and therefore the risk of reducing density during wintering increases. It is also advisable to increase the seeding rate in case of insufficient moisture and poor soil cultivation, when the field germination of seeds is reduced.

Excessive seeding rates for winter rape plants contribute to the elongation of the central shoot, which increases the risk of freezing or lodging during the growing season, creates ideal conditions for the development of diseases, and reduces their productivity. Lower seeding rates lead to undesirable consequences: increased weed infestation, insufficient number of pods per unit area, and lower yields.

Under unfavourable conditions and late sowing dates, the amount of seed per unit area should be increased by 10-20 per cent. As a rule, rapeseed is sown using a conventional row method with row spacing of 12.5-15 cm. Such crops are more productive than wide-row crops as a result of continuous shading of weeds by rapeseed plants in the early stages of their development. Wide-row sowings (45 cm) are used for seed production purposes, and inter-row loosening is necessary. After sowing rapeseed, the field is rolled, especially in dry weather. In case of soil crust formation or weeds appearance in the white thread phase, pre-emergence harrowing with light harrows is carried out (if soil herbicides were not applied). In order to increase winter hardiness of rapeseed plants in years with prolonged warm weather in autumn and sufficient rainfall, to prevent overgrowth of plants, one of the plant growth regulators should be applied in the 3-5 leaf stage: Beregina, v.r. (2 l/ha); Biotransformer, (300-400 granules/ha); Biosil (Emistim C), v.r. (5-10 ml/ha); Vermistim K, v.r. (5-8 l/ha); Redostim, v.r. (50 ml/ha); Retacel Extra R 68, p.a. (up to 6 l/ha); Setar (0.3-0.5 l/ha); Sinchroly SL, p.a. (1-2.0 l/ha); Stabilan 750 SL, p.a. (1.5-2.0 l/ha). By reducing the height of the stem and slowing down the growth of the vegetative mass in autumn, they contribute to the development of the root system, thereby reducing lodging, increasing the number of lateral branches, increasing the number of pods and seeds. After all, 70 per cent of the future harvest is laid during the autumn growing season of rapeseed plants.

Timely protection of rapeseed crops from grain borer (a place in the crop rotation) is mandatory, as rapeseed is not competitive with it, is strongly suppressed and stunted. For this purpose, use one of the recommended graminicides. In the 2-4 leaf stage, rapeseed crops are treated with Aramo 45 (1.2-2.3 l/ha), Achiba 50 ES (1.0-3.0 l/ha), Panther (1.7-2.0 l/ha), Targa Super (1.0-3.0 l/ha), and Fusilade Forte (1.0-2.0 l/ha). The following herbicides are used against dicotyledonous weeds: Galera Super (0.2-0.3 l/ha), Salsa (20-25 g/ha), Butizan 400 (1.75-2.5 l/ha), Butizan Star (1.75-2.5 l/ha), Lontrel (0.3-0.5 l/ha), Lontrel Grand (0.12-0.2 l/ha). The application of tank mixtures of herbicides has an excellent effect against rape and other dicotyledonous weeds: Butyzan Star (2 l/ha) + Salsa (25 g/ha), Galera Super (0.3 l/ha) + Salsa (25 g/ha), Proponit (2 l/ha) + Salsa (25 g/ha).

If the crops are underdeveloped, they should be treated with growth stimulants. For this purpose, use one of the following products: Adob (macro + micro) (2.5-5.0 kg/ha); Biostim oil (1-2 litres/ha); Liquid nitrogen fertiliser (UAN) (50-80 kg/ha); Ecolist multicomponent (2-5 litres/ha); Ecolist mono (1-2 litres/ha); Novalon (Nitriflex) (4-16 kg/ha); Novofert (25-50 kg/ha); Reacom Plus (4-6 l/ha); Ruth (0.8 l/ha); Solu (1-8 l/ha); Solubor DF (5-6 kg/ha); Fanat; Zeolite (macro+micro) (2-5 l/ha), etc. The application of microelements can be carried out in combination with other plant care measures if their timing coincides (protection against pests, diseases, etc.).

When winter oilseed rape plants resume vegetation in spring, it is necessary to ensure balanced mineral nutrition of plants, as well as 1-2 times treatment with one of the preparations with retardant properties to delay the stemming phase of plants and achieve maximum branching in later stages of development.

The pre-spring and partially spring periods are among the most critical for oilseed rape plants. The rapid increase in positive temperatures can lead to a shortening of the plant's interphase periods, so early spring fertilisation with nitrogen fertilisers is essential.

Nitrogen mineral fertilisers should be applied as early as possible in order to take advantage of the short day for the vegetative development of winter rape plants. First of all, it is necessary to feed weakened crops, increasing the dose of nitrogen by 40-60 kg/ha. All forms and types of nitrogen fertilisers can be used for the plant: ammonium nitrate, urea, ammonium sulphate, etc., but preference is given to those containing amide form and sulphur. Nitrate forms should be used on weak crops, as they cause intensive growth of the leaf surface, which increases the risk of lodging.

It is advisable to apply nitrogen fertilisers on thawed soil, but too early application can lead to leaching of nitrates or surface runoff. It is better to use urea to prevent possible leaching of nitrates into groundwater.

As rapeseed plants undergo generative differentiation, further nitrogen demand arises, so the second dose of nitrogen fertiliser should be applied at the stage of large buds, but no later than the beginning of flowering. The amount of the second dose is determined as the difference between the total amount of nitrogen applied and the amount of the first dose (Table 3.6).

Table 3.6

Prerequisites for increasing or decreasing the dose of nitrogen for fertilisation of winter rape plants

Nitrogen rates should be increased by 20-40 kg/ha	Nitrogen rates should be reduced by 20-40 kg/ha
poor plant development	powerful development of the stem
low soil nutrient content: humus - 1.5-1.8 per cent, $P_2 O_5 < 120$ and $K_2 O < 150$ mg per kg of soil	place in the crop rotation: annual grasses, legumes, tilled plants
place in the crop rotation - seed plants	dry early spring
heavy clogging with overwintering weeds	
plant density less than 30 plants/m ²	

In order to reduce the negative impact of adverse weather conditions on the productivity of rapeseed plants, it is highly effective to apply microfertilisers such as Aquarin, Vuxal, Ecolist, Crystal, Rostok and others, which contain the required amount of microelements in a form accessible to rapeseed plants to provide them with the plant during certain periods of the growing season. In case of low soil availability, at least two of the most deficient microelements are added to the fertiliser according to the cartogram. It is most advisable to apply them in the budding phase as a foliar feeding in conjunction with pest control spraying.

Rapeseed is damaged by many pests and diseases. To protect against cruciferous flea beetles, rapeseed borer, rapeseed sawfly, cabbage aphids, cabbage whitefly and others, rapeseed crops are sprayed with insecticides Biscaya (0.3-0.4 l/ha), Fury (0.07 l/ha), Fastak (0.1-0.15 l/ha). When treating crops with Fastak insecticide, it is forbidden to use the stalks (straw) of rapeseed plants for feeding livestock, and the oil for food and in the food industry.

For downy mildew, use Cineb (2.4 kg/ha) or 80 per cent Polycarbacin (2.5 kg/ha). To prevent the death of bees, do not treat rapeseed crops during the flowering period.

Harvesting. Rapeseed ripens unevenly, and the pods are prone to cracking, which leads to significant seed losses. Rapeseed is harvested both directly and separately.

To accelerate and simultaneously ripen the crops, *desiccate them* 7-10 days before harvesting with Reglon Super (2-3 l/ha) and Reglon Air (2 l/ha). Basta 150 SL desiccant (2.0-2.5 l/ha) is used 12-14 days before harvesting. On weeded areas, it is advisable to use Roundup (3 l/ha), Dominator (3 l/ha), and Glyphogan (3 l/ha) herbicide 2 weeks before harvesting. They kill weeds and dry the plants. Desiccation reduces seed losses during harvesting and saves energy costs for drying the seeds.

To reduce seed loss during harvesting, the crops are sprayed with Nu-Film 96EC (di-1-P-mentenu), a plant growth regulator. This product creates a strong, elastic, water-resistant film that glues the pods together and prevents cracking. The film restricts the flow of water into the pods, while water is easily lost to the outside. The film is so elastic that it can be easily stretched as the mass of seeds in the pod increases. Plants do not dry out after application, continue to vegetate and accumulate plastic substances in the process of photosynthesis. This is important, as the pods of rapeseed plants form more than 80 per cent of the crop. During the last days of ripening, the yield increase is the highest. That is, this preparation does not act as a desiccant - the pods ripen and dry evenly. Apply Nu-Film 96 EC approximately 2-3 weeks before harvest at a rate of 0.7 litres/ha.

The main method of harvesting rapeseed plants is *direct harvesting*, in which rapeseed is harvested at technological maturity (moisture content of 10-15 per cent) but before the pods begin to crack. The seed is dark brown or black, hard. When touched, the seeds should "rustle" in the pods. The optimum humidity is 12 per cent. Harvesting at humidity below 10 per cent is not recommended due to high losses. At a moisture content of more than 14 per cent, drying costs increase significantly. The productivity and quality of the harvest depends on the seed losses at the combine cutterbar. Sometimes they can reach up to 90 per cent of the total losses during

harvesting (several centners per hectare).

Seed losses can be significantly reduced by using combines with Power Flow headers or by equipping the combine header with a passive divider or vertical side knife and extending its platform, installing an extended cutting unit (the so-called "rapeseed table"). Only with the rape table or belts on the Power Flow header do the seeds that fly out of the pods during the stem cutting process end up in the header instead of on the ground (Fig. 3.3). Unlike cereals, rapeseed threshes well at night, which makes it possible to use the equipment around the clock. To minimise losses during harvesting, it is carried out with a high stem cut, 2-5 cm below the lower tier of pods. This not only reduces seed loss, but also significantly reduces its moisture content and the amount of plant impurities.

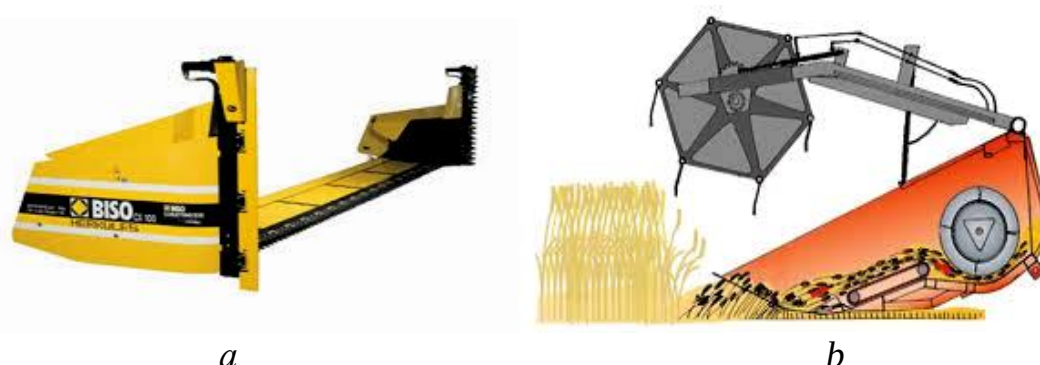


Fig. 3.3. Harvesters for harvesting rapeseed plants:

a - Biso rapeseed table; *b* - diagram of the Power Flow harvester of Massey Ferguson combines

Separate harvesting. As a rule, separate harvesting is associated with significant losses and is used on crops with high weed infestation, as well as in case of uneven seed maturation (for example, field edges near forest plantations). Plants are mowed into swaths when the lower leaves have fallen off, 50 per cent of the pods are lemon yellow, the seeds are light cherry, and the moisture content is 25-35 per cent. During this period, the oil content is the highest, and its accumulation stops; the protein content is high, and the chlorophyll is completely decomposed. The crop is mowed with ZhVP-6; ZhVP-4.9; ZhVN-6; ZhBA-3.5; ZhRB-4.2 reapers at a speed of 4-6 km/h. The cut should be 20-25 cm high, but the lower pods should not be cut off. It is advisable to mow and thresh in the morning and evening. The speed of the reel is equal to the speed of the reaper.

After 3-6 days after mowing, when the seed moisture content is reduced to 10-12 per cent, the swaths are threshed with combines equipped with swath pickers. To reduce seed losses, it is advisable to thresh in the morning, evening and night. Separate harvesting is recommended in areas weeded with chamomile, clinging marigold, or with uneven maturation of rapeseed plants. In case of uniform maturity and clean crops, only direct combining is recommended.

Rapeseed is harvested with seed harvesters that are adapted to harvest small-seeded plants: Massey Ferguson, Claas, John Deere, Case, Lan, Slavutych. For long-

term storage, the moisture content of the seed must be brought to 6-8 per cent. The seeds are immediately cleaned and dried upon arrival at the flowering stage. At high humidity, they turn white, mouldy and lose germination and technological qualities in 1-2 days.

3.3.3 Spring rape (*Brassica napus*)



Spring rape seeds contain 35-45% semi-drying oil (iodine number 101), 20-26% protein, and 17-18% carbohydrates. Spring rapeseed oil has excellent nutritional qualities and is widely used in various sectors of the economy. Oilcake from low-erucic varieties is a good animal feed, while oilcake from the new "00" and "000" varieties is also a high-protein component for food production.

The green mass is used for feed. It contains 4.9-5.1 per cent protein, which is twice as much as the green mass of corn and sunflower plants. Spring rape is grown in post-cutting, post-harvest and intermediate crops.

Spring rape originated in Europe. In Ukraine, rapeseed has been cultivated since the early 18th century. The largest areas under spring rapeseed cultivation are in Sumy, Kyiv, Chernihiv and Zhytomyr regions. According to the State Statistics Committee of Ukraine, as of 2012, the area under spring rapeseed was 114.7 thou hectares, compared to 19 thou hectares in 1997. The yield of spring rapeseed is 30-50% lower than that of winter rapeseed and averages 1.3-1.6 t/ha in Ukraine. Therefore, in regions with suitable climatic conditions, producers prefer to grow winter rapeseed.

Biological characteristics, varieties. Spring rapeseed is less demanding on growing conditions than winter rapeseed. Taking into account the biological characteristics of the plant, areas near the northern limit of possible sunflower cultivation are more favourable for spring rape plants, where the hydrothermal coefficient is above one and the sum of positive temperatures is above 1800⁰ C.

Spring rape is a cold-resistant plant, seeds germinate at temperatures of +1...3⁰ C, seedlings can tolerate frosts of -3...5⁰ C, and adult plants can tolerate frosts of -8⁰ C. The vegetative mass grows best at temperatures of +18...20⁰ C. During flowering and seed ripening, the optimum temperature is +23...25⁰ C.

Requirements to moisture. Rapeseed is a moisture-loving plant. Its water requirement per unit of dry matter is 600-700 units. In terms of this indicator, rapeseed exceeds seed by 1.5-2.0 times. Seeds require 60 per cent of water by weight to germinate, and the optimum moisture content in the topsoil is 80 per cent of the lowest moisture capacity.

The need for moisture during the growing season varies: in the first 5-7 weeks after germination, it is insignificant, and plants absorb the most water during the budding and flowering periods. Drought at this time significantly reduces seed yields. As a result of dry weather during flowering, flowers can even fall off (the phenomenon of "inflorescence"), and the flowering period can be shortened, which in turn leads to

a decrease in seed productivity. A well-developed root system is able to withstand significant tissue dehydration during the day and quickly restore leaf assimilation activity at night under dry conditions.

Requirements to light. Spring rapeseed is a long-day plant that is quite demanding on lighting. Thickened crops have a small area of plant illumination and are characterised by low productivity and crop quality.

Soil requirements. Spring rapeseed is less demanding on soils than winter rapeseed due to a more developed system of small roots in the upper horizon of the root system. It requires soils with a neutral or slightly acidic soil solution reaction (pH 5.5-6.8). Soils that are heavy in texture, with a waterproof subsoil, and light soils with insufficient thermal conductivity are not suitable for growing this plant, so rape grows poorly in depressions and in places with a close groundwater table.

Spring rape is a cross-pollinated plant. The growing season lasts 90-110 days. Seedlings appear 5-6 days after sowing. In the initial period (20-25) days, it grows slowly. Flowering begins on the 35-45th day after germination and lasts for 20-35 days.

Varieties and hybrids with a low content of erucic acid and glucosinolates include: Arion, Antocian, Iris, Kletninny 8, Ataman, Nikitinetsky, Sriblyastiy, Sirius, PR45N72, Yura, Mirko KL, Delight, Belinda, Geros, Larissa, etc.

Agricultural technology. *Place in the crop rotation.* When placing spring rape plants in a crop rotation, it should be borne in mind that in the initial period of development it grows slowly and is quite strongly suppressed by weeds. Therefore, the areas allocated for this plant should be free of weeds, especially those whose seeds are difficult to separate.

Crop rotations of spring rape plants can include both clean and occupied pairs, as well as winter wheat, barley, and legumes; for the conditions of the central Forest-Steppe, row crops and perennial grasses. It is not advisable to grow rape plants after crops that have common pests, in particular sugar beet and plants of the cabbage family. In a crop rotation with sugar beet or cruciferous plants, rapeseed should occupy no more than 25 per cent of the area. The plants may be returned to their original place no earlier than in 4-5 years.

It is not recommended to sow spring rape plants in weak and sparse winter rape crops, as this creates a 3-4 week difference in the maturation of these two forms, and increases crop damage by pests and diseases. Spring rape is a good place in the crop rotation for other plants. It loosens the soil with its root system, and the relatively large amount of plant residues after harvesting rapeseed plants contain easily digestible nutrients. Experiments confirm that grain yields after rape plants are 0.4-0.6 t/ha higher than after cereals as a place in the crop rotation.

Soil cultivation. The system of soil cultivation measures is primarily aimed at preserving moisture and killing weeds as much as possible, as well as levelling the soil surface. After harvesting, the stubble is peeled off in the crop rotation, followed by high-quality ploughing. Good effect is achieved by stubble peeling to a depth of 6-8 cm with LDG-10 stubble peelers and BDT-7 disc harrows. It is recommended to plough the stubble to a depth of 20-22 cm, and on fields weeded with perennial weeds - to a depth of 25-30 cm.

One of the main conditions for obtaining a high yield when growing spring rape

is careful preparation of the soil for sowing and creation of a seedbed. This is due to the plant's small seeds. If the soil has not been levelled in autumn, then when it is physically ripe, harrowing is carried out with heavy harrows BZTS-1.0 or medium harrows BZSS-1.0.

Pre-sowing tillage is carried out immediately before sowing with KG-4 and KPS-4 cultivators to a sowing depth of 2-3 cm with KZK-6 or APOG-6 rollers. The best quality of pre-sowing soil cultivation is achieved by using combined units such as Europak, AG-6, etc., which allow for several technological operations to be performed in one pass with high quality.

Fertilisation. Rapeseed is demanding on nutrients. Rapeseed uses (in kg): 50-60 nitrogen, 25-35 phosphorus, 25-40 potassium, and 3-5 times more calcium, magnesium, boron, and sulphur than seed plants to produce 1 tonne of main product. Spring rape responds well to organic and mineral fertilisers. Manure (20-30 t/ha) is best applied as part of the crop rotation. In on-farm crop rotations, liquid manure is used for spring rape with an application rate of 50-100 m³ /ha. The full rate of phosphorus and potash fertilisers is applied for ploughing. Most of the nitrogen fertiliser (1/2-2/3 of the total norm) is applied for pre-sowing cultivation in the form of ammonium nitrate. The rest of the nitrogen is used to feed the plants at the 5-6 leaf stage and budding. Spring rapeseed is an intensive nutrition plant. Fertilisers are an effective means of increasing yields of spring rape plants, one of the most active and fastest-acting environmental factors that affect plant metabolism, growth and development, as well as factors of direct action on plants, i.e. a direct increase in their productivity. Mineral nutrition has a major impact on the growth dynamics of vegetative organs during the growing season. In addition, mineral fertilisers have been shown to reduce disease incidence by 2-3 per cent. In order to realise its biological potential, it is necessary to apply optimal rates of mineral fertilisers. The required amount of fertiliser for the northern Forest-Steppe zone of Ukraine is within the range of N₉₀₋₁₂₀ P₆₀₋₉₀ K₆₀₋₉₀ , for the central zone - N₆₀₋₉₀ P₆₀ K₆₀ . In the Polissya zone, the highest yield of rapeseed green mass was ensured by applying mineral fertilisers at the rate of N₁₅₀ P₉₀ K₁₂₀ .

Rapeseed plants need sufficient sulphur to grow successfully. The sulphur requirement is 25-25 kg/ha at a yield of 2.5 t/ha. Rapeseed responds well to micronutrients such as boron, manganese and molybdenum. To obtain a yield of more than 2.0 t/ha, it is recommended to apply: boron (B) - 300-600, manganese (Mn) - 200-500, molybdenum (Mo) - 200 g/ha. Zinc, cobalt and copper, as a rule, do not have a significant effect on the seed yield of spring rape plants. When there is a lack of boron in the soil, plants slow down their growth, young leaves have a lighter shade, and the edges of the leaf blades are curled. Older leaves show spots of reddish to red-purple colour. In plants with a lack of molybdenum, necrotic spots are observed on the lower older leaves, accompanied by necrosis of the edges of the leaf blades. The leaves curl at the edges and become spoon-shaped, and fewer flowers are formed. If fertilisation with molybdenum is required, it is more advisable to treat the seeds of rapeseed plants with this trace element before sowing rather than applying it to the soil.

Manganese availability varies depending on the pH and soil moisture content. On light soils that are poor in this element, its deficiency is manifested at pH values

above 6.0. The content of soluble manganese decreases by 100 times for each unit of pH with increasing pH. So, liming the soil is important. The pH value largely determines the mobility of nutrients and their availability to plants. Depending on the type of soil, the pH should be between 6.2 and 7.0 (lower on light soils and higher on loams). To achieve this, it is necessary to apply lime fertilisers to the place in the rapeseed crop rotation, because the pH values change only after 18-24 months.

The exact rate of mineral fertiliser application is calculated based on the nutrient supply of the soil in the particular field where rapeseed is to be grown.

Sowing. To fully realise the genetic potential of the variety, it is necessary to use high-quality seeds for sowing. An important preventive measure against mould, *Alternaria*, *Phomosis*, *Perospora*, bacteriosis, etc. is the treatment of cleaned and calibrated rapeseed with one of the fungicides: Acrobat (2 l/t), Maxim XL (5 l/t), TMTD (3.0 l/t), Vitavax 200, w.p. (2.0-3.0 kg/t), Rovral FLO, h.p. (8.0 l/t). To protect from pest damage in the initial stages of growth, the seeds must be treated with insecticidal treatments (Cruiser 350 FS, hp (4.0 l/t), Cruiser OSR, hp (15.0 l/t), Cosmos (4 l/t), Gaucho (10.5 kg/t), which protect seedlings and young seedlings for 40-45 days. In addition, Cruiser has the so-called "vigor effect", i.e. it has a stimulating effect on the root system, resulting in more active plant development, more uniform seedlings and better drought tolerance. The use of an insecticidal treatment is an important element of the protection system, because in case of massive pest infestation and hot weather, even in 1-2 days, rapeseed seedlings can be completely destroyed.

Early sowing is the best (the optimal level of soil temperature at a depth of 5 cm is +5...7⁰ C). In this case, rapeseed uses moisture better, is less weedy and damaged by pests. Late sowing leads to a 10-30 per cent reduction in yield.

The seeds are sown in a conventional row method with a row spacing of 12.5-15 cm, depending on the soil type and its moisture content: 1.5-2.0 cm on medium and heavy soils and 2-3 cm on light soils. Wide-row sowing method with a row spacing of 45 cm is used on seed plots. The optimal plant density for spring rape varieties and hybrids differs and depends on the recommendations of the originators of the varieties, their origin and early maturity, and is 80-120 plants/m². With the row seeding method, 1.2-1.4 million germinating seeds are sown per hectare for varieties and 1.0-1.2 for hybrids (seed weight rate is 3.5-5 kg/ha). For some hybrids of spring rape plants of foreign selection, the maximum seeding rate reaches 800 thousand germinating seeds/ha.

The care of spring rape crops includes a range of measures aimed at preserving seedlings, destroying weeds, protecting plants from pests and diseases, and creating favourable conditions for their growth and development.

Weeds cause the most damage during the first phases of plant growth and development. In the second half of the growing season, rapeseed plants suppress them, as at this time the plant forms a large above-ground mass and can compete with weeds. If the technology involves the use of soil herbicides, they are applied after levelling the field by combine harvesters. They are worked into the soil with the help of a harrow coupling. In particular, against annual cereal and dicotyledonous weeds, Butizan 400, 40 per cent c.e. (1.75-2.5 l/ha), Butizan Star (1.75-2.5 l/ha), Dual Gold 960 EU, c.e. (1.6 l/ha), Command, 48 per cent c.e. (0.2 l/ha) are used by spraying crops before and

after germination.

The effective effect of most soil herbicides lasts for 30-40 days after their application and is not able to reliably control seedlings and germination of late spring weeds. Therefore, in the agrotechnics of growing rapeseed plants to protect crops from annual and perennial cereals, Aramo 50, c.e. (1.0-2.0 l/ha), Select 120, c.e. (0.4-0.8 l/ha) are applied; against dicotyledonous root-sprouting before the beginning of stemming of rapeseed plants - Galera Super, v.(0.2-0.3 l/ha), Lontrel 300, 30 per cent a.i. (0.35-0.5 l/ha), Lontrel Grand (0.15-0.20 l/ha), Salsa 75 v.g. (20-25 g/ha); against annual dicotyledons and some cereals, use Kerb 50W, 50 per cent a.i. (1.0 l/ha) in the phase of 3-4 leaves of the plant. The use of tank mixtures of Galera Super (0.2-0.3 l/ha) + Nurel D (0.6 l/ha) + Zelek Super (0.4 l/ha) is effective.

The range of advantages provided by the development of highly effective herbicides Galera and Salsa allows us to significantly expand the possibilities and areas of cultivation of traditional varieties and hybrids of rapeseed plants. This ensures maximum flexibility in the choice of varietal composition, which maximises yields and profitability, and eliminates problems with controlling the fall of resistant rapeseed plants (e.g. Clearfield *technology*) for several years in subsequent plants.

Plant protection against pests and diseases is carried out throughout the growing season. Among the pests, cruciferous fleas cause the most damage to spring rape seedlings, and during the period of active growth and development, rapeseed flower beetle, rapeseed sawfly, cabbage aphid, seed and stem borer.

The beginning of flowering of spring rapeseed plants coincides with the flowering of winter rapeseed, so a strong spread of pests can be expected due to their transition from winter rapeseed plants. If cruciferous flea beetles (5 individuals/m²) or rapeseed flower beetle (2-3 beetles per plant during budding and 5-6 individuals per plant during flowering), rapeseed whitefly and cruciferous cryptic borer (3 individuals/m²), aphids (more than 2 colonies/m²) are detected, it is advisable to use insecticides provided for in the "List of Pesticides and Agrochemicals Permitted for Use in Ukraine". Decis, 2.5 per cent c.e., Karate 050 ES, c.e., Bazudin, 600 EW, v.e., Sumi-Alpha, 5 per cent c.e. are effective,(0.3 l/ha), Fastak, 10 per cent h.e., (0.1-0.15 l/ha), Buldok, 2.5 h.e., (0.3 l/ha), Nurel-D (0.8 l/ha), Fastak (0.1-0.15 l/ha). When treating crops with Fastak insecticide, it is forbidden to use the stalks (straw) of rapeseed plants for feeding farm animals, and the oil for food and in the food industry.

The most common diseases of spring rape plants are Alternaria, downy mildew and bacteriosis. Under favourable conditions for the development and widespread spread of diseases, it is necessary to carry out chemical protection of crops. If signs of phomosis, downy mildew in the rosette phase and Alternaria during pod formation are detected, the crops are treated with the fungicide Aliette, 80 percent w.p. (1.2-1.8 kg/ha), etc.

Harvesting. In the pre-harvest period, special preparations called "stickers" are used to reduce yield losses due to pod cracking. One of the most common in production is New-Film-17 and Elastic (active ingredient: carboxylate styrene-butadiene copolymer, 450 g/l; formulation: emulsion concentrate). It is recommended to apply the products 4-3 weeks before harvesting, when the pod does not crack when bent to a V or U shape. The consumption rate of the product is 0.8-1.0 l/ha, the working solution

- 250-400 l/ha (for ground spraying) and 50-90 l/ha - for aerial spraying. The principle of the product's action is to form a semi-permeable polymer membrane on the treated plant surface, which allows water to evaporate from the pod surface and at the same time prevents moisture from penetrating the plant tissues.

To accelerate and simultaneously ripen the crops, desiccate them 7-10 days before harvesting with Reglon Super (2-3 l/ha) and Reglon Air (2 l/ha). Basta 150 SL desiccant (2.0-2.5 l/ha) is used 12-14 days before harvesting. On weeded areas, it is advisable to use Roundup (3 l/ha), Dominator (3 l/ha), and Glyphogan (3 l/ha) herbicides 2 weeks before harvesting. They kill weeds and dry the plants. Desiccation reduces seed losses during harvesting and saves energy costs for drying the seeds.

In order to preserve the yield of rapeseed plants, *direct harvesting* should be preferred on unweeded crops. Direct harvesting is used before the seeds are fully ripe. The optimum seed moisture content for threshing should be 10-13 per cent. At a moisture content below 10 per cent, seed losses can reach 50 per cent. To reduce losses, harvesting should be carried out in the morning and evening. Rapeseed is harvested with seed harvesters that are adapted for harvesting small-seeded plants. During harvesting, special attention should be paid to the cutterbar, as up to 90 per cent of all yield losses are caused by the cutterbar. It should also be noted that the cutterbar should be moved 40-50 cm forward relative to the transverse auger (when equipped with rapeseed tables). To minimise losses, it is recommended to harvest at a high cut, 2-5 cm below the level of the lower tier of pods. This not only reduces losses, but also significantly reduces seed moisture and impurities.

Separate harvesting. Separate harvesting is usually associated with significant losses and is used on crops with high weed infestation and uneven seed maturation. The plants are mowed into swaths when the lower leaves have fallen off, 50 per cent of the pods are lemon yellow, the seeds are light cherry, and the moisture content is 25-35 per cent. The cutting height of the plants should be at least 20-25 cm, so that the swath "hangs" on the stubble and dries. In 3-6 days after mowing, when the seed moisture content is reduced to 10-12 per cent, the swaths are threshed by combines equipped with swath pickers. To reduce seed losses, threshing should be carried out in the morning, evening and night.

When threshing, make sure that the seeds are not damaged, as their quality deteriorates during storage. The content of impurities in the bin mass is allowed to be no more than 10 per cent; the content of oil impurities (broken and crumbled seeds) is no more than 3 per cent. To prevent injuries, the seeds should be threshed at a drum speed of 600 rpm, and in case of direct combining, the number of revolutions should be increased to 800 at increased combine speed.

After threshing the rapeseed plants, the seeds must be immediately cleaned and dried to 7-8 per cent moisture content.

3.3.4 Mustard (*Sinapis*)

Mustard is a valuable oil plant. Two types of mustard plants are grown: grey (Sarepta) and white. The seeds of grey mustard plants contain 35-47 per cent fat, and white mustard seeds contain 30-40 per cent. In addition to fat, mustard seeds contain 25-32 per cent protein and up to 0.5-1.7 per cent essential oil. Fatty mustard oil is a



low-drying oil (the iodine number of oil from grey mustard plants is 102-108, and white mustard oil is 92-122).

Mustard seeds contain 25-32 per cent protein, and the oilcake and meal can be used in animal and poultry feed after special processing. Mustard can be used for green fodder or as a component in feed mixtures (100 kg of green mass of mustard plants during the period of fodder ripeness contains 11-14 feed units with 186-196 g of digestible protein in each).

The seeds of mustard plants also contain glucosides: sinigrin (3.4-4.1 per cent) in grey mustard plants and sinalbin (8.7-9.6 per cent) in white mustard

plants. The presence of these glucosinolates makes it possible to use mustard for the production of muskmelons and to include it in food seasonings.

Mustard plants are used to extract oil, which is widely used in the confectionery, margarine and baking industries and for food. The oil produced by cold pressing is of high quality. Hot pressing adds the glucoside sinigrin, which has a pungent mustard smell and unpleasant taste.

Table mustard, mustard pomace, mustard, etc. are produced from the mustard plant cake. In the northern regions, white mustard is also grown as a fodder plant, fed to animals during the flowering period.

Mustard seeds contain a significant amount of essential oil, which is used in the perfume industry.

Mustard is a good honey plant. During the flowering period, 50-100 kg of honey can be obtained from 1 hectare of crops, which is second only to flower and linden honey in quality. Mustard is a phytosanitary agent in crop rotation. It can cleanse the soil of root rot pathogens that affect seed plants. The root secretions of white mustard plants provoke the development of nematode cysts, and the larvae that hatch cannot develop further and die. After the white mustard plants, the number of pests, in particular wireworms, decreases in the soil.

Mustard improves the agrophysical properties of the soil and increases its organic matter content. It is a good green manure plant and has valuable phytomeliorative properties (root secretions convert inaccessible, hardly soluble forms of soil nutrients into those available to plants). Among oilseeds, mustard is the most moisture-preserving crop in the crop rotation. It is one of the best places in crop rotations for many plants, especially for cereals.

Southeast Asia is considered to be the homeland of the grey (Sarepta) mustard plant, and the Mediterranean is considered to be the homeland of the white mustard plant. Mustard has long been cultivated in India, China, Egypt, and Central Asia. In , it was first introduced to the Lower Volga region near the village of Sarepta (hence the name Sarepta mustard) in the early 18th century.

In Ukraine, blue and white mustard is grown on small areas. The yield of blue mustard plants is 1.0-1.2 t/ha, and white mustard plants is 1.2-1.5 t/ha.

Biological characteristics, varieties. Mustard goes through four periods in its growth and development, which are divided into 7 phenophases and 12 stages of organogenesis. The periods of formation of vegetative and generative organs, flowering and seed ripening depend on weather conditions and agricultural practices: in sunny, dry weather and insufficient nutrients, the duration of the phenophases and stages of organogenesis is reduced, and seed yields are reduced. Under optimal weather conditions and with sufficient nutrient supply, the duration of the growth and development periods is extended. As a result, greater plant productivity is formed, which means an increase in the overall seed yield.

Temperature requirements. Grey mustard is relatively undemanding to heat. Seeds begin to germinate at a temperature of $+3...5^{\circ}\text{C}$, seedlings appear in 15-18 days, and friendly seedlings in moist soil - at a temperature of $+15...18^{\circ}\text{C}$ - 5-6 days after sowing. Seedlings are resistant to a decrease in temperature: they can withstand frosts of $-3...5^{\circ}\text{C}$, and during the period of true leaves - a short-term decrease in temperature to -10°C .

Under favourable conditions, the plants form a developed rosette. In dry conditions and thickened crops, plants can move to stemming, bypassing the rosette phase. The optimum temperature for the growth and development of grey mustard plants is $+18...20^{\circ}\text{C}$, and during the period of pod formation - seed ripening $+23...25^{\circ}\text{C}$.

A characteristic feature of grey mustard plants is their high drought tolerance. Depending on climatic conditions and cultivation techniques, the growing season lasts 80-110 days. The required sum of effective temperatures for optimal yield is $750-800^{\circ}\text{C}$.

White mustard is a more cold-resistant plant than grey mustard. White mustard seeds can germinate at temperatures of $+1...2^{\circ}\text{C}$. Friendly seedlings appear in moist soil at a temperature of $+12...15^{\circ}\text{C}$ 5-6 days after sowing. Seedlings can withstand frosts down to -6°C . White mustard continues vegetative growth and flowering at temperatures of $+5^{\circ}\text{C}$. For its maturation, it is sufficient that the air temperature is $+10^{\circ}\text{C}$, which is the lowest for cold-resistant plants. White mustard grows and develops better in temperate climates. The vegetation period of white mustard plants is shorter than that of blue mustard and is 70-90 days. When white mustard plants are grown in the northern regions of Ukraine, its yield and oil content of seeds increase, and the iodine content of the oil increases. The sum of effective temperatures for obtaining an optimal yield is $650-700^{\circ}\text{C}$.

Moisture requirements. The critical period in relation to moisture in grey mustard plants is most pronounced during seed germination, as well as during the budding and flowering periods. For seed swelling and germination, the moisture requirement is 120 per cent of its weight. The amount of water required to form a unit of dry matter (transpiration coefficient) is 420. With relatively high drought tolerance, high yields of grey mustard seeds can be achieved under conditions of optimal soil moisture. In case of prolonged moisture deficit in the soil, especially during the flowering period, there is a significant reduction in the duration of this phase, flowers and ovaries may fall off, and the yield decreases by 15-20 percent, and in some very dry years - by 30-40 percent. The optimal moisture supply for grey mustard plants is

200-250 mm during the growing season.

White mustard requires more moisture than grey mustard. The optimum moisture availability during the growing season is 350-450 mm. In the arid conditions of southern Ukraine, white mustard is more demanding on moisture than grey mustard and is inferior in yield. Under irrigation, the yield of white mustard seeds in the experiments of the Institute of Irrigated Agriculture increased by 2-2.5 times

Soil requirements. Grey mustard is much more demanding on soil fertility than white mustard. Black earth and chestnut soils are the best for it. On poor soils, it develops a weak root system, which significantly reduces drought tolerance and yield. Heavy, floating and saline soils are of little use.

White mustard can be cultivated on less fertile soils: dark grey, grey forest, sod-podzolic. Light sandy soils, heavy clayey soils, swampy soils with a waterproof subsoil layer are not suitable for it, as they do not develop a good root system and soils with a high water table. Its root system has the ability to absorb nutrients from hardly soluble compounds. To form 1 tonne of seed, it takes 55-60 kg of nitrogen, 25-30 kg of phosphorus, and 45-50 kg of potassium from the soil.

Varieties of grey mustard plants: Mriya, Tavrychanka, Retro, Terrafit, Rakety, Dizhonka, PR45G12; white: Carolina, Pidpecheretska, Talisman, Berivska, Podolyanka, Svityaz.

Agricultural technology. *Place in the crop rotation.* Most agricultural plants are suitable as a place in the crop rotation for mustard plants: annual and perennial grasses, legumes, seeds (early and late). It is not recommended to sow mustard after cabbage in crop rotations; the following plants are also not desirable as a place in the crop rotation: sunflower, flax, buckwheat. Mustard itself plays a positive role in crop rotation: it improves the phytosanitary condition of fields, agrophysical properties, and increases soil fertility. The correct inclusion of mustard plants in crop rotation is essential for consistently high yields and cost-effective production. Mustard is placed in crop rotations designed for the growing zone or specialised crop rotations are introduced, where the share of mustard plants can be 25-33 per cent at maximum saturation with seed plants. The introduction of specialised crop rotations makes it possible to exclude mustard from beet rotations and significantly reduce the harmfulness of the beet nematode on both plants. When grown in field crop rotation, mustard should be returned to its original place no earlier than in 3-4 years, keeping a gap between sugar beets of at least 3 years

Soil cultivation. Improved tillage is used to grow mustard plants. Weed-free fields are peeled twice to 6-8 and 8-10 cm and ploughed to 22-25 cm. In the presence of perennial weeds, layer-by-layer tillage and ploughing at 27-30 cm is carried out. Effective snow retention. In the spring, when the soil reaches physical maturity, the fields are harrowed with tooth harrows to seal in moisture and pre-sowing cultivation is carried out to a depth of 3-4 cm with simultaneous harrowing and looping.

Fertilisation. Mustard, like other plants, is autotrophic by type of nutrition, i.e. plants synthesise organic matter through the assimilation of mineral salts, water and carbon dioxide. Plants absorb 95 per cent or more of carbon dioxide through the leaves, and can also absorb ash elements (*K, Na, Ca, Mg, P, Si, Cl*) from aqueous solutions, and sulphur and nitrogen through foliar feeding. However, the bulk of nitrogen and ash

elements are supplied to plants from the soil through the root system. The supply of nutrients to mustard plants determines the growth and development of plants, their resistance to diseases and pests, and ultimately, the yield of seeds. To ensure the high efficiency of mineral fertilisation and to obtain an optimal seed yield from mustard plants, it is necessary to regulate soil acidity. If the pH (salt) of the soil is below 6.5, liming is necessary. Only when there is a sufficient amount of lime in the soil can so-called soft humus be formed, which is the most valuable form of humus substances. Phosphorus and potash fertilisers are best applied for autumn ploughing or pre-sowing cultivation, and nitrogen fertilisers are best applied before sowing. In areas of sufficient moisture, nitrogen should be applied separately: 2/3 of the norm - before sowing, the rest - in top dressing. Mustard is a halophilous plant; when chlorine-containing forms of potassium fertiliser are applied, the plants respond well to them and yields increase. On acidic soils, sulphates are more effective than potash fertilisers.

Fertiliser application rates are calculated based on the size of the plant and the planned harvest, soil fertility and place in the crop rotation. Fertiliser rates depending on the cultivation technique are as follows: N - 40-80, P₂ O₅ - 40-60, K₂ O - 40-80 kg/ha of active ingredient. In addition to macrofertilisers, mustard plants also need microfertilisers for balanced nutrition if there is a lack of them in the soil. The functions of each nutrient are specific and no one element can replace another.

Sowing. High yields of mustard plants can be achieved only with timely and high-quality sowing, optimal seeding rates of seeds treated with disinfectants, and adherence to the recommended sowing depth. We use sorted conditioned seeds with a germination rate of at least 85 per cent and 98 per cent purity. The list of pesticides and agrochemicals approved for use in Ukraine does not include seed treatment products and mustard plant growth stimulants. However, if necessary, the company uses products registered for rapeseed plants: Acrobat (2 litres per tonne), Maxim XL (5 litres per tonne) and TMTD (3.0 litres per tonne). To protect from pest damage in the early stages of growth, the seeds must be treated with insecticidal treatments (Cruiser 350 FS, h.p. (4.0 l/t), Cruiser OSR, h.p. (15.0 l/t). Seed treatment with the recommended insect-fungicidal seed treatment agents allows to protect seedlings, germination and young plants for 30-45 days.

Mustard, as a plant with long daylight hours, requires early sowing. Under such conditions, time is gained for good vegetative development, the threat of pest damage is reduced and mustard crops are much less affected by diseases. With late sowing, mustard plants enter the generative phase faster, which reduces the seed productivity of the plants.

The timing of sowing mustard plants depends on the growing area and the climatic conditions prevailing at the time of sowing. Research and production have proven that this plant should be sown as early as possible. This is approximately during the period of sowing spring barley plants, or immediately after sowing early spring cereals.

Mustard is sown in a continuous row method with row spacing of 12-15 cm. The optimal seeding rate for mustard plants is 1.8-2.0 million germinating seeds/ha. Reducing the seeding rate or increasing it leads to a decrease in yield.

The depth of seed placement depends on the soil type, mechanical composition

and moisture content. On light soils, the optimum seeding depth is 2.5-3.0 cm, while on heavy soils it is 1.5-2.0 cm. Mustard is sown with seed drills that can provide the prescribed seeding rate and the appropriate seeding depth. It is better to compact the soil for sowing mustard plants before sowing, because when it is rolled up after sowing, in the event of precipitation, a soil crust forms, which can lead to thinning of the seedlings.

Crop care. Crop care for mustard plants includes a set of measures aimed at preserving seedlings, creating optimal conditions for plant growth and development, and protecting crops from weeds, diseases and pests. Pests can lead to significant losses (30-60 per cent) or even complete crop failure.

When sowing treated seeds in the initial stages of growth and development of mustard plants, weeds can cause the greatest damage. This is because mustard grows more slowly in the initial stages of growth than weeds - early spring, rhizome and root sprouting weeds. Among the biological methods of weed control, sowing vetch-oat or other mixtures on weedy fields can be considered effective, as the green grass suppresses weeds and the weediness of the field decreases in subsequent years.

Among the agronomic measures to protect against weeds, the following are effective: peeling or disking stubble immediately after harvesting, placement in a crop rotation, and autumn ploughing. To protect against rhizome weeds (creeping wheatgrass), cultivation over a disced field using spring-loaded machines is effective. In case of high weed infestation of crops with rhizome and root weeds, it becomes necessary to use continuous chemicals based on glyphosate.

Various studies have shown that chemical protection is expedient and economically justified when more than 100 weeds of various species are weeded per 1 m², except for the tenacious crabgrass and perennial root weeds. Given the weed seed reserves in the soil (especially in the Western region of Ukraine), the use of soil-applied herbicides for mustard cultivation is economically feasible. Soil herbicides that can be used to protect crops from weeds may contain the following active ingredients: clomazone, metazachlor, trifluralin. Preparations with trifluralin as the active ingredient are used before sowing with mandatory cultivation with a cultivator or heavy harrows. Herbicides with the active ingredients clomazone and metazachlor are best applied after sowing (up to three days).

During the growing season, if soil herbicides were not applied, seedling herbicides are used in case of weed infestation of mustard plants: Galera Super (0.2-0.3 l/ha) or Lontrel Grand, 75 per cent by weight (0.12-0.2 l/ha). The preparations are applied from the 2-4 true leaf stage to the beginning of flower buds. When applying herbicides in the stemming phase, a slight manifestation of phytotoxicity is possible. The above-mentioned post-emergence herbicides are particularly effective against pink and yellow thistles, self-sowing poppies, chamomile, clinging marigold, quinoa, galinsoga, as well as bitterroot, bindweed and cowpea in the initial stages of development (1-2 true leaves).

Graminicides are effective against annual cereal weeds, which are especially common in Polissya and Forest-Steppe and can cause great damage to mustard crops: Aramo 45 (1.2-2.3 l/ha), Achiba 50 ES (1.0-3.0 l/ha), Panther (1.7-2.0 l/ha), Targa Super (1.0-3.0 l/ha), Fusilade Forte (1.0-2.0 l/ha), etc. If mustard crops are weeded with

creeping wheatgrass, use one of the above-mentioned products with higher application rates. The effectiveness of herbicides and other pesticides used for protection during the growing season is improved by adding auxiliary substances (adjuvants) to the working solution. These substances help to reduce the surface tension of aqueous solutions, which ensures complete wetting of the treated surface, and also improves the penetration of the working solution regardless of wax coating and leaf hairiness. The use of these substances in tank mixtures makes spraying resistant to precipitation wash-off. One of the best products in this group is Silvet. Application rate on cabbage plants: when applying post-emergence herbicides - 0.1 l/ha per 100-200 l of water, insecticides and fungicides - 0.1 l/ha per 150-200 l of water. Significant damage to mustard plants can be caused by pests and diseases. The yield loss from these pests can reach 30-50 per cent or more. The most common pests of mustard plants include: cruciferous fleas (black, light-footed, wavy, blue, notched), rapeseed sawfly (trach), rapeseed flower beetle, and cabbage aphid. To protect mustard crops against pests, the following products have been registered and approved for use: Vantex, 6 percent mcf (gamma-cyhalothrin, 60 g/l) - 0.06 l/ha, Nurel D, 55 percent c.e. (chlorpyrifos, 500 g/l + cypermethrin, 50 g/l) - 0.6 l/ha.

The most common diseases of mustard plants are: blackleg, downy mildew (peronosporosis), alternaria, phomosis, powdery mildew, and mucous bacteriosis. In favourable conditions for the spread and development of diseases, it is recommended to treat crops with fungicides. Against downy mildew: preparations based on mancozeb, metalaxyl, aluminium fosetyl; Alternaria, phomosis: preparations based on boscalid, dimoxystrobin, carbendazim, methanazole, propiconazole, tebuconazole.

Harvesting. Grey mustard and white mustard differ in their ability to crumble. White mustard is characterised by a lower ability to shatter, while grey mustard shatters more than rapeseed. Therefore, the timing, methods and technical means of harvesting mustard plants are crucial for obtaining the final results.

In order to accelerate seed ripening, as well as in case of high weed infestation of mustard plants, desiccation of crops is carried out two weeks before harvesting with one of the glyphosate-based preparations: Glyphogan, Dominator, Roundup with a consumption rate of 3.0 l/ha or Reglon Super 150, v.p. (3.0 l/ha). Desiccation reduces the intensity of disease damage to crops.

In the pre-harvest period, substances with adhesive properties are used to reduce yield losses during biological ripening of seeds, especially of grey mustard plants. One of the most commonly used is Elastic (active ingredient: carboxylate styrene-butadiene copolymer, 450 g/l; formulation: emulsion concentrate). It is recommended to apply the product 4-3 weeks before harvesting, when the pod does not crack when bent to a V or U-shape. Application rate is 0.8-1.0 l/ha, working solution - 250-400 l/ha (for ground spraying) and 50-90 l/ha - for aerial spraying.

The principle of the product's action as a pod glue is to form a semi-permeable polymer membrane on the treated plant surface, which allows water to evaporate from the surface of the pod and at the same time prevents moisture from penetrating the plant tissues. Unlike pinolenes, Elastik does not require daylight for polymerisation, which is an important advantage when applying the product in the early evening or evening. Elastik is a fully synthetic product characterised by a stable quality of effective action.

It can be used in tank mixtures to improve the effectiveness of desiccants. The application rate is 0.5-0.7 l/ha.

To preserve the yield and quality of mustard plants, direct harvesting should be preferred. Direct harvesting with a combine harvester begins when the seeds are fully ripe and the main stem has a moisture content of no more than 15 per cent. Mustard should be harvested only with combines that are adapted for harvesting small-seeded plants. To minimise losses during harvesting, it is recommended to mow at a high cut (5-10 cm below the level of the lower pods). This not only reduces losses, but also significantly reduces seed moisture and impurities.

Practice shows that when harvesting mustard plants, the reel of the harvester should be moved upwards and as far back as possible to avoid shaking the seeds out of the pods and shedding them in front of the harvester. In case of dense stalks of grey mustard plants, it is recommended to remove the reel. The tine rake should enter the stem to a depth not exceeding its width. The rotational speed of the reel should be close to the speed of the combine.

White mustard is harvested by direct harvesting when the seeds are fully ripe, as its pods hardly crack when ripe.

The cleaned seed should be stored with a moisture content of no more than 10 per cent.

3.3.5 *Camelina sativa*

The seeds of camelina plants contain 35-46 per cent fat, which is used mainly for technical purposes. The oil is used to make high-quality varnishes and paints and green soap. The oil is used in the textile and metallurgical industries. The nutritional quality of camelina oil is low. It is significantly inferior to sunflower oil in terms of taste due to its bitter taste. During long-term storage, the bitterness of camelina oil increases.

The cake of camelina plants is fed to animals in small doses. This is because it contains glucosides that are harmful to the body. 100 kg of oilcake contains 115 feed units.

Redhead has a short vegetation period and can be grown as an intermediate and post-harvest plant.

In Ukraine, pearl millet is grown on small areas in Polissya and the Northern Forest-Steppe. The average seed yield is 1.0-1.2 t/ha.

Biological characteristics. Rye is a spring annual herbaceous plant of the cabbage family. It is a cold-resistant plant that is not picky about environmental conditions. The seeds of the cowpea plants germinate at temperatures of $+1...2^{\circ}\text{C}$. Seedlings can withstand frosts down to -12°C . During the growing season, it is insensitive to drought. It grows well on sandy loam and podzolic soils. Clayey heavy soils are unsuitable for growing cowpea plants. The camelina is a self-pollinating, early maturing plant of short day length. The length of the growing season of cowpea plants is 60-90 days.



The following varieties of camelina plants are zoned in Ukraine: Gorny, Stepovy 1, Mirage.

Features of cultivation techniques. The best *places in the rotation of camelina* plants are winter seed and tilled plants. The main *soil cultivation is the same* as for other oilseed spring cabbage plants. As a very small-seeded plant, it requires thorough pre-sowing tillage. Redhead responds well to the application of mineral *fertilisers*, especially phosphorus fertilisers. Full mineral fertiliser at the rate of N P K₄₅₄₅₃₀ is applied under autumn tillage. During sowing, phosphate mineral fertilisers are applied to the rows. Rye is sown early, simultaneously with early spring seed plants, using the usual line method. Seeding rate is 8-10 kg/ha. Seeds are sown to a depth of 1.5-2 cm. When the topsoil dries up, the seeding depth is increased to 3-4 cm with post-sowing rolling.

To protect against weeds, during the germination period, the crops of camelina plants are harrowed across the direction of sowing with tooth harrows. If pests appear, the crops are treated with insecticides.

Pigeonpea is harvested both separately and by direct harvesting. Separate harvesting is started when the lower pods are brown and the seeds are hardened. After drying, the swaths of cowpea are picked up and threshed with converted seed harvesters for harvesting small-seeded plants. The seeds are stored at a moisture content of no more than 9-10 per cent.

3.3.6 Oilseed flax (*Linum usitatissimum* L.)



The term "oilseed flax" includes two groups of plants: flaxseed and flaxseed. The seeds of flaxseed contain more fat - 44 per cent compared to 42 per cent in mezzeumok. At the same time, the height of mezzeumok plants is higher, the stems contain more fibre and can be used to produce textile fibre, and the latter can be used to make yarn. The fibre from kudriash straw can only be used to make cotton wool, paper and as a packaging material.

Flaxseed contains 42-48 per cent fat. Depending on the variety and growing conditions, it contains five fatty acids in the following percentages: oleic - 17.6 per cent, linolenic - 56.6 per cent, linoleic - 14.5 per cent, palmitic - 5.7 per cent and stearic - 3 per cent. The fatty acids in flaxseed oil are mostly unsaturated, which is why it dries well and is in demand as a raw material for the paint and varnish, perfume, and other industries. The iodine number is an indicator of the content of unsaturated acids in oil. For flaxseed oil, this figure is 165-192. Flaxseed cake is a valuable concentrated animal feed (33 per cent protein, 7 per cent oil and 9 per cent fibre).

Oil flax is a valuable food and health product. The high content of unsaturated fatty acids in the oil prevents vascular diseases. According to folk and scientific medicine, flaxseed has medicinal properties. In addition to fat, they contain protein, carbohydrates, organic acids, vitamin A, and enzymes. If you pour hot water over it,

boil it for a few minutes, insist on it, and then strain it, you get a mucous liquid that can be used to treat stomach ulcers and gastritis. Flaxseeds are used to produce linetol, a drug used to treat skin burns. Flaxseed oil can be eaten. It was almost the only oil that saved the inhabitants of Polissia in the pre-war and first post-war decades. Here, the farmsteads grew mezheumok flax, the seeds of which were used to produce edible oil, and the stems were used to make fibre for the production of various household fabrics.

The oilcake, a product of seed processing, contains 6 to 12 per cent fat and 38 per cent protein. The nutritional value of 1 kg is 1.15 kcal and it has 260 g of digestible protein. The chaff produced during flax threshing and seed cleaning is also valuable for feeding animals, especially pigs. It has a nutritional value of 0.27 kcal per kg and contains 20 g of digestible protein. Today, demand for flaxseed is growing worldwide, and its uses are expanding. It is used to produce dietary products, cosmetics, and new medicines. In recent years, Ukraine has seen a clear trend towards increased oilseed flax production. This is primarily driven by export demand for flaxseeds from the EU, the US and Canada, which amounts to about 40 thousand tonnes. In 2012, 62.9 thousand hectares were under flaxseed in Ukraine. The main regions of oilseed flax cultivation are in the South, although in recent years the area has been increasing in the central and northern regions.

Biological characteristics, varieties. During the growing season (85-110 days), flax has the following growth and development phases: seedlings, herringbone, budding, flowering, and ripening.

Temperature requirements: Oil flax is more heat-demanding than long-flax plants. It requires little heat and moisture during seed germination. The swelling period is 50 hours, the seed begins to germinate at a temperature of $+3...5^{\circ}\text{C}$, and seedlings appear at $+6^{\circ}\text{C}$. Flax seedlings can withstand frosts down to $-3...4^{\circ}\text{C}$, and two-week-old plants - down to -6°C . However, the plant is demanding of heat during ripening (optimal temperature is $+20...22^{\circ}\text{C}$). In cloudy weather with a decrease in temperature, it ripens slowly.

Moisture requirements. Oilseed flax is a drought-resistant plant. Its water requirement is less than that of long flax, but its transpiration rate is high - 420-690. When there is a lack of water in the first half of the growing season, the developmental phases are much shorter and the yield is reduced. Compared to other plants, the root system is underdeveloped, but it has a high absorption capacity. It constantly grows deeper and absorbs moisture from deeper soil layers, which makes it more drought-resistant than other spring crops.

Soil requirements. Flax is demanding on soil fertility. It takes out 2-3 times more nitrogen, phosphorus and potassium from the soil per 1 tonne of seed yield than seed plants. For this reason, flax crops should be sown on soils with sufficient levels of available nutrients. The best soils for flax are chernozems and chestnut soils. It is not advisable to sow flaxseed on heavy swampy and brackish soils. In Ukraine, 12 varieties of flaxseed are grown for flaxseed oil production, including Iceberg, Blue-Orange, Debut, Eureka, Zolotystyy, Nadezhnyy, Orpheus, Yuzhnaya Nitsa, Sympathetic, and others.

Agricultural technology. Place in the crop rotation. The best places in the flax crop rotation are winter seed crops, legumes, tilled plants, and perennial grasses. It is

not recommended to sow flax only after sunflower to prevent *Fusarium* and other diseases, and after cabbage to reduce flea damage. Flax should be returned to its original place in the crop rotation no earlier than in 5-6 years.

Soil cultivation. The main soil cultivation is carried out using the improved fallow system. Immediately after harvesting, the stubble is peeled off to a depth of 6-8 cm. If weeds sprout, the field is cultivated with cultivators and harrowed at the same time. To control root-emergent weeds (field thistle, spurge), a combination of tillage with ploughshares and herbicides is effective.

After the weeds grow back in the rosette phase (4-5 leaves), they are sprayed with Roundup herbicide at a dose of 4-6 litres/ha. In late September - early October, the field is ploughed to a depth of 22-25 cm with mandatory levelling. If the autumn winter crop has not been levelled, it is harrowed in early spring. However, after spring levelling, moisture is quickly lost in the sowing layer of soil. On the field levelled in autumn, pre-sowing cultivation is carried out to a depth of 3-4 cm. The best quality of soil preparation for sowing is ensured by the use of combined units RVK-3.6, LK-4, AG-6, Compactor, Europak, etc. In one pass, they cultivate, destroy weeds, level, crush clods, compact the soil and create optimal conditions for seed germination. No other agrotechnical measure has the same effect on seed germination and stem alignment as pre-sowing cultivation.

Fertilisation. Flax plants have a short growing season, and the root system has a rather weak absorption capacity, so the plant responds well to mineral fertilisation. The optimal rates are N P K_{45-60 60-80 70-90}. Phosphorus and potassium fertilisers are applied for main cultivation, nitrogen fertilisers - in spring, for pre-sowing cultivation, paying special attention to the uniformity of their application. The greatest amount of nitrogen is absorbed by flax from the beginning of the germination phase to flowering. Plants need phosphorus throughout the growing season. The need for potash fertilisers increases during budding - flowering and seed formation.

Sowing. Flax seeds are treated 2-3 months before sowing with Vitavax 200 (1.5-2 l/t), Vitavax 200 FF (1.5-2.0 l/t), Maxim 025 FS (1.0 l/t). To increase the resistance of flax plants to diseases (bacteriosis, polysporosis), it is advisable to add trace elements to the seed treatment agent. Often, to protect seedlings from flax flea beetles, seeds are treated with insecticidal treatments: Cruiser 350 FS (0.5 l/t).

Flax is sown as early as possible, together with early spring plants, which contributes to better development of the root system of plants, they germinate faster and outgrow weeds. Flax grows and develops in more favourable conditions with relatively low air temperatures and sufficient soil moisture. Plants sown early are more resistant to disease and lodging, and ripen earlier. The seeding depth is 3-4 cm, with the field being rolled up after sowing.

The crop is sown with seed drills with anchor coulters, using the conventional row method with a row spacing of 15 cm and a seeding rate of 5-7 million germinating seeds per hectare, or 50-70 kg/ha. When oilseed flax is used for fibre and oil production, the seeding rate is increased by 10-15 kg. A significant decrease in field germination is observed when seeds are planted in dry soil and insufficient contact of the seeds with the soil (when sowing seeds with disc coulters), so the field is rolled

with ring-toothed rollers after sowing. To destroy the soil crust, harrowing is carried out across the rows.

Crop care. Flaxseed grows slowly at the beginning of the growing season and reacts very negatively to weed infestation, resulting in a decrease in yield and product quality. The root system of weeds is much more developed than that of flax. First and foremost, it is necessary to make the most of the possibilities of agrotechnical weed control. These include crop rotation, semi-steam or improved tillage, high-quality spring soil preparation, a rational fertilisation system, timely and high-quality sowing with conditioned seeds, etc.

On flax crops, Treflan soil herbicide (1.6-2.0 l/ha) is applied before sowing, during sowing, after sowing, but before plant emergence against annual cereal and dicotyledonous weeds (with immediate incorporation).

However, flax crops are often heavily weeded with such weeds as wild radish, field mustard, quinoa, bitterroot, flaxseed, spurge, cowpea, blue cornflower, field chamomile, thistles, chicken millet, grey mouse, wheatgrass, etc. To control their number in flax crops, herbicides Agritox (0.7-1.2 l/ha), Bazagran (3.0 l/ha), Bazagran M (2.0-3.0 l/ha), 2M-4X 750 (0.5-0.75 l/ha), Dicopur MCPA (0.5-0.75 l/ha), Lontrel (0.1-0.3 kg/ha), Lontrel Grand (0.04-0.12 kg/ha), Lenok, 85 per cent (8-10 g/ha), Pik (0.015-0.020 kg/ha), Harmony (15-25 g/ha). For more effective weed control, it is recommended to use a tank mix: Harmony, 10 g + 2M-4X, 600 ml/ha. It is not recommended to use Trend 90 surfactant on flax crops. The interval between treatments with Harmony and graminicides should be 5 days.

To protect flax crops from annual and perennial cereal weeds, it is necessary to apply herbicides such as Zelek Super (1-1.25 l/ha), Panther (1-2 l/ha), Select 120 (0.4-1.8 l/ha), Targa Super (2.0-3.0 l/ha), Fusilade Forte (0.5-2.0 l/ha), Centurion (0.4-0.8 l/ha). Herbicides are selected depending on the species composition of the weeds. Tank mixtures of anti-cereal and anti-dicotyledonous products, such as Lenok + Panther, are highly effective.

To protect crops from flax bollworm, the crops are sprayed with 10 per cent fURY (0.15 l/ha). To protect against a complex of diseases (fusarium, anthracnose, rust, stranding) in the herringbone phase, the crops are treated with copper chloride, 90 percent w/w (2.2 kg/ha); benlate, foundationol, 50 percent w/w (1 kg/ha). *Harvesting.* Flax is a plant with an incomplete type of vegetation, so shoots can grow in rainy weather: in this case, desiccation with Basta or Reglon Super should be applied (five to ten days before harvesting).

Mowing into swaths begins when 50-75 per cent of the bolls are ripe and the seed moisture content is 25-30 per cent. The cutting height should be 12-14 cm. The swaths are selected and threshed at a seed moisture content of 12 per cent. When used for oil and fibre, flax is cut into swaths at the yellow ripeness stage. The cutting height is 10 cm. When desiccants are used and under dry conditions, oil flax is harvested by direct combining with seed harvesters.

3.3.7 Oil poppy (*Rapaver somniferum*)



Poppy seeds are divided into two groups according to the nature of their use: *oilseeds* and *opium*. Oil poppy seeds contain 46-56 per cent drying oil (iodine number 131-143), 20-25 per cent proteins, 19-20 per cent carbohydrates, 5-7 per cent ash and 6-10 per cent fibre.

Poppy seeds are cold-pressed to extract oil, which is used as a foodstuff or in the confectionery and canning industries. The oil obtained by extraction is used to make drying oils and high-quality paints, as well as premium soaps. The oil poppy cake contains about 32 per cent protein and 10 per cent oil. Its seeds are also used in the confectionery and bakery industries, and its meal is used to feed animals.

Opium poppies are grown to produce the narcotic substance opium, which is used as a raw material for the manufacture of medicines. The poppy plants have thick-walled capsules with a well-developed system of milky spikes. The milky juice (latex) is used to produce opium, which contains about 25 alkaloids (morphine, narcotine, codeine, etc.).

Poppies originate in the Mediterranean. Poppies were known in Greece 5 centuries before Christ, and from there they spread to India and China via Asia Minor. In our country, the first information about the poppy plant dates back to the period of Kyivan Rus (XI century). In Asian countries, poppies are grown to produce the narcotic substance opium, which is used to make medicines.

The high prices for poppy products make it a highly profitable business. Until 1986, the area under oilseed poppy cultivation in Ukraine covered 8,000 hectares. Its boxes were used in the pharmaceutical industry. A large number of medicines were produced on their basis. As a result of the fight against drug addiction, oil poppy cultivation was banned in 1986. However, at the time of independence, the Government of Ukraine approved the National Programme for Combating Drug Abuse and Illicit Trafficking and instructed the Ukrainian Academy of Agrarian Sciences (UAAS) to develop new varieties of oil poppy with a low content of narcotic substances. Scientists at the Institute of Cruciferous Plants of the UAAS developed the Berkut oil poppy variety with a low drug content (0.05-0.07 per cent), which is ten times lower than in varieties grown in Ukraine before 1986. The oilseed poppy variety Berkut passed state variety testing and was included in the Register of Plant Varieties of Ukraine in 1996 in the section "Oilseeds", while the varieties Gerlach and Coral were included in the Register in 2001. Order No. 29 of the Ministry of Agrarian Policy of Ukraine dated 03.03.2000 approved the charter of the specialised association of agricultural producers Ukrmak as the main organisation for the cultivation and use of poppy. It is responsible for providing agricultural enterprises of all forms of ownership with seeds of the first reproduction of poppy varieties listed in the Register of Plant Varieties of Ukraine.

Only oilseed poppy is grown in Ukraine. It is most commonly sown in Poltava,

Kharkiv, Vinnytsia, Khmelnytskyi and other regions. The average yield of poppy seeds in Ukraine is 0.8-1.0 t/ha, with the average yield at the variety plots being around 2.0 t/ha.

Biological characteristics, varieties. Oilseed poppy is very picky about soil and climatic factors. The plant does not tolerate significant shading and requires much more moisture than seed plants. That is why it is sown mainly in Polissya, Forest-Steppe and in some sub-zones of the Steppe.

Temperature requirements. Poppy is a fairly cold-resistant plant. Its seeds begin to germinate at $+2...3^{\circ}\text{C}$, seedlings can withstand frosts down to -5°C . Favourable temperature for plant growth before flowering is $+15^{\circ}\text{C}$, and during flowering - seed ripening - $+20...25^{\circ}\text{C}$.

Moisture requirements. In different periods of growth and development, the demand for moisture is different. The poppy shows the greatest need for water before flowering, after which the demand for moisture decreases and moderately dry and warm weather is preferable for the formation of the crop at this time. A poppy seed absorbs 100-110 per cent of its weight in water.

Soil requirements. Poppy is a rather picky plant. It requires fertile soils with sandy loam and loamy texture. The best soils for poppies are chernozem and chestnut, as well as non-marshy soils of river valleys. Dry sandy and heavy waterlogged soils, salt marshes and salt marshes are unsuitable for poppy cultivation. *Requires* a neutral or slightly acidic soil solution reaction. An important biological feature of poppy is its high demand for mineral nutrients: poppy consumes twice as much phosphorus and potassium to produce one tonne of economic output as wheat plants use to produce 1 tonne of grain. To produce 1 tonne of seeds and the corresponding amount of straw, poppy seeds take out 55 kg of nitrogen, 22 kg of phosphorus, 53 kg of potassium and 56 kg of calcium from the soil.

Among the poppy varieties released in Ukraine are Berkut, Blue Jubilee, Lubensky 7, Coral, Novinka 198, and Start.

Agricultural technology. The best crop *rotations* for poppies are those plants that leave behind a weed-free field with sufficient crop residues and moisture. For Polissya and Forest-Steppe conditions, the best crop rotations are winter seed and legumes, sugar beet, potatoes, rapeseed, and mustard. In the soil and climatic conditions of the steppe zone, the best crop rotations are fallow, fallow and winter crops that follow pure fallow.

It is not recommended to place poppy crops after sunflower plants, perennial grasses, corn plants and other plants whose root system penetrates deeply and dehydrates the soil during the growing season. Permanent poppy crops are unacceptable; they should be sown in the same place no earlier than 3-4 years later. Oilseed poppy itself is a good place in the crop rotation for many agricultural plants.

Soil cultivation. The most important stage in poppy cultivation is basic and pre-sowing tillage. After cereals, legumes and rape plants, it is necessary to peel and harrow, which creates favourable conditions for germination of weed seeds, accelerates the decomposition of crop residues, inhibits the development of diseases, and reduces moisture loss from the topsoil. After that, we apply continuous herbicides (Roundup, Hurricane Forte, etc.) and plough to a depth of 20-25 cm.

Spring tillage consists of early spring harrowing and pre-sowing tillage. Pre-sowing tillage is carried out at the optimum time, coinciding with the full maturity of the soil. It is best to carry out pre-sowing soil cultivation with combined tools - RVK-3.6, RVK-5.4, Compactor, Europak. If pre-sowing tillage is carried out with cultivators, then after cultivation, the soil is rolled with ring-spur rollers.

Fertilisation. Organic fertilisers (20-30 t/ha) are best applied to the poppy crop rotation. When fertilising poppies, the ratio of N:P:K=1:1:1 should be observed. Phosphorus and potash fertilisers are applied for basic tillage at the rate of 45-60 kg/ha of each element. For pre-sowing cultivation, 45-60 kg/ha of nitrogen is applied, and during sowing, superphosphate is applied in the rows (P_2O_5 15-20 kg/ha). Many years of experience show that it is not recommended to apply nitrogen fertilisers during sowing, as this can inhibit the development of the root system. Therefore, the rest of the nitrogen fertiliser (30-40 per cent) is applied during fertilisation at the stage of the developed rosette. In addition to the main nutrients, poppies need trace elements, primarily boron and molybdenum. Trace elements are usually applied foliarly.

Sowing. To protect against disease and pest damage in the initial stages of growth, the seeds must be treated with Cruiser OSR, t.k.s. (35.0 l/t), TMTD, Vitavax (3 l/t). In addition, Cruiser produces the so-called "vigor effect", i.e. it has a stimulating effect on the root system, as a result of which plants develop more actively, seedlings are more uniform and better tolerate drought.

Timely, high-quality sowing at the optimum time ensures that the poppy shoots are well established. Late sowing of oilseed poppy results in seedling failure. Poppy is sown in early spring, in the first days of field work, along with barley and oats. Approximate sowing dates in the Steppe zone are the third decade of February - first decade of March, provided the soil is already well matured, in the Forest-Steppe zone - the second - third decade of March and in Polissya - the third decade of March. Sowing poppies is usually unsuccessful, so the field is sown with late plants.

The sowing date depends on the temperature regime. As a rule, poppies should be sown only in well-tilled and mature soil with a temperature of 10 cm above $+3^{\circ}C$. Well-prepared soil ensures that the seeds are evenly embedded to the same depth, which for oilseed poppy is 1.5 to 2 cm. If the seeds are sown deeper than 2.5 cm, the seedlings may not make their way to the soil surface.

The best method of sowing is wide-row sowing with row spacing of 45-60 cm. In case of high plant density and the use of herbicides in agricultural techniques, poppy can be sown using the usual row method. The seeding rate is 2 kg/ha. If the sowing of oilseed poppy is delayed, the seeding rate is increased by up to 10-20 per cent. Precision seeders are used for sowing.

Crop care. Poppy seeds practically do not germinate if it has rained and a soil crust has formed. To destroy it, harrows, rollers or rotary hoes are used. When seedlings appear, the first inter-row loosening (layering) is carried out to a depth of 2-3 cm. If necessary, carry out 3-4 more loosening of row spacings to a depth of 6-8 cm.

If the germination rate allows, harrow the crops across the rows. Harrowing is most effective when the weeds are in the white thread stage.

In the phase of 2-3 true leaves, they form a plant density. The optimal number of plants per 1 m^2 is 60-70 pcs. Plants may be placed together in groups of 2-4 with a

distance of 15 cm between them. After the density is formed, there can be from 7-10 to 20-25 plants per 1 m of row, depending on the row spacing. There should be 350-500 thousand plants per 1 ha.

To protect crops from annual dicotyledonous weeds, the herbicide Callisto (0.2-0.25 l/ha + surfactant (mandatory) is applied in the 2-4 leaf stage of poppy. It is recommended to apply Dicuran (2.5-3.0 kg/ha) and Starane Premium (0.3-0.4 kg/ha) herbicides at the stage of 4-6 leaves of poppy.

Harvesting. The signs of poppy ripening are the browning of the leaves and capsules. Ripe seeds spill out with a characteristic noise when the capsules are shaken. Poppies are harvested by direct harvesting and by separate harvesting.

Poppy plants have capsules at different distances from the soil surface, so it is recommended to harvest them with *direct combine* harvesters that ensure uniform cutting of capsules with short stem lengths. Before harvesting, poppy plantations should be cleared of tall weeds, and covered flows, seed cleaners and containers should be prepared. The speed of the combine harvester should not exceed 5-6 km/h when harvesting poppies.

The combine thresher should be set so that the threshing process results in the bin containing the boxes and seeds that have been crushed into pieces. The gaps between the decks and the drum are set at 8-10 mm, and the speed of the threshing drum should be within 800-1000 revolutions per minute. If the poppy pods are poorly separated from the stems, the gaps in the threshing apparatus reduce or increase the number of revolutions of the drum. When harvesting and threshing very dry poppies, the gap between the drum and the deck is increased and the number of drum revolutions is reduced to prevent high crushing of the pods. All elevator inspection windows, seed auger flaps, hoppers and other places where seed loss can occur are sealed.

The harvested mass is unloaded from the combine's hopper and transported to a covered trough, where the seeds are immediately separated from the crushed boxes, as a delay in separating the heap leads to rapid self-heating. Seed separation is carried out on the OVP-20 seed cleaning machine, and poppy seeds are cleaned on the Petkus-Giant, Petkus-Selectra and other cleaning machines.

Split method. First, the poppies are cut into swaths at a high cut with reapers. The mown poppies are often placed in doughnuts or wort bins for drying. This measure is used when the weather is unstable. The dried plants from the windrows or wort are threshed with combines.

Combines are converted to thresh small-seeded plants. During threshing, measures should be taken to avoid contamination of poppy seeds with soil. Seeds contaminated with soil lose their nutritional quality. After threshing, the seeds are dried to a moisture content not exceeding 10 per cent. For food purposes, the seeds, as well as the boxes, can be dried at a coolant temperature of +60⁰ C. Poppy seeds are stored in dry, ventilated rooms with an air humidity of no more than 60 per cent. For long-term storage, it is better to store them in bulk (in storerooms with a wooden floor with a layer of 15-20 cm) and shovel them at least once a month, monitor seed moisture, and dry the grain if necessary.

3.3.8 Castor oil (*Ricinus*)



Castor oil is an important high-oil plant. Its seeds contain 50-55 per cent of non-drying oil (iodine number 82-86), and the kernel contains 65-70 per cent. The oil is very viscous, does not solidify at low temperatures ($-15...18^{\circ}\text{C}$), ignites only at high temperatures ($+300...310^{\circ}\text{C}$), and is poorly soluble in petrol and other organic solvents. Therefore, it is the best lubricant for aircraft engines and mechanisms operating in difficult conditions.

Castor oil is used in various industries, including aviation, leather, perfumery, electrical engineering, soap making, textiles, pharmaceuticals, metalworking, etc. It is also used for the production of linoleum, various synthetic

substances and in construction.

For medical purposes, castor oil is used, pressed in a cold process, which does not contain toxic substances.

Castor oil leaves can be used to feed some species of silkworm. The seeds and oilcake contain a very poisonous substance called ricinin (taxalbulin), so they are not used for animal feed. Glue is made from the cake and used as fertiliser

Castor oil is native to Africa. It has long been grown in Egypt, from where it spread to Asia and America, and later to Europe.

Castor oilseed rape is mainly cultivated in tropical and subtropical countries, covering 1.3 million hectares, with a yield of 0.9 tonnes per hectare and production of 1.2 million tonnes. Its main crops are concentrated in South and Southeast Asia and South America. The largest producers of castor oilseeds are India, Brazil, China, and Ecuador, Thailand, Pakistan, Indonesia, and Ukraine.

Biological characteristics, varieties. Castor oilseed rape (*Ricinus L.*) belongs to the botanical family *Euphorbiaceae*. In Ukraine, it is grown as an annual plant, and in tropical countries as a perennial plant. One species (*R. sottypus*) is common in production, of which four subspecies are distinguished. Two subspecies are of the greatest importance: *Iranian castor oilseed rape* (*R. iranensis*) and *blood-red castor oilseed rape* (*R. sanguinea*). Castor bean varieties belonging to the first subspecies have green or green-red aerial organs, and the fruits crack when ripe. In the second subspecies, the aerial organs are blood-red, the fruits do not crack when ripe.

During the growing season castor oilseed rape goes through the following phases of growth and development: germination, formation of the central panicle, flowering, ripening of seeds of the central and lateral panicles of the first, second and subsequent orders. Of practical importance is the identification by V.O. Moshkin of the interphase periods of castor oilseed rape: germination (sowing - germination - 10-15 days), vegetative growth (germination - flowering of the central panicle - 35-70 days), fruit formation (flowering of the central panicle - harvesting ripeness - 35-90 days). The length of the growing season, depending on the form, is 130-155 days.

Temperature requirements. This is a thermophilic plant, its seeds begin to germinate at temperatures of $+12...13^{\circ}\text{C}$. However, friendly seedlings appear at $+16...18^{\circ}\text{C}$. Castor bean seedlings die in frosts of -1°C , and adult plants in autumn cannot withstand a drop in temperature to -3°C . Normal growth and development of plants occurs at temperatures of $+25...30^{\circ}\text{C}$. At lower temperatures, the ripening period is delayed, and the yield and oil content of the seeds are reduced. High temperatures have a negative impact on yield. For the formation of a normal harvest, the sum of active average daily temperatures of $3000-3500^{\circ}\text{C}$ is required.

Moisture requirements. Castor oilseed rape is a moisture-demanding plant. In areas where less than 300 mm of precipitation falls during the growing season, it is impossible to grow a high yield without applying measures to accumulate moisture in the soil (deep ploughing, irrigation, etc.). The transpiration coefficient varies widely, from 300 to 600. Optimal soil moisture is 70-80 per cent HB. However, excessive moisture, especially in autumn, leads to excessive growth of the vegetative mass, prolongs the growing season and reduces the oil content of the seed. With a lack of moisture in the soil, the yield is sharply reduced, and in dry weather, there is a massive shedding of flowers and fruits; at the same time, oil yield is significantly reduced.

Light requirements. Castor oilseed rape is a light-loving plant with a short day. Lack of light during the formation of generative organs negatively affects its productivity. The growth and development of plants is also negatively affected by the presence of weeds in the crops and excessive thickening of plants. Therefore, for better illumination of castor oilseed rape, it is important to destroy weeds in a timely manner and to form an optimal plant density.

Soil requirements. Castor oilseed rape is quite demanding on soils and nutrients. The best for it are well-permeable, fertile sandy loam and loamy chernozems, chestnut and grey forest soils. Heavy clay, swampy, saline and light sandy soils are unsuitable for castor oilseed rape. The optimum reaction of the soil solution is pH 6-7.3. In terms of nutrient removal, castor oilseed rape is significantly higher than winter wheat. With the formation of 1 tonne of seeds, it removes 64-68 kg of nitrogen, 14-20 kg of phosphorus, and 52-56 kg of potassium from the soil.

The following castor oilseed rape varieties are zoned in Ukraine: Gromada, Khortytska 1, Khortytska 3, Khortytska 7, Olesya, Roksolana, Rosava.

Agricultural technology. Place in the crop rotation. Castor oilseed rape crops are placed after the best crop rotation - winter wheat, legumes, and fallow land. Castor oilseed rape should not be sown after plants that dry out the soil, such as sunflower plants and corn. To reduce the damage caused by *Fusarium*, castor oilseed rape should be sown on the same field no earlier than 8 years later. Castor oilseed rape is a good crop rotation for cereals.

Soil cultivation. After harvesting winter crops, the soil is peeled to a depth of 8-10 cm with harrowing and, in dry weather, rolling. Ploughing for winter crops in the second half of September - early October to a depth of 25-27 cm.

Pre-sowing cultivation consists of early harrowing in one or two traces and several subsequent cultivations, which are carried out as needed from the beginning of spring work until the castor oilseed rape is sown. The pre-sowing period is used to clear the field of weeds and preserve soil moisture. For the first time, the crop is cultivated

to a depth of 10-12 cm across the direction of ploughing with simultaneous harrowing and rolling. On weedy areas, after 10-15 days, it is cultivated for the second time to a depth of 8-10 cm, and immediately before sowing - to the depth of seed placement (6-8 cm). Simultaneously with cultivation, the area is harrowed, and in dry weather - rolled.

To protect against weeds, Treflan herbicide (2-5 l/ha) is applied with immediate incorporation for pre-sowing cultivation, during sowing or after sowing, but before castor oilseed rape emergence. The application rate of the herbicide is reduced on light soils, and increased on medium and heavy soils.

Fertilisation. Castor oilseed rape responds well to organic fertilisers. The application of 20 tonnes per hectare of manure significantly increases the seed yield. The effectiveness of mineral fertilisers depends on soil characteristics. On leached chernozems, nitrogen-phosphorus fertilisers provide the largest yield increases, while on carbonate and ordinary chernozems, phosphorus or nitrogen-phosphorus fertilisers provide the largest yield increases. The main fertilisers used are organic and mineral fertilisers (N P₄₀₆₀ or P₆₀). On leached chernozems, the doses of nitrogen-phosphorus fertilisers are increased to N P₆₀₉₀. Fertilising the rows during sowing at the rate of N P₁₀₁₀₋₁₅ is quite effective. If fertiliser was not applied in autumn, it is applied locally in spring at the same time as sowing, burying it 7-8 cm deeper than the seeds. The rates of nitrogen and phosphorus fertilisers applied to castor oilseed rape under irrigation are increased to 90-120 kg/ha. Castor oilseed rape is sown during a period of steady warming, when the average daily soil temperature at the depth of seeding reaches +10...12° C and the danger of seedling death from frost has passed. For the southern regions of Ukraine, the best time to sow castor oilseed rape is the end of April. Before sowing, the seeds are treated with Vitavax to protect them from diseases.

Castor oilseed rape is sown in a wide-row dotted method with row spacing of 70 cm. There should be 40-50 thousand plants per hectare. With the dotted seeding method, 5-6 seeds are sown per metre of row length. For small-seeded varieties, the seeding rate is 10-12 kg/ha, and for large-seeded varieties - 20-25 kg/ha. The seeds are sown to a depth of 7-8, and 10 cm if the soil moisture is insufficient.

Crop care. It is not recommended to roll the crops, as this leads to cotyledons breaking off during emergence and a decrease in yield.

Crop care begins with harrowing, which is carried out as needed, stopping 4-5 days before emergence. Harrowing is especially necessary in cold, rainy weather, when seedlings appear in 20-25 days. As soon as the seedlings appear, cultivate the row spacing. When 3-4 true leaves appear on the plants, the crops are thinned out. When using the dotted seeding method, 3-4 plants are left per metre of row length. The plant density should be 40-45 thousand plants per hectare in the southern Steppe regions and 50-55 thousand plants per hectare in the northern regions. The number and depth of loosening is set taking into account the weediness of the field and weather conditions. The first cultivation is carried out to a depth of 6-7 cm, and the second - to 9-10 cm. Subsequently, in rainy weather and in irrigated areas, the depth of cultivation is increased to 10-12 cm, and in dry weather it is reduced to 6-7 cm. To INCREASE THE yield and accelerate ripening, it is recommended to pinch castor oil. It is carried out in two ways - *by pinching the growth point of the main stem of plants during the formation*

of 4-5 true leaves (used in the southern regions) or by pinching the *growth point on the side branches* during the formation of 2-3 leaves. On seed plots, pinching is carried out only on the lateral branches. It promotes better development of the central bunch and accelerates ripening and yield increase by 0.15-0.25 t/ha. To accelerate the ripening of castor oilseed rape, desiccation of crops is carried out before harvesting, which helps to dry the plants. For desiccation, use Reglon Super 150 SL (3-4 l/ha) or a mixture of magnesium chlorate (10 kg/ha) with Reglon Super 150 SL (1 l/ha).

Harvesting. Castor oil bean ripens unevenly: first, the lower clusters on the main stem, and later on the first and second-order branches. Castor bean should be harvested when the bolls in the central clusters dry up and turn brown, and for branched varieties, in the first-order clusters. Castor oilseed rape varieties whose bolls do not crack are harvested in a single-phase process using a KKS-6 castor oilseed rape harvester. This yields 80 per cent of pure seeds and up to 20 per cent of unripe capsules. The clean seeds are cleaned, sorted and dried to a moisture content of 12 per cent. Green pods are cleaned of coarse impurities using the OVP-20A machine and dried. For air-solar drying, the heap is spread on the platforms with a layer of 10-15 cm and periodically shovelled. Depending on the weather, the drying time is 3-10 days.

Seed castor oil is dried at a temperature of +35...40, and commercial castor oil - +65...75⁰ C. Seeds are stored at a humidity not exceeding +10⁰ C.

Castor bean varieties whose capsules crack when ripe are harvested by hand. The tassels are cut off, taken to the tick, threshed, dried and sorted.

2.3.9 Safflower plants (*Carthamus tinctorius*)



Safflower is an oil plant that is grown in arid regions. Safflower seeds contain 32-37 per cent of semi-drying oil (iodine number 115-155) and up to 12 per cent of protein. In terms of oil production per hectare, safflower is inferior to sunflower and rapeseed, but superior to mustard, flax, and camelina. Safflower oil (extracted from the kernels of the achenes) tastes almost the same as sunflower oil. It is used for food purposes and is applied in various food industries. It is widely used in cooking in Eastern countries.

Safflower oil is widely used in cosmetics. Due to the fact that it is very rich in unsaturated fatty acids, it penetrates the skin faster and is absorbed almost instantly. It has a softening and moisturising effect, provides a barrier (protective) function of the skin. Safflower oil is also used as a raw material for technical needs. Extracted from the whole seed, the oil has a bitter taste and is used to produce drying oil, white paint, enamels, soap, and linoleum. The achenes of the safflower plant are good fodder for poultry. The cake is a good concentrated feed for animals. 100 kg of oilcake contains 55 feeding units.

The flowers of the safflower plant are used to extract the yellow dye cartamine,

which is used in carpet production and for dyeing fabrics, as well as in cooking as a substitute for saffron.

The safflower plant is native to Ethiopia and Afghanistan. It was cultivated in Egypt, India and China before Christ, and has long been grown in Central Asia, Saudi Arabia, Syria, Palestine, North Africa, the Caucasus and Turkmenistan, Europe and since the 18th century. The average seed yield is 1.0-1.2 t/ha, and under favourable conditions it can reach 2.0 t/ha or more.

Biological characteristics, varieties. Phenological observations of the development of safflower plants are focused on the same phases as those of sunflower plants, as these plants are from the same botanical family and are very similar in biology. The growing season lasts 105-130 days. Safflower plants are an annual herbaceous plant of the Asteraceae botanical family. It is a thermophilic and very heat-resistant plant that can withstand prolonged drought and is adapted to dry continental climates. Seeds germinate at temperatures of $+2...3^{\circ}\text{C}$. Seedlings can withstand frosts down to $-3...6^{\circ}\text{C}$. The safflower plant is most demanding of heat during the flowering-ripening period. In humid and cloudy weather, flowers fertilise much less well than in dry weather. The safflower plant is undemanding to soils, even withstanding salinity. However, when grown on fertile black soil, the yield of the safflower plant increases significantly. Safflower is a short-day plant. Safflower plant varieties differ from each other in the length of the growing season, yield, huskiness, fat content in the seeds, and the presence or absence of thorns on the leaves and wrappers of the baskets. The Register of Varieties Suitable for Distribution in Ukraine includes 3 varieties of safflower - Solnechnyi, Stepovyi and Professor Mashanov.

Features of cultivation techniques. Safflower plants are placed in the row crop wedge of the crop *rotation*. The best places in the crop rotation for it are winter and spring spiced plants sown in pairs or after perennial grasses, as well as row crops. It is acceptable to place a safflower plant after a corn plant. Safflower plants are a good place in the crop rotation for spring spiced plants.

Soil cultivation for safflower plants is the same as for sunflower. On weedy fields, deep ploughing combined with layer-by-layer peeling provides good results. Mineral fertilisers are applied under the main cultivation at the rate of N P K₄₅₆₀₃₀. The effectiveness of fertilisers increases in wet years.

Safflower plants are sown in the early stages, simultaneously with early spring seed plants, with seeds of at least 95 per cent germination and at least 95 per cent purity. The sowing method is wide-row with row spacing of 45 cm. The seeding rate is 10-12 kg/ha. The seeding depth is 5-6 cm; when the topsoil dries, the seeding depth is increased to 6-8 cm.

Safflower crops are managed in the same way as sunflower crops. It consists of rolling the soil after sowing, harrowing before and after emergence (in the phase of two or three pairs of true leaves across the rows) and 1-3 inter-row cultivations (if necessary). Safflower plants are harvested by direct harvesting, because the seeds do not fall out of the basket when they are ripe. However, if the harvesting period is delayed and the crops are left standing, the seeds may spill out during harvesting. Harvesting starts when all the plants and baskets turn yellow and the seeds are hardened by the converted and adjusted seed harvesters.

3.3.10 Coriander plants (*Coriander sativum*)



Coriander plants are one of the most important essential oil plants. The fruits of the coriander plant contain 1.5-2.7 per cent of essential oil, the main component of which is the terpene alcohol linalool, which is used as a starting substance for the synthesis of fragrant substances. Coriander essential oil and its components are used in the perfumery and cosmetics, confectionery, alcoholic beverage, tobacco and other industries. In addition to essential oil, coriander fruits contain 17-28 per cent of fatty oil, which is used in the textile and metallurgical industries, as well as for the manufacture of soap and printing inks. The seeds of the coriander plant are used in baking and

confectionery production and as a spicy seasoning for canned fish, pickling cucumbers, etc. Coriander seed meal, which contains about 6 per cent fat and up to 30 per cent protein, is used as livestock feed. Coriander plants are considered a good honey plant - bees can collect about 500 kg of honey from one hectare.

Coriander originates from the Mediterranean and is one of the oldest cultivated plants. It has been grown in Ukraine since the early nineteenth century and is now a leading essential oil plant. It is most common in Zaporizhzhia, Mykolaiv, and Kirovohrad regions. The seed yield is 1.2-1.5 tonnes per hectare.

Biological characteristics, varieties. *Temperature requirements.* It is moderately demanding to heat. Its seeds begin to germinate at temperatures of $+6...8^{\circ}\text{C}$. Seedlings appear at temperatures of $+10...12^{\circ}\text{C}$. Seedlings can withstand frosts down to minus $-7...8^{\circ}\text{C}$. The optimum temperature for plant growth is $+18...20^{\circ}\text{C}$. Coriander plants are most demanding for heat in the flowering and ripening phase. However, excessively high temperatures at this time have a negative impact on fruit formation. The sum of positive temperatures for full fruit ripening of coriander plants is 1900-2000 $^{\circ}\text{C}$.

Moisture requirements. Coriander plants are a moisture-loving plant. To swell, the fruits absorb 120-125 per cent of water by weight of the seed. After germination to massive stemming, coriander plants consume little moisture and tolerate soil drought well. The critical period for moisture supply is the flowering phase. The transpiration coefficient is about 600. Coriander plants are light-loving, long-day plants. Shading reduces the branching of plants.

Soil requirements. Coriander is quite picky about soil and nutrients. The best soils for it are those with a good structure, sufficient nutrients and a neutral soil solution reaction. It provides the highest yields on fertile black soils when phosphorus-nitrogen fertilisers are applied. Heavy clay, sandy and saline soils are unsuitable for it. Winter and spring forms of coriander are known in the plant. In Ukraine, the spring form is grown, which is characterised by a long period of seed germination (15 to 20 days) and slow growth at the beginning of the growing season. Under normal growing conditions,

the growing season lasts 95-110 days. The following phases occur during the growing season: germination, stemming, flowering and ripening. Varieties: Kirovogradsky, Garant, Yantar, Oksamit, Nectar, Garant, Medun.

Agricultural technology. *Place in the crop rotation.* Coriander plant crops are placed after winter crops on fertilised pairs, legumes and fertilised tilled plants. It should not be planted after plants that dry out the soil and leave the field late, such as sunflower, sugar beet, and Sudanese grass. Return to the previous field no earlier than in 4-5 years.

Coriander plants are well suited for winter cereals, maize plants, and sunflower plants in crop rotation.

Soil cultivation. The system of basic tillage after grain crops consists of stubble peeling and early autumn ploughing to a depth of 27-30 cm. Semi-steam tillage is also effective. After planting row crops, ploughing is carried out to a depth of 22-25 cm. Early ploughing provides higher yields than late ploughing. Spring tillage consists of harrowing, looping and pre-sowing cultivation with simultaneous harrowing. The best quality of soil preparation for sowing is ensured by the use of combined units such as Europak. On fields that are free of weeds, one cultivation is limited to the depth of seed placement (3-4 cm).

Fertilisation. Due to the increased requirements of coriander plants for nutrients, especially nitrogen, organic and mineral fertilisers must be applied for deep ploughing. When placing coriander crops after manure-fertilised winter crops, only full mineral fertiliser is applied for autumn ploughing at the rate of 45-60 kg/ha of active ingredient. If no organic fertiliser was applied to the place in the crop rotation, it should be applied to the coriander plants (20-30 t/ha). It is also effective to apply granular superphosphate (50-70 kg/ha) and ammonium nitrate (25-30 kg/ha) in the rows during sowing.

Coriander plants are sown in early spring in the first days of field work. For sowing, germinated seeds are used (*fermentation*), which accelerates the emergence of seedlings by 5-6 days and increases the yield by 200-300 kg/ha. The technique is as follows: the soaked seeds (at the rate of 60 litres of water per 100 kg of seeds) are thoroughly mixed and rolled into a heap, where they are gradually warmed up to +18...20⁰ C. At this temperature, the seeds are kept until germination begins. As soon as 2-3 per cent of the seeds are sprouted, they are rolled out and gradually dried. Before sowing, the seeds are treated with a seed dressing. Sowing is carried out using conventional row or wide-row methods with a row spacing of 45 cm. The seeding rate for continuous row sowing is 20-25 kg/ha or 2.5-3.0 million seeds per 1 ha, and for wide-row sowing - 10-14 kg/ha or 1.5-1.8 million seeds/ha. The seeds are sown to a depth of 3-4 cm.

Crop care. After sowing, the crops are rolled with ring-toothed or ring-spur rollers. Conventional harrows or rotary hoes are used to protect the crops from weeds and destroy the crust before and after emergence. On wide-row crops, 2-3 inter-row cultivations are carried out with cultivators.

To control the degree of weed infestation, soil herbicides are applied: Gezograd (2-4 litres/ha), Treflan (6 litres/ha) (with immediate planting), Dual Gold (1.3 litres/ha), Linuron (4-6 kg/ha), and post-emergence coriander plants are treated with Luvaran (1.3-1.6 litres/ha) and 2,4-D (2.0-2.5 litres/ha) in the 2-3 true leaf stage. To improve

pollination, an apiary is placed on the crops during the flowering period at the rate of 2 bee colonies per hectare. Coriander plants do not ripen at the same time. Overripe fruits easily crumble and litter the field with carrion. In addition, the amount of fatty oil in overripe fruits increases and the content of essential oil decreases. In this regard, special attention is paid to the timing and quality of harvesting the coriander plant. It is harvested both by direct harvesting and by separate harvesting. To accelerate the ripening of coriander plants, during the period of browning of 40-50 per cent of the umbels, the crops are treated with Reglon Super (desiccation) at a dose of 2-3 litres/ha. After 3-5 days, coriander plants are harvested by direct harvesting. Separate harvesting is started when 30-40 per cent of the fruit is brown, and more than 80 per cent of the fruit is in the seed areas. The coriander plants are mowed with reapers, leaving stubble 20-25 cm high. When the fruit in the windrows reaches a moisture content of up to 15 per cent, the windrows are picked up and threshed by seed combines at a reduced number of drum revolutions (500-600 rpm).

The seeds are cleaned, sorted, dried to a moisture content of no more than 12 per cent and stored in dry rooms.

3.3.11 Cumin plants (*Carum carvi*)



The seed of the cumin plant contains 4-7 per cent essential oil and 14-22 per cent fatty oil. The essential oil is used in the alcoholic beverage, pharmaceutical, perfumery, tobacco, and other industries. The seeds of the cumin plant, which have a pleasant spicy taste, are used in cooking, the canning industry, and in the manufacture of special types of bread. The fatty oil is used as a technical raw material. The fatty oil is a good concentrated feed for livestock. The meal is used for livestock feed. Caraway plants are a valuable honey plant. The cumin plant is native to Europe, where it often grows wild in meadows, forest edges, and slopes. It is one of the oldest plants,

and its seeds have been found in Stone Age buildings. Cumin plants were grown in Kyivan Rus as early as the 7th century, and since the 16th century, essential oil has been extracted from it. The main areas of cumin plants in Ukraine are concentrated in Lviv, Ternopil, and Khmelnytsky regions. Its yield is 0.6-0.9 t/ha, and can reach 1.2-1.5 t/ha.

Requirements to temperature. Cumin plants are undemanding to heat. Seeds begin to germinate at a temperature of $+6^{\circ}\text{C}$. It is characterised by high winter hardiness. In the rosette phase, it can withstand severe frosts due to the presence of a significant amount of sugars in its roots during wintering. Temperatures above $+30^{\circ}\text{C}$ negatively affect the formation of the crop and the accumulation of essential oil.

Moisture requirements. A biological feature of the cumin plant, like other plants in the celery family, is the long germination period of seeds (110-116 per cent of the fruit weight needs moisture for swelling). It produces high yields only in conditions of

sufficient moisture. Most moisture is required during stemming and flowering.

Light requirements. It is a light-loving plant, especially in the first year of vegetation. When sown under the cover of other plants, its yield decreases. In thickened crops, when shaded in the rosette phase, in the second year of vegetation, the caraway plant does not form flower-bearing shoots.

Soil requirements. Cumin plants grow well on various types of soil. Swampy, acidic, and dry soils are unsuitable.

At the beginning of the growing season, caraway plants grow very slowly: it takes 11-13 days from germination to the formation of the first true leaf, so crops can become weedy. In the second year of life, under conditions of high agricultural technology, all plants usually enter the generative phase. The most suitable soils for caraway plants are chernozems and grey podzolic soils, light in texture with a shallow groundwater table.

Varieties: Podolsky 9, Pultovsky, Sluch, Tonus.

Agricultural technology. Place in the crop rotation. Caraway is sown on well-vegetated soils after fertilised winter crops. In the year of fruiting, it leaves the field early, so it is a good place in the crop rotation for winter and other plants.

Soil cultivation consists of twice-daily peeling and deep ploughing by 27-30 cm. Harrowing and cultivation are carried out in the spring. Pre-sowing tillage is carried out using combined tools.

Fertilisation. Manure (25-30 t/ha) and complete mineral fertiliser (30-40 kg/ha of active ingredient) are applied to caraway plants. When placing caraway plants after manured winter crops, only mineral fertilisers are applied. Caraway plants use fertilisers well, which are applied in two doses. In the first year of vegetation, during the last loosening of row spacings, phosphorus and potash fertilisers are applied at 40 kg/ha of each element. In the second year after overwintering, nitrogen mineral fertilisers are applied in early spring at the rate of 40-50 kg/ha.

Sowing. The best time to sow is in early spring at the beginning of field work. However, summer sowing in July is also effective after early fallow periods. Sprouted seeds are used for spring sowing. The technology for germinating caraway seeds is the same as for coriander seeds. Caraway plants are sown in a wide-row method with row spacing of 45 cm. The seeding rate is 8 kg/ha or 1.7-1.8 million germinating seeds per 1 ha. The seeds are sown to a depth of 2-3 cm.

Crop care. After sowing, the area must be rolled. Caring for caraway plants before emergence consists in destroying the crust with light harrows or rotary hoes. As soon as the seedlings appear, harrowing is carried out. Since caraway plants develop a small rosette of leaves in the first year of life, which slightly shades the soil, the crops become weedy, and during rains the soil is very compacted. Therefore, during the growing season, the crops need to be cultivated at least 4-5 times. In the first year of the growing season, the crops are fertilised with full mineral fertiliser at the rate of 20-30 kg/ha of active ingredient: for the first time in spring and for the second time in autumn. Thin out thickened crops during the period of 3-4 true leaves formation, leaving plants at a distance of 10-12 cm in a row.

Crop care in the second year consists of harrowing the crops across the rows, two or three loosening of the soil between the rows and early spring fertilisation with

full mineral fertiliser at the rate of 20-25 kg/ha of active ingredient. Fertilisers are applied during the first spring loosening of the soil, incorporating them to a depth of 10-12 cm.

On heavily weeded fields, Treflan herbicide (4-6 l/ha) is applied for pre-sowing cultivation or Gezagard (4-5 l/ha) before the caraway plant emerges.

Harvesting. The fruits of the caraway plant do not ripen at the same time, and ripe ones crumble easily. The separate method is used to harvest 35-40 per cent of the fruit when it is brown, and direct harvesting - 50-60 per cent. The cut caraway plants are left in windrows for 3-4 days to dry. The dried swaths are threshed immediately. Seed moisture content during storage should not exceed 10-11 per cent.

3.3.12 Fennel (*Foeniculum vulgare*)



Fennel fruit is used to extract essential oil (4-6 per cent), which is 50-60 per cent anethole. Essential oil and anethole are used in the food, perfumery, cosmetics, pharmaceutical and other industries. Anethole is used to synthesise obepin, an aromatic substance used in perfumery. The fruit also contains 18-20 per cent of fatty oil, which is used for technical purposes. Fennel meal, which contains 18-22 per cent protein, is used as concentrated feed. Fennel is a honey plant.

Fennel is considered to be native to the Mediterranean. Today it is grown in Western Europe, India, Japan and other countries. In Ukraine, fennel began to be grown in the 1930s. The main fennel crops are concentrated in the Chernivtsi region and Crimea. The average yield is 0.5-0.6 tonnes per hectare.

Biological characteristics, varieties. *Requirements to temperature.* Fennel seeds begin to germinate at a temperature of +6...8⁰ C, and germination occurs at +20⁰ C. Seedlings can withstand frosts down to -8⁰ C.

Moisture requirements. Fennel is a moisture- and light-loving plant. It requires the most moisture from the beginning of stemming to full flowering. Shading and cloudy, cold weather extend the growing season. Dry winds during the flowering period reduce the yield.

Soil requirements. Fennel grows well and produces high yields on chernozem and dark grey podzolic soils.

It begins to bear fruit in the first year of life. The growing season lasts 139-147 days. Varieties: Zephyr, Crimean, Mertsyshor, Chernivtsi 3.

Features of cultivation techniques. In the crop rotation, fennel is placed after winter and spring cereals, sugar beet, potato plants, annual grasses, etc. *Soil cultivation* is carried out in the same way as for other essential oil plants of the celery family. For fennel, it is recommended to apply full mineral fertiliser in autumn at the rate of N P K₄₀₋₆₀ 60-80 60-80. During sowing, granulated phosphorus superphosphate (10-15 kg/ha P₂ O₅) is applied to the rows. Fennel is sown simultaneously with early spring seed plants

using the wide-row method with row spacing of 45-60 cm. The seeding rate is 8-10 kg/ha. The seeds are sown to a depth of 2-3 cm. After sowing, the seeds are rolled with ring rollers.

Crop care includes pre-emergence and post-emergence harrowing and loosening of row spacings. During the phase of the first or second true leaves, the density of crops is formed by transverse thinning (bouqueting according to the scheme: 30 cm cut, 20 cm bouquet) or manual weeding. Leave 6-8 fennel plants per 1 m of row. Start harvesting when the fruits are ripe on the first-order umbels. A sign of fruit ripeness is their easy breakdown into two halves. After drying, the swaths are picked up and threshed using converted seed harvesters. Cleaned and sorted seeds are stored at a moisture content of no more than 12-13 per cent.

3.3.13 Anise (*Pimpinella anisum*.)



Anise fruits contain 2.5-4 per cent essential oil, 16-22 per cent fatty oil and up to 20 per cent protein. The main component of anise essential oil is anethole alcohol (80 per cent), which is widely used in medicine, veterinary medicine, perfumery, food and pharmaceutical industries.

Anise seeds are used in baking, canning and confectionery. Young leaves and flowers are used for pickling and marinating vegetables and fruits.

Fatty oil is used to make varnishes, paints, soaps, oleic acid, etc. The cake is used as a good concentrated animal feed. 100 kg of oilcake contains 85 feed units. Anise is a honey plant.

Anise originated in Asia Minor. Today it is grown in many countries in Asia and Europe. In Ukraine, anise is grown on small areas in the Forest-Steppe zone. The yield is 1.0-1.5 tonnes per hectare.

Biological characteristics, varieties. Anise (*Pimpinella anisum* L.) is an annual plant of the botanical family *Apiaceae*. Anise, compared to coriander, is a more demanding plant for heat. Seeds begin to germinate at a temperature of +4...5° C, but friendly seedlings appear at +10...15° C. The optimum temperature for plant growth and development is +24...25° C. Anise plants are most sensitive to heat during flowering, fruit formation and ripening.

Moisture requirements. Anise is a moisture-loving plant. Seeds need about 150 per cent of water by weight to be able to bloom. It is most demanding on moisture during flowering and fruit formation.

Soil requirements. Anise is quite picky about soils and nutrients. The best for it are fertile light to medium loamy soils free from weeds. Clay and sandy soils, as well as soils with a high water table, are unsuitable. Anise is particularly sensitive to the presence of nitrogen and potassium in the soil. Anise is a *light-loving plant*. The growing season lasts 120-150 days.

The Artek variety is included in the register of recommended varieties.

Features of cultivation techniques. In the crop rotation, anise is placed after

winter cereals, tilled plants, and annual grasses. It should not be sown after coriander plants, which clog crops with carrion.

Soil cultivation consists of autumn ploughing to a depth of 22-25 cm, early spring harrowing and pre-sowing cultivation. Full mineral fertiliser is applied for ploughing at the rate of 45-60 kg/ha of nitrogen, phosphorus and potassium. Granulated superphosphate (10 kg/ha P_2O_5) is used during sowing, and when the leaves form a rosette, they are fertilised with nitrogen-phosphorus fertilisers (10-15 kg/ha).

Before sowing, the seeds are heated and treated with air and heat (TMTD, 4 kg/t). Anise is sown simultaneously with early spring seed plants. On fields free of weeds, a conventional row seeding method is used, and on weedy fields, a wide-row seeding method (45 cm) is used. The seeding rate for the conventional row sowing method is 18-20 kg/ha, and for the wide-row method - 10-12 kg/ha. Seeds are sown to a depth of 3-4 cm.

Crop care includes pre-emergence and post-emergence harrowing and at least three inter-row cultivations in areas with a wide-row sowing method. To control weeds, the soil herbicide Treflan (3.0-4.0 l/ha) is used, which is applied for pre-sowing cultivation or before germination for harrowing. Anise is also resistant to 2,4-D herbicides, which can be applied at the rosette stage (2-4 true leaves). Combining the use of soil herbicide Treflan (3.0-4.0 l/ha) with post-emergence 2,4-D (2.0-2.5 l/ha), you can control weeds in the plant and avoid manual weeding. Anise ripens unevenly and crumbles easily when stagnant. Harvesting begins when the middle umbels are ripe.

At this time, the fruits acquire a greenish-grey colour. In this state, anise crops are harvested separately. Liquefied and fallen crops are harvested by direct harvesting at the beginning of full ripeness. The seeds are cleaned, sorted, dried and stored at a moisture content of no more than 12 per cent.

3.3.14 Peppermint (*Mentha piperita*)



Peppermint (*Mentha piperita*) The essential oil is extracted from the leaves (2-4 per cent), inflorescences (4-6 per cent), and stems (up to 0.3 per cent by weight of dry matter). The main components of mint oil are menthol (41-84 per cent), menthone (9-25 per cent), pinene, limonene and other substances. The more menthol in the oil, the higher its quality. Menthol has the ability to dilate the blood vessels of the heart, brain, and lungs. Even Pliny the Elder (Rome) wrote that the smell of mint stimulates the brain, so students were recommended to wear mint wreaths. Mint oil is used in the pharmaceutical, food, perfumery, and alcoholic beverage industries. Mint leaves are used in medicine and as a spice for pickling and preserving vegetables. Fresh and dry leaves are

used to flavour various dishes, drinks, tea, and vinegar. It contains ascorbic acid (up to 25 mg per cent), carotene (up to 8 mg per cent), rutin (up to 14 mg per cent), and has a characteristic refreshing, cool taste.

Mint decoctions help with respiratory and stomach diseases, angina pectoris, dizziness, and have analgesic, vasodilating, and calming effects.

Peppermint was introduced to the plant about 300 years ago. It originates from England. In Ukraine, it began to be grown in the early eighteenth century, and now its main areas are located in Chernihiv, Cherkasy, Sumy, Kyiv and Poltava regions. The yield of dry aboveground mass is 1.5-2.0 t/ha.

Biological characteristics, varieties. *Temperature requirements.* Mint is undemanding to heat. In spring, mint vegetation is restored at temperatures of $+2...3^{\circ}\text{C}$. It tolerates frosts down to -8°C during this period. The optimum temperature for growth is $+18...20^{\circ}\text{C}$, and for the synthesis of essential oil - $+22...25^{\circ}\text{C}$. During the growing season (from germination to flowering), mint needs a temperature range of 1500 to 1600 $^{\circ}\text{C}$. Higher temperatures in the summer months inhibit branching, yield, and oil content. In years with warm winters, mint overwinters well, but at temperatures of $-15...20^{\circ}\text{C}$ without snow cover or special shelter, it freezes out. First, the above-ground shoots (whips) die, and then the rhizomes. Under conditions of prolonged low temperatures, the number of inflorescences on plants decreases and sparse flowering of the herbage is observed.

Moisture requirements. Mint is a moisture-loving plant. Optimal conditions for its growth and development are created at a soil moisture content of at least 80 per cent. It is particularly demanding on moisture in the period from the beginning of branching to flowering. In case of insufficient moisture, the plants form a small number of stems with small leaves, resulting in low yields of aboveground mass and reduced collection of high-quality oil. Mint does not tolerate prolonged drought and responds well to irrigation.

Light requirements. Peppermint is very light-demanding. It is a long-day plant and thrives best in adequate light. It needs at least 12 hours of light for normal development. If you move the plant to the north, where the day length increases, the mint shortens its growing season, develops faster and blooms. With favourable day length and sufficient light, it produces high yields of above-ground phytomass with a high content of high-quality oil. In case of insufficient light, a smaller leaf surface is formed, the leaves die off quickly and the yield of quality oil decreases dramatically.

Soil requirements. Mint has high requirements for soil fertility and moisture. It grows best on alluvial soils in river valleys, as well as in areas with a high groundwater table that do not flood in spring. The most suitable soils for it are light textured chernozems and vegetated peatlands.

Mint is propagated by rhizomes, shoots or seedlings. It is propagated by seeds only in breeding. The mint growing season (from planting to technical ripeness of the leaves) lasts 120-130 days.

Mint varieties are zoned in Ukraine: Zagrava, Ukrainian peppermint, Pryluky 14, Likarska 1, Lidiya, Chornolysta.

Agricultural technology. *Place in crop rotation.* Due to the high requirements for soil fertility, mint is placed in special crop rotations. Vegetable plants, perennial legumes, and fertilised winter crops are the best places for it in crop rotations. It is usually grown in one place for 2-3 years in a row, but the plants are very susceptible to rust.

Soil cultivation for mint is the same as for other industrial plants. When it is placed after fertilised winter crops, it is peeled and then ploughed to a depth of 22-25 cm. After perennial grasses, tobacco, hemp, and vegetable plants, ploughing is carried out immediately after harvest. In early spring, harrowing and cultivation is carried out in 2 traces to a depth of 10-12 cm.

Fertilisation. The application of organic and mineral fertilisers is mandatory when growing mint. For mint, it is recommended to apply manure at the rate of 30-40 t/ha and full mineral fertiliser on podzolic black soil at the rate of 60-70 kg/ha of nitrogen, 45-50 kg/ha of phosphorus and 60-70 kg/ha of potassium. On vegetated peatlands, only phosphorus and potassium fertilisers are applied in higher doses.

Planting. When growing mint by rhizomes or shoots (lashes), after spring tillage, furrows are cut to a depth of 8-10 cm. The row spacing is 45-50 cm. Plant the rhizomes or shoots in the first days of spring work during the sowing of early spring crops, laying them at the bottom of the furrow in moist soil with a continuous tape. The rhizomes are pressed to the moist soil, and the furrows are covered with plumes. Up to 1.0-1.5 tonnes of rhizomes are planted per hectare. Mint is also planted with seedlings in furrows, cut with a marker and pre-watered. The row spacing, as with rhizomes, is 45-50 cm, and the distance between plants in a row is 12-15 cm.

Crop care. One or two pre-emergence harrowing with medium or heavy harrows is carried out. Post-emergence harrowing is stopped when the plant height reaches 6-8 cm. After germination, 3-4 cultivations and 1-2 fertilisations are carried out. The first loosening of the soil in the aisles is recommended to a depth of 10-12 cm, and subsequent loosening to a depth of 6-7 cm.

An important measure to increase the yield of mint is its fertilisation with local and mineral fertilisers. The most effective early fertilisations are those carried out during the first and second inter-row cultivations (the first 5-6 days after emergence).

On weedy fields, before planting mint, apply herbicides Treflan (4 litres/ha), Nabu (2-3 litres/ha), Poast (2-3 litres/ha). In the phase of 4-6 leaves of mint, the crops are treated with Bazagran (3 l/ha) or Gezagard (3-5 l/ha). On mint plantations left for the second year, in autumn, at the beginning of a steady cold snap, ploughing is carried out to a depth of 15-18 cm with full rotation of the cut. In dry years, ploughing is carried out in early spring. As soon as the seedlings appear, cultivators with knife tines or thinners cut row spacings 45-50 cm wide. Mint plantations in the third year are cultivated with BDT-3 disc harrows to a depth of 5-6 cm. After each mowing, mint plantings are fertilised with mineral fertilisers at a dose of N₉₀ P₁₂₀ K₉₀. Mint responds well to irrigation. With irrigation, two crops are harvested per year. Watering maintains soil moisture at 80-85 per cent of HB. The best method of irrigation is sprinkling with an irrigation rate of 450-500 m³ /ha of water.

Harvesting. Mint is harvested in the first year during the period of mass flowering, and in subsequent years - in the budding phase. Mint is mowed with mowers at a low cut (6-8 cm). This is when the highest leaf yield and oil yield is obtained.

Before harvesting, the areas are carefully cleared of weeds and wild mint species, as the latter reduce the quality of the raw material. The mint is harvested with legume harvesters, and in small areas it is mowed by hand. The mown mint is raked into small windrows after drying and left to dry for 1-2 days.

The well-dried mint is transported to special currents and laid out in windrows or narrow, pointed stacks, where it is dried. The windrows and stacks are moved daily. The dried plants are threshed. Grinding the leaves leads to oil loss. When growing high-commentol varieties, leaves and stems are used to extract essential oil. According to modern harvesting technology, the mown and air-dried plants are collected by balers in bales weighing 25-40 kg and sent to the plant.

Mother liquors. Mother liquors are used to grow planting material. For each hectare of mint area, 0.1-0.15 hectares of mother plants are required for planting with rhizomes, and 0.1 hectares for planting with seedlings. The areas where the largest yields of mint are harvested and which are located in places protected from cold winds are left for mother plants. Specific weeding is mandatory on mother plants, and the harvest is harvested later than on conventional commercial crops (during the period of full flowering). This promotes better rhizome development and increases their winter hardiness. During harvesting, the plants are mowed at a height of 15 cm to keep snow off in winter. The mother plants left over for the winter are covered with straw manure, peat cover and other materials, and snow retention is carried out in winter. In early spring, the plantations are opened and the rhizomes are harvested. For this purpose, the KPM-2 root thinner is used, or the area is cultivated up and down and the rhizomes are combed out with harrows.

For planting, select rhizomes and shoots that are not damaged by frost and disease.

3.3.15 Sage (clary sage) (*Salvia selarea*)

Clary sage flowers contain 0.2-0.35 per cent of valuable essential oil, the main component of which is esters (50-77 per cent). The oil has a pleasant smell of amber,



orange, bergamot. Sage essential oil is used in the perfumery, cosmetics, food, soap-making industries and in medicine. A special quality of the oil is its fixing properties and it is used for the synthesis of stable fragrances of a wide range. The fatty oil obtained from sage seeds (25-32 per cent) is used to make high-quality drying oil and is used in ceramic and porcelain production.

Sage is a valuable honey plant.

Nutmeg is a relatively young plant. It was first grown in France. In Ukraine, it has been grown since 1929. The main crops are located in the Crimea and Zaporizhzhya region. The yield of inflorescences is 3.0-4.0 tonnes per hectare.

Biological characteristics, varieties. Sage is an undemanding plant to heat. Seeds begin to germinate at temperatures of $+8...10^{\circ}\text{C}$. It is characterised by relatively high cold and frost resistance. Seedlings can withstand temperatures down to $-6...8^{\circ}\text{C}$, and adult plants in the phase of developed rosette - down to -30°C . The optimum temperature for growth and development is $+18...20^{\circ}\text{C}$. During flowering, an elevated temperature of $+25...30^{\circ}\text{C}$ is favourable, due to which the content of essential oil increases. Sage is a drought-resistant plant, but it is demanding of moisture during germination. The seed absorbs 3-4 times and the fruit coat 40 times more water than its own weight. Sage requires a significant amount of moisture in the spring, when plants in their second year of life develop a large leaf surface and form flowers. However, during the ripening period, sage can easily withstand drought. Sage is picky about light, especially in the early stages of development. Young plants do not tolerate shading. It develops better with a daylight hours of 14-16 hours.

Soil requirements. Sage is not very picky about soils. It can even be grown on stony soils, but black earth and carbonate loamy soils are preferred. Sandy soils are of little use. Sage is a cross-pollinated plant. It is pollinated mainly by bumblebees and bees. In the first year of life, sage forms a basal rosette of leaves, in the second year it forms stems, flowers and fruits. On second-year crops in the southern regions of Ukraine, flowering begins in early July and ends in August.

Varieties: Annual, Crimean late, Crimean annual, Mriya, S-785. The varieties are suitable for mechanised cultivation and harvesting.

Agricultural technology. *Place in the crop rotation.* Sage is stirred after winter wheat plants or tilled plants in field and fodder crop rotations. It is returned to its original place in 4-5 years.

Soil cultivation. The main soil cultivation is stubble peeling followed by ploughing to a depth of 27-30 cm. On heavily weeded fields, sage is cultivated using layer-by-layer tillage, which involves moldboard and moldboard loosening to different depths. To control rhizome weeds (creeping wheatgrass, gummint), the field is disked lengthwise and crosswise to a depth of 10-12 cm to crush the rhizomes, after which they are deeply ploughed with a plough with a skimmer. Pre-sowing cultivation is carried out to a depth of 5-6 cm with simultaneous harrowing. Soil herbicides Nabu (1.5-3.0 l/ha), Prometrin (3 l/ha), Poast (1.5-3.0 l/ha) are *applied* for pre-sowing cultivation. For deep ploughing, apply full mineral fertiliser at the rate of 60 kg/ha of the active substance of each element. In the second year of life, during the period of spring vegetation recovery, $\text{N}_{40-50} \text{P}_{40-50} \text{K}_{40-50}$ are *applied*. Sage is sown before winter, when the soil temperature drops to $+4...5^{\circ}\text{C}$, so that the seeds do not germinate before the onset of cold weather. The sowing method is wide-row with a row spacing of 70 cm. Sowing depth is 2-4 cm. The seeding rate is 8-12 kg/ha, which ensures a sowing density of 300-400 thousand plants per 1 ha in the first year of vegetation, and 150-200 thousand per ha in the second year.

Crop care. At the beginning of spring work, destroy the crust by harrowing the crops across the rows. In the phase of 1-2 pairs of leaves, the row spacing is loosened to a depth of 6-8 cm. After closing the rows, no inter-row cultivation is carried out. In the first and second year of life, the crops are fertilised with nitrogen and phosphorus fertilisers at the rate of 30 kg/ha of active ingredient, working them in with plant feeder

cultivators to a depth of 10-12 cm. Fertilisation is effective in the first year at the stage of two pairs of true leaves, and in the second year at the beginning of the growing season.

After harvesting, the sage stubble is cut at a low cut and removed from the field. Immediately afterwards, the row spacing is loosened to a depth of 8-10 cm. On plantations in the second year of life, harrowing is carried out across the rows in two traces in spring. Later, the row spacing is loosened to a depth of 7-10 cm. An obligatory agricultural measure is the control of sage weevil and mosquitoes, for which the crops are treated with one of the preparations: Actelik, Bazudin, Karate Zeon. Harvesting. Sage harvesting begins when the essential oil content in the flowers is at least 0.12 per cent. The period of technical ripeness of sage coincides with the milky-wax ripeness of the seeds in the lower fruits of the flower. The flowers are cut with conventional silage or converted seed harvesters. The cut mass is immediately transported for processing, because even short-term storage (within 3-4 hours) leads to a loss of 40-50 percent of the essential oil.

3.3.16 Lavender plants (*Lavandula vera*)

Essential oil is accumulated in all parts of plants, but most of it is in flowers -



0.8-3.0 per cent. The most valuable components of essential oil are its main components - linalyl acetate (30-56 per cent), linalool (10-12 per cent), as well as geraniol, nerol, camphor, etc. The oil is used in the perfumery and cosmetics, soap-making, food, and pharmaceutical industries. The flowers and oil are used in medicine to treat various diseases; it is a good antiseptic. Lavender plants are a valuable honey plant, with 100-150 kg of honey harvested from 1 hectare.

Lavender was first grown in England in the late 16th century. It is also common in France, Bulgaria, Hungary, Spain, and Japan. In

Ukraine, commercial crops were established in the Crimea. Lavender is propagated vegetatively in production. The largest sown areas are located in Crimea - 3.6 thousand hectares. The average yield of fresh inflorescences is 2.0-3.0 tonnes per hectare. The yield of essential oil is 15-35 kg/ha.

Biological characteristics, varieties. As a mountain plant, lavender is quite cold-resistant. In the Crimea, it tolerates temperatures down to -20°C . In the presence of a 25 cm thick snow cover - up to -28°C . Older plantations are less resistant to frost. Seedlings in the phase of 4-5 pairs of leaves can withstand frosts down to $-8...10^{\circ}\text{C}$. Lavender prefers warm weather during the growing season and hot weather during flowering. This helps to increase the yield of raw materials.

Moisture requirements. Lavender is a drought-tolerant plant. Excessive soil or atmospheric moisture leads to disease and plant loss. However, a lack of moisture in the first half of the growing season (before flowering) leads to a decrease in yield.

Light requirements. Lavender plants are light-loving plants. Shading reduces the size of the flowers, the oil content in them, and the shoots are very elongated. It is grown in areas with a southern slope.

Soil requirements. Lavender is undemanding to soils and grows well on poor sandy loam and carbonate soils. Heavy, cold soils with high acidity and a high groundwater table are unsuitable for lavender. The main method of its reproduction is vegetative. Plants reach full development in 3-4 years. Zoned lavender varieties are resistant to diseases and pests and are suitable for mechanised cultivation: Record, Steppe, Hay, Early.

Agrotechnology. *Site selection.* Lavender is placed outside the crop rotation, as it grows in one place for 15-25 years. New plantations are established after cereals or annual grasses. Lavender can be grown on floodplains.

Soil cultivation. After harvesting, continuous-acting herbicides (Hurricane Forte, Roundup) are applied to the crop rotation. The areas designated for lavender are ploughed to a depth of 45-50 cm. During the spring and summer of the following year, the field is kept in a state of black fallow. In late September and early October, the field is cultivated with chisel cultivators to a depth of 22-25 cm. Lavender plants respond positively to fertilisation. For plantation ploughing, 30-35 t/ha of manure is applied together with mineral fertilisers ($N_{80-100} P_{80-100}$). The following year, in autumn, full mineral fertiliser is applied at the rate of $N_{80-90} P_{80-90} K_{80-90}$. When planting lavender, superphosphate is added with irrigation water (P_{10}). Fertilisation of lavender plantations with mineral fertilisers begins in the second year of life with the start of commercial harvesting of inflorescences. It is better to fertilise with nitrogen fertilisers in spring, and with phosphorus-potassium fertilisers in autumn.

Planting. Lavender seedlings are planted with a planting machine or manually according to the 1.0 x 0.5 m or 1.2 x 0.5 m patterns. The planting depth is 20-25 cm. When planting, the root collar is buried 5-6 cm below the soil surface. The optimal planting time is the second half of October and November. It can be planted during the thaw in winter or early spring. Recently, lavender plantations have been established by sowing seeds in a permanent place in November, before the soil freezes. The seeding rate is 4.5 kg/ha, and the row spacing is 1 m.

Care. Care consists in loosening row spacing (4-5 times), timely replanting of lavender to replace dead plants. The first loosening of row spacing is carried out at the end of March with a KRN-4.2 cultivator to a depth of 8-10 cm. Subsequent ones to a depth of 10-12 cm. Every year, after harvesting the inflorescences, the bushes are pruned, removing dry and damaged branches. After that, the bushes are rejuvenated by cutting them by 1/2 of the annual growth with the POL-1 machine. The plantation rejuvenation is repeated every 5-6 years of industrial use. To kill weeds, in addition to continuous herbicides, the soil herbicide Treflan (2.5 l/ha) is applied, as well as seedling herbicides: 2,4-D 500 (3.0-4.0 l/ha), Lontrel (1.0-1.7 l/ha), Nabu (5.0-7.5 l/ha), Poast (5.0-7.5 l/ha).

Harvesting. Harvested 4-5 days after flowering, when 50 percent of the flowers have bloomed (late June - early July). Cut off flower stalks 10-12 cm long. Freshly picked flowers are immediately sent for processing. On rainy and cloudy days, the oil yield decreases, so flowers are not harvested in such weather.

3.4 SPINNING PLANTS

Spinning plants are grown for their fibre, which is used to produce various fabrics for household and technical purposes. The world's agriculture grows spinning plants, which are divided into two groups. The first group includes the most common spinning plant in the world, cotton, in which elementary fibres are formed on the seed skin in the form of modified epidermal cells, and the second group includes bast plants (flax and hemp), in which fibre is formed in the stems in the form of long bast fibres.

The seeds of all spinning plants contain oil that is as good as sunflower oil and is used for food and for various technical purposes. The oilseed production waste - cake and meal - is a valuable concentrated feed for animals.

Ukraine grows flax and hemp plants, while cotton, jute, kenaf, and rope are less common and promising spinning plants.

3.4.1 Plants Long flax (*Linum usitatissimum*)



Flax is the main spinning plant in Ukraine. It produces two valuable products: fibre and seeds. The main product of flax is fibre, which is formed in the stems. The morphological characteristics of the stems determine the yield and quality of fibre, the amount of which, depending on the variety and growing conditions, can be 20-30 per cent. Long and thin stems contain more fibre and are of better quality than thick and short stems.

The quality of flax fibre is much higher than that of hemp, jute and rope. Its strength is twice that of cotton and three times that of wool. Textile companies use the fibre to produce various fabrics that are long-wearing, very hygienic, antistatic, easy to wash, and resistant to decay. Linen batiste, clothes, sheets, and

canvas are very valuable. Inferior quality fibres are used to make tarpaulins, sackcloth, packaging fabrics, ropes, twine, threads, and fire hoses.

Flaxseed contains 35-39 per cent of fast-drying oil and up to 23 per cent of protein. The oil is a valuable food product and is used in the food, margarine and confectionery industries. Due to its content of unsaturated fatty acids (oleic, linoleic, linolenic, and isolinolenic), the oil helps to reduce blood cholesterol. The oil dries quickly and is suitable for making drying oil, varnishes, and paints. It is used in soap making, pharmaceutical, electrical, paper, rubber and other industries. Flax seeds and oil are used as medicines. The oil is used to produce linetol, a drug for the treatment and prevention of atherosclerosis. Recently, the fescue, which remains after the fibre is separated from the stems, has also been widely used. Flax mills use it to make boards for furniture production, as well as paper, cardboard and technical ethyl alcohol.

Flax also has fodder value. One kilogram of seed contains 1.8 feed units.

Flaxseed cake, a by-product of flaxseed processing into oil containing 6-12 per cent fat and 32-36 per cent easily digestible proteins, is also a valuable concentrated feed. In terms of nutritional value, 1 kg of cake is equivalent to 1.2 feed units. It is used as an important component in the production of compound feed. It is superior in terms of feed quality to other plant cakes because it is easily digested by animals

The long-stemmed flax plant is an ancient plant known as far back as 4-5 thousand years before Christ in India, China and Egypt. It spread in our country in the fifteenth century. At the beginning of the eighteenth century, state-owned rope and linen mills were built in . From the early years of the twentieth century, our country became the main exporter of fibre abroad. At the end of the twentieth century, Ukraine sowed flax plants on an area of 100-160 thousand hectares, depending on the demand for fibre. However, in recent years, the area under flax has sharply decreased. The largest areas under flax are concentrated in Zhytomyr, Chernihiv, Volyn, Lviv, Rivne, Ivano-Frankivsk and Kyiv regions. The average fibre yield in Ukraine is 0.4-0.5 tonnes per hectare. On flax farms that have implemented intensive flax agro-technology, the yield of long fibre reaches 1.0-1.2 t/ha and of seeds - 0.5-0.8 t/ha.

Biological characteristics, varieties. Flax belongs to the botanical family *Linum L.* and includes more than 200 species. Only one species is of industrial importance - common flax (*Linum usitatissimum L.*). The European-Asian subspecies of flax is divided into 4 groups of varieties: *long-flax*, *mezzemok*, *curly flax*, and *creeping flax*. A significant part of the crops in our country is allocated to long-flax plants, which are grown primarily for fibre production. The fibre, in the form of fibrous or bast-like bundles in a ring in the stem bark, consists of individual elementary fibres glued together by a pectin substance. *Elementary fibres* are elongated cells with pointed ends, 15-40 mm long. Each bundle contains 25-40 fibres. The bundles, when joined together, form a technical fibre ribbon.

The amount and quality of fibre varies in different parts of the stalk. At the base, 12 per cent of the fibre is located, in the middle part - up to 35 per cent. The fibre in this part is long, thin, tightly bundled and of high quality. In the upper part of the stem, the fibre content is about 28-30 per cent. The number of elementary fibres in the bundle decreases, so the fibre is less strong here.

The quality of the long fibre is assessed by a number, which is determined organoleptically by comparing it with a standard sample. According to the standard, long fibres are graded by numbers depending on their quality. In addition, the quality of long fibre is characterised by technological features such as strength, flexibility, tint, quality, spinning ability. *Temperature requirements.* Flax is a temperate plant. Flax seeds begin to germinate at +3...5⁰ C. The optimum temperature for its growth and development is +16...17⁰ C. Young seedlings can withstand frosts down to -3.5...4⁰ C. The optimum temperature for plant growth and development is: during the germination period +9...12⁰ C, in the herringbone phase - +14...16⁰ C, during flowering - seed formation - +16...18⁰ C.

The sum of effective temperatures for its development during the growing season is 1400-2000⁰ C. Flax grows and develops well in moderately warm, even cool weather without sudden changes in temperature during the day and night. In hot weather flax forms thick stems with a low content of coarse fibre.

Moisture requirements. Flax is very demanding on moisture. Its transpiration coefficient is 400-430. It grows best at a soil moisture content of 70 per cent HB. It requires the most water during the budding and flowering phases. Lack of water in the soil during budding and flowering leads to the death of the upper part of the stems and even the death of crops. After flowering, flax becomes less demanding on moisture. On the contrary, frequent rains during this period can lead to the development of fungal diseases, lodging and rotting of flax plants. This makes mechanised harvesting more difficult, part of the crop is lost, and its quality deteriorates. At the same time, the plants cannot withstand excessive water content in the soil. Flax grows poorly on waterlogged soils and in fields with a close occurrence of groundwater. Flax is a long-day plant with relatively low sunlight intensity. It has been established that a long day contributes to better development of the technical length of plants and the formation of better quality fibre. Intense sunlight increases stem branching, which reduces the quantity and quality of fibre. The most favourable for flax is the alternation of sunny and cloudy days. In such conditions, in thickened crops, plants grow long, thin stems that branch only from above. The direction of the rows is also important. If they are placed from north to south, the rows are better illuminated, and the growth and development of the flax is enhanced.

Nutrient requirements. Flax is a plant that is very demanding on the nutrient content of the soil. This is because it has an underdeveloped root system, which is also characterised by a low absorption capacity. The absorption period of the bulk of nutrients is short for long flax, limited to the budding and flowering phases. The total nutrient requirement of flax is very high. To produce 1 tonne of fibre, flax takes out 80 kg of nitrogen, 40 kg of phosphorus and 17 kg of potassium from the soil. The nutrients from the plant's mineral fertilisers are used unevenly by flax: 70-80 per cent of nitrogen, 15-20 per cent of phosphorus, and 50-60 per cent of potassium.

Soil requirements. Long flax plants require structurally fertile and vegetated soil with a slightly acidic reaction (pH 5.9-6.5). It grows best on sod-podzolic loamy or loamy sandy loam soils. Flax also produces good yields on fertilised sod-podzolic sandy loam and soddy loam soils. Light sandy and sandy loamy soils are not very suitable for flax, as they are poor in nutrients and have poor moisture retention. Flax suffers from drought on sandy soils. Heavy clay soils warm up slowly in the spring and form a crust after rain, which is an obstacle to the tender flax seedlings coming to the surface of the soil. It is not recommended to sow flax on acidic peat soils. Limestone soils produce coarse and brittle fibres. Zoned varieties of flax in Ukraine: Tomsky 16, Irma, Kyivsky, Rushnychok, Sinilga, Ukrainsky 3, Mogylivsky 2, Charivny, etc.

Agricultural technology. *Place in crop rotation.* The long-flax plant is demanding in terms of crop rotation. Frequent cultivation in one field results in flax fatigue, which reduces or completely destroys the flax yield due to the accumulation of fusarium, anthracnose and polysporosis pathogens in the soil. To prevent flax boll weevil, flax should not be grown in the same field for more than 6-7 years. Crops are placed in low areas of the crop rotation, avoiding closed saucers, as it can get wet. According to research institutions and best practice, the best places in the rotation of flax are winter wheat over a layer of perennial grasses or spring seeded after fertilised row crops. According to research institutions, when full mineral fertilisation was

applied after perennial grasses, winter cereals and potato plants, almost the same yields of flax were obtained, but the yield and quality of long fibre were higher when grown on a rotation of perennial grasses, more often after winter wheat plants.

In recent years, flax plants tend to lie down after high-yielding perennial grasses. This is because grasses accumulate a lot of nitrogen in the soil. This reduces the yield and quality of fibre and seed. For this reason, in advanced farms, flax is grown mainly on the turnover of the perennial grass layer after winter wheat.

A complete mineral fertiliser should be applied to winter and spring seed crops that are used as a place in the flax rotation ($N_{60-80} P_{60-80} K_{60-80}$). Flax has low soil depletion. It can be followed by winter and spring seed crops, potatoes, buckwheat and other plants in the crop rotation.

Soil cultivation. High-quality soil cultivation provides optimal water, nutrient and air conditions for plants. It should clear the field of weeds as much as possible, create a fine clod structure, and perfectly level the soil surface. The method of tillage depends on the type of soil, its place in the crop rotation, weediness and moisture. Soil cultivation is divided into primary and pre-sowing cultivation.

The main cultivation depends on the place in the crop rotation. After perennial legumes, the field is ploughed with a plough with a skimmer to a depth of 20-22 cm, and if the arable layer is thicker, to a depth of 25-27 cm. After cereals, it is recommended to cultivate the soil for flax in the crop rotation using the improved fallow tillage method. The stubble is removed to a depth of 6-8 cm with LDG-10 or LDG-15 stubble harvesters, or to a depth of 10-12 cm with BDT-, BDV-6.3 disc harvesters or PPL-10-25 ploughshares. The ploughing is carried out in the early stages, with the emergence of weeds, to a depth of 20-22 cm.

The semi-steam method is more effective in clearing the topsoil of weeds. It is based on ploughing with simultaneous harrowing (or rolling in dry weather) immediately after harvesting the crop in the crop rotation - no later than 15 August. To ensure even distribution and incorporation of the sod, the skimmers are installed 32-34 cm in front of the main plough body to a depth of 8-10 cm. The ploughing depth should not exceed the depth of the arable layer. During ploughing, it is important not to turn the subsoil (infertile soil layer) to the soil surface, as even a small amount of it in the arable layer reduces the field germination of seeds, the density of the stem and contributes to the disease of plants with Fusarium.

As the weeds germinate, the soil is cultivated 2-3 times using the KPS-4 with simultaneous harrowing. The first cultivation is carried out at a depth of 10-12 cm, the second - at 8-10 cm, and the third - at 6-8 cm. Weed seeds germinate from the topsoil and are destroyed by the next cultivation. A new seed is brought to the surface, which also germinates and is destroyed. At the same time, this treatment depletes and destroys the vegetative organs of rhizome and root weeds. The last cultivation is carried out 2-3 weeks before the onset of frost, so that weed seeds that have been uprooted from the lower soil layers have time to germinate and the seedlings are destroyed by frost.

When flax is planted after potato or root crops, the field is ploughed to the ground without preliminary peeling or limited to surface shallow tillage.

Spring tillage is aimed at preserving moisture in the soil, creating a levelled field surface and a firm seedbed, which ensures uniform seed placement to a depth of 1.5-

2.0 cm. Early spring cultivation begins when the soil is physically ripe. Use a combination of heavy or medium harrows and harrow in 2-3 traces to loosen the topsoil well. Medium- and heavy loamy and compacted soils should be cultivated with a cultivator with lancet tines after early harrowing or instead of it. The depth of such cultivation should not exceed the depth of the last autumn cultivation. 5-7 days after the early spring tillage, when weeds germinate, pre-sowing tillage is carried out. It is carried out with an aggregate of three rows of tooth harrows: the first - heavy (BZTS-1.0), the second - medium (BZSS-1.0), the third - light (ZOR-0.7). On heavy, moist soils, cultivation is carried out for the second time, simultaneously with harrowing.

On light, excessively loosened soils, the field is rolled before sowing to ensure even seed placement. This increases field germination by 10 per cent. The quality of the soil tillage is essential for friendly and levelled emergence.

The best quality of soil preparation for sowing is ensured by the use of combined units RVK-3.6, LC-4, APG-6, Compactor, Europak, etc. In one pass, they cultivate, destroy weeds, level, crush clods, compact the soil and create optimal conditions for seed germination. No other agrotechnical measure has the same impact on seed germination and stem alignment as pre-sowing cultivation.

After harvesting, in case of heavy weed infestation with perennial cereals (wheatgrass, etc.), it is recommended to apply continuous herbicides on the stubble: Roundup, Hurricane, Buran, Glyphos, Glyphogan. Ploughing for winter cereals is carried out after the complete death of weeds, not earlier than 3 weeks after spraying the field.

Fertilisation. Flax absorbs nutrients unevenly across growth stages and periods, and uses them unevenly. Flax consumes the most nutrients from the soil during the budding phase - 48 per cent of nitrogen, 65 per cent of phosphorus and 59 per cent of potassium of the total nutrients absorbed during the growing season. That is why easily soluble fertilisers are preferred. In particular, ammonium nitrate and ammonium sulphate, potassium salt, potassium magnesium, boron superphosphate, etc. are used. The best potash fertilisers are considered to be chlorine-free. Complex fertilisers can also be used: ammophos and LFM (liquid and complex fertilisers).

When applying fertilisers for flax, the effect of each of the main nutrients on the yield and fibre quality must be taken into account. It has been established, for example, that sufficient nitrogen supply to plants has a positive effect on the yield of long fibre, while excessive nitrogen supply causes lodging and increased disease damage to flax, which reduces fibre yield and worsens fibre quality. A sufficient level of phosphorus nutrition helps to shorten the growing season of flax while increasing fibre yield. Rational potassium nutrition increases the number of elementary fibres in fibre bundles, which has a positive effect on the yield of long fibre and its quality. Potassium also increases the resistance of flax to lodging.

Mineral fertiliser application rates for flax are determined in accordance with the agrochemical survey of the soil. According to research institutions, to obtain a high fibre yield (at least 10 c/ha) on sod-podzolic soils containing up to 15 mg P₂O₅ per 100 g of soil, 90-120 kg/ha of phosphate fertiliser should be applied to flax. On soils containing more than 15 mg of mobile phosphorus per 100 g of soil, this yield can be achieved with 60-90 kg/ha of fertiliser. The rate of potash fertiliser for flax plants

depends on the availability of exchangeable potassium in the soil. On soils that are well supplied with potassium (at least 20 mg K_2O per 100 g of soil), 60-90 kg/ha of fertiliser is applied, and on soils that are insufficiently supplied (10-15 mg K_2O per 100 g of soil), 90-120 kg/ha of active ingredient is applied.

When determining nitrogen fertiliser rates for flax, the crop's place in the rotation is taken into account. After cereals with a grain yield of more than 4.0 t/ha, 20 kg/ha of nitrogen fertiliser (70 kg/ha of ammonium nitrate) is applied, and with a grain yield of 2.0-4.0 t/ha - up to 25-30 kg/ha (80-90 kg/ha of ammonium nitrate). Only on sparsely vegetated soils with a grain yield of less than 2.0 t/ha of nitrogen fertiliser is applied up to 50 kg/ha (up to 150 kg/ha of ammonium nitrate).

Phosphorus and potassium fertilisers should be used in autumn for ploughing or deep cultivation, and nitrogen fertilisers in spring for pre-sowing cultivation. Part of the phosphorus fertiliser (50 kg/ha of superphosphate) is applied to the rows during sowing of long flax.

On soils with insufficient nitrogen supply, apply full mineral fertiliser in the ratio N:P:K as 1:2:3, and on soils rich in nitrogen - 1:3:4.

Flax is most in need of boron among the trace elements. Boron superphosphate or boric acid is used. With a scattered application of 200-300 kg/ha of boron superphosphate, the flax plant is provided with boron. Boric acid (0.3-1.5 kg/ha) is more appropriate to apply together with herbicides. On peatlands, copper sulfate (25 kg/ha) or pyrite cinder (250-500 kg/ha) is used.

Sod-podzolic soils for flax need to be lime-lime. However, limestone fertilisers, when applied directly to flax, have a negative impact on fibre quality, so they are fertilised as part of the crop rotation. Depending on the soil acidity, the following fertiliser doses are set: at pH 4.5 and below - 2.5-3 t/ha, pH 4.6-5 - 2-2.5 t/ha, and at pH 5.0-5.5 - 1.5-2 t/ha.

Manure and peat composts are not applied directly to flax, as this causes uneven stems, plants often lie down, and fibre quality deteriorates.

Sowing. For sowing, cleaned, sorted flax seeds with a purity of 98-99 per cent) and germination rate of 90-95 per cent are used. The seed must be free from disease, free from weeds and other impurities, uniform in size and well filled, brown in colour, shiny, smooth, not musty or rancid.

To increase germination and germination energy, the seeds are heated by air and heat for 4-5 days in the sun. They are spread in a thin layer of 5-10 cm on a bed or tarpaulin and shovelled several times a day. The treated seeds are not subjected to air and heat heating. Seeds are treated with Vitavax 200 (1.5-2 l/t), Vitavax 200 FF (1.5-2.0 l/t), Maxim 025 FS (1.0 l/t). To increase the resistance of flax plants to diseases (bacteriosis, polysporosis), it is advisable to add trace elements to the seed treatment. Often, to protect seedlings from flax flea beetles, seeds are treated with insecticidal treatments: Cruiser 350 FS (0.5 l/t).

To ensure timely harvest and improve the conditions for trestle ripening (August), preference should be given to early and mid-season flax varieties. Early-ripening varieties have a growing season of 65-75 days, mid-ripening varieties - 76-85 days, and late-ripening varieties - 86-105 days.

Friendly germination, levelled stem, high yields are ensured by a sowing method

in which the seeds are more evenly distributed over the area and planted to the same depth. For this purpose, long flax plants are sown mainly in a narrow-row method with a row spacing of 7.5 cm using SZL-3.6, SZ-3.6A-02, SZ-5.4-02 or Mistral pneumatic seeders. With intensive cultivation techniques, permanent tramlines are left unseeded for crop care, overlapping the 8th and 17th seeding units (as in the cultivation of cereals) for the application of fertilisers, herbicides, insecticides, and defoliant.

Increasing the row spacing worsens the uniformity of the plants in the area, and they thicken in the rows. For seed plants, long flax is sown in a wide-row (45 cm) or strip method (45x7.5x7.5 cm) with a lower seeding rate. Flax seeds are small and have a small supply of nutrients, so they are sown shallowly. On loamy and clayey soils, the optimal seeding depth is 1-1.5 cm, on light sandy loamy soils - 1.5-2 cm, but not more than 3 cm. If the seed goes deeper than 3 cm, the sowing is stopped, the field is additionally rolled and sown again. If the seeds are sown deeper than 3 cm, the seedlings are thinned out and an uneven stem is formed. Increasing the sowing depth to 5 cm dramatically reduces germination: the cotyledons cannot break through to the soil surface and die. Of great importance is the fact that flax seeders are equipped with anchor coulters that compact the "seed" furrow, draw moisture from the lower soil layers, ensure evenly deep seeding with loose soil, simultaneous germination of plants and their uniform development.

The morphological structure of flax stalks and the number of normally developed bolls per stalk is largely determined by the density of the stalk. In thickened crops (up to the permissible limit), the stems stretch in height and grow thinner, the elementary fibres are thin and elongated, so the fibre is more flexible and stronger than in sparse plant stands. In sparse crops, thicker stalks are formed with lower fibre content and poorer quality. The number of seed pods, on the contrary, is higher on the stems of thinned crops.

The optimum plant density before harvesting for lodging-resistant varieties is 2000-2200 units/m² (20-22 million/ha), and for medium-resistant varieties - 1800-2000 units/m² (18-22 million/ha). This density is ensured by sowing 25-28 million/ha (125-150 kg/ha) and 22-25 million/ha (110-130 kg/ha) of seeds in well-prepared soil. Varieties that are more resistant to lodging (Mogilevsky) are sown at 25-27 million/ha, and less resistant varieties (Tomsky 16, Ukrainsky 2) at 23-25 million/ha. On fertile soils, to avoid flax lodging, the seeding rate is reduced by 10-15 per cent, while on heavy loamy soils, on the contrary, it is increased by the same amount.

Flax is an early sowing plant. It is sown at the earliest possible time, simultaneously with early spring seed plants, or immediately after their sowing. A prerequisite is sowing in well-developed soil, when it is not smeared during cultivation and warmed to a depth of 10 cm to +5...8° C.

When flax is sown at the optimum time, the plants develop a better root system, germinate quickly and outgrow weeds. The plants grow and develop in more favourable conditions with relatively low air temperatures and sufficient soil moisture, are more resistant to disease and lodging, and ripen earlier, which makes it possible to harvest in July and August, and to lay the trestle in August. Flax should be sown within 3-4 days. Delayed sowing reduces fibre and seed yields and product quality.

Crop care. After sowing, the field is rolled. Crop care also includes the timely

destruction of the soil crust that can form after heavy rains on loamy soils, protection against weeds, pests, diseases, and sometimes fertilisation. The soil crust makes it difficult for flax sprouts to reach the surface, increases water evaporation, and worsens the air and nutrient regimes of the soil, which negatively affects plant growth and development. It is destroyed by light harrows ZBP-06, mesh harrows BSN-4 or BS-2, ring-spur rollers ZKKSH-6, scarred rollers, rotary hoes MVN-2.8. The machine should move across or diagonally to the direction of the rows. It is better to harrow when the sprouts are short, no more than the length of a flax seed. The crust is destroyed by rolling both before and after emergence.

Flax grows slowly at the beginning of the growing season and reacts very negatively to weed infestation, resulting in a decrease in yield and product quality. The root system of weeds is much more developed than that of flax. Therefore, weeds consume water and nutrients faster and more intensively, limiting their supply to flax plants. In addition, weeds shade flax, reducing soil temperature, and are a source of pests and diseases. First and foremost, it is necessary to make full use of the possibilities of the agrotechnical method of weed control. These include crop rotation, semi-pair or improved basic tillage, high-quality spring soil preparation, a rational fertilisation system, timely and high-quality sowing with conditioned seeds, etc.

On flax crops, the soil herbicide Treflan (1.6-2.0 l/ha) is applied before sowing, during sowing, after sowing, but before the plant emergence (with immediate incorporation) against annual cereal and dicotyledonous weeds. However, flax crops are often heavily weeded with such weeds as wild radish, field mustard, quinoa, bitterroot, flaxseed, spurge, cowpea, blue cornflower, field chamomile, thistles, chicken millet, grey maretail, wheatgrass, etc. To control their number in flax crops, herbicides Agritox (0.7-1.2 l/ha), Bazagran (3.0 l/ha), Bazagran M (2.0-3.0 l/ha), 2M-4X 750 (0.5-0.75 l/ha), Dicopur MCPA (0.5-0.75 l/ha), Lontrel (0.1-0.3 kg/ha), Lontrel Grand (0.04-0.12 kg/ha), Pik (0.015-0.020 kg/ha), Harmony (15-25 g/ha). For more effective weed control, it is recommended to use a tank mix: Harmony, 10 g + 2M-4X, 600 ml/ha. It is not recommended to use Trend 90 surfactant on flax crops. The interval between treatments with Harmony and graminicides should be 5 days.

To protect flax crops from annual and perennial cereal weeds, it is necessary to apply herbicides such as Zelek Super (1-1.25 l/ha), Panther (1-2 l/ha), Select 120 (0.4-1.8 l/ha), Targa Super (2.0-3.0 l/ha), Fusilade Forte (0.5-2.0 l/ha), Centurion (0.4-0.8 l/ha). Herbicides are selected depending on the species composition of the weeds. Tank mixtures of anti-cereal and anti-dicotyledonous products, such as Lenok + Panther, are highly effective.

Flax crops can be severely damaged by diseases that dramatically reduce the yield and quality of flax products. In some cases, the crops are significantly thinned out or completely destroyed. The most harmful are: *Fusarium wilt* - plants droop, leaves wither and dry, roots rot; *Fusarium browning* - at the beginning of ripening, the entire aerial part of the plants turns brown, the stem becomes brittle, the bolls crumble; rust - orange-rusty spots appear on the leaves and stems in the form of tubercles; *polysporosis* - brown and then dark brown spots form on flax stems in the affected areas, the stem becomes brittle; *bacteriosis* - the growth point or top of the plant dies, young plants die en masse, during budding and flowering, the leaves turn yellow and

red, curl; *strand* - yellow-brown spots appear on cotyledon leaves, later the leaves on the stem turn brown and fall off, the stem is also spotted.

The plants can be protected from disease damage by agronomic measures. First and foremost, flax should not be returned to the same field until 6-7 years later. A scientifically based ratio of nitrogen, phosphorus and potassium increases the plant's resistance to fusarium, anthracnose, rust and ascochytosis. Not only can a lack of fertilisers be harmful, but also an excess of them. For example, one-sided nitrogen nutrition causes lodging and disease; excessive amounts of lime contribute to the spread of bacteriosis. It is important to adhere to the optimal sowing dates and seeding rates.

Plant protection against diseases with fungicides is combined with weed or pest control. In the herringbone phase against anthracnose, flax strands are treated with Fundazole (50 per cent w.p.) at a rate of 1.0 kg/ha. To protect against Fusarium, anthracnose, flax is sprayed on the sprouts and in the herringbone phase with a 0.4 per cent suspension of copper chloroxide (90 per cent w/w) at a rate of 2.2 kg/ha. Add 300 g of boric acid to the tank mixture, and if necessary, other trace elements.

Flax is damaged by many types of pests, but the most damaging are the flax flea, flax thrips, flax moth, gamma moth, and alfalfa moth. With the emergence of seedlings, flax fleas appear on the field, feeding on cotyledonous and young true leaves, after which the plants die, and if they survive, they lag behind in growth and become low-yielding. Fleas are particularly damaging in dry and hot weather. To protect flax from pests, the List of Pesticides and Agrochemicals Permitted for Use in Ukraine includes only one insecticide, Fury (10 percent of the chemical equivalent), with an application rate of 100-150 g/ha (spraying crops in the germination phase). A good effect of flax protection against fleas and other pests can be achieved by edge treatment of crops, when the field is cultivated along the perimeter to a width of 30-50 m 1-2 days before emergence.

Harvesting. There are 4 stages of ripeness in long flax: green, early yellow, yellow and full.

In the green ripeness phase, the stems and capsules are green, the leaves dry up and turn yellow in the lower third of the plant. The seed contains a milky liquid. The fibre in this phase is thin but fragile. In the early yellow ripeness stage, the leaves fall off on the lower half of the stem and all leaves except the apical one turn yellow. The seeds in 65-75 per cent of the yellow-green capsules are light green with a yellow nose. In the rest of the boxes, they are light yellow. When flax is harvested at this stage, the fibre is of the highest quality. In the yellow ripeness phase, the plants and all the leaves turn yellow. In 50 per cent of the bolls, the seeds are yellow, while the rest are light brown. There are also bolls with pale green seeds. The quality of the fibre deteriorates slightly at this stage. At full ripeness, the leaves fall off, the bolls turn brown, the seeds turn brown, harden, and the fibre is coarse and stiff.

Flax harvesting should begin 2-3 days after the onset of early yellow ripeness, and the main harvest should be made in the yellow ripeness phase. If necessary, in the early yellow ripeness phase, desiccate the crops with Reglon Super desiccant (2.0-3.0 l/ha). The combine harvester method ensures a high level of mechanisation of harvesting (LKV-4A, LK-4K or foreign-made combines) and post-harvest processing

of flax products. The flax harvester selects flax, combs the bolls, spreads the straw on the flax field or ties it into sheaves, and piles the flax heap into trailers.

Several methods of combine flax harvesting have been developed and introduced into production: with simultaneous binding into sheaves and selling the straw to the primary processing plant; with spreading into strips on the flax field, picking up and binding the straw into sheaves after drying with the PTN-1 and PTP-1 pickers and selling the straw to the flax mill; with spreading into strips on the flax field to produce straw with the use of OSN-1 to turn the stalks during drying and harvesting of the finished straw by PTH-1 and PTP-1 pickers, tying it into sheaves and selling it to the flax mill.

Studies by many research institutions have shown that the production of flaxseed tress on flaxseed is almost identical to its aging in natural meadows. The conditions of flax curing can be improved by sowing such cereal perennial grasses as meadow fescue, pasture ryegrass and others under flax.

During the aging process, when the top layer turns grey, the strip is turned over by the OSN-1 machine. This improves its physical and mechanical properties and quality. The chips are lifted when they turn grey, the fibrous layer is separated by continuous ribbons along the entire length of the stem, and the wood breaks easily and is separated from the fibrous layer. To lift the chips, we use the PTN-1 and PTP-1 pickers.

The most advanced way of selling flax raw materials is through the field-to-factory scheme. When flax is harvested with the LKV-4P combine and the straw is tied into sheaves, it is transported to the flax mill after drying. Industrial methods for preparing the meal have been developed and implemented. First of all, it is heat soaking in a liquid heated to $+25^{\circ}\text{C}$. The process takes 3-4 days, and with advanced technology (liquid regeneration, use of accelerators), the finished straw is ready in 40-60 hours.

After soaking, the liquid is drained off, the trust is washed with cold water, unloaded and squeezed using special OPL-2 and OPL-2MS machines. During the spinning process, the pellets are washed first with cold and then with hot water and then fed to a conveyor dryer.

The dried rayon is milled on MLKU-6A mills. The resulting fibre is processed on TL-40A flax-weaving machines to produce long fibre. Waste from the carding process is processed on special KL-25M machines to produce short fibre.



3.4.2 Cannabis plants (*Cannabis sativa*)

Cannabis is a spinning plant grown for fibre and seed. Cannabis fibre (18-23 per cent yield) is long and coarse, but has great strength and does not rot when kept in water for a long time. The fibre is used to make fabrics, tarpaulins, sailcloth, burlap, fire hoses, ropes, twine, cords, and valuable paper. Cannabis fabrics are antistatic, hygienic, and absorb up to 30 per cent of sweat and 95 per cent of ultraviolet rays. Clothes made of such fabrics are recommended for people prone to rheumatism, skin allergies, and spinal diseases. Coarse,

short fibre (oakum) is used for caulking ships, walls of houses, etc.

Waste from the primary processing of hemp is used to make plastics, building insulation boards, furniture boards, plywood, fuel briquettes, and pulp.

Cannabis seeds contain 30-35 per cent fat, 18-23 per cent protein, 20 per cent starch, 15 per cent fibre, and 4-5 per cent ash. Cannabis oil has high taste, is used as a food product, and after refining, it is used in the canning, fish and confectionery industries. It is rich in easily digestible fatty acids - linoleic, linolenic, gamma-linolenic, which contributes to the formation of gamma globulin, which masses antibacterial and antiviral bodies. Thanks to this, new drugs have been created for the treatment of asthma, sclerosis, epilepsy, cosmetic products for skin care, etc. Fast-drying oil is widely used for the production of drying oil, paints, varnishes, putties, soaps, etc. Paints made with hemp oil are very resistant. Therefore, they are used to paint iron roofs and other external metal objects. Cannabis seeds are also used to extract vitamins and phytin, which are used in medicine. Extracts from hemp leaves have pronounced antibacterial properties.

Cannabis cake is a valuable concentrated protein feed for animals. It contains 25-30 per cent protein, 8-10 per cent fat, 20 per cent fibre, etc. 1 kg of oilcake is equivalent in terms of digestible protein content to 2.9 kg of oat plants or 3 kg of barley plants, 3.1 kg of corn plants, and 15.3 kg of potato plants.

Cannabis plants are suitable for cultivation on reclaimed soils. Today, technologies have been developed to produce interior finishing materials from hemp fibre and fescue (wood, marble, and other stone types). In combination with other components, it is possible to produce products that are as strong as natural diamonds and quartzite and can withstand high temperatures and aggressive environments. Cannabis raw materials are suitable for the manufacture of individual components in the automotive and aircraft industries. It is considered a plant of the 21st century.

The Cannabis plant is a very ancient plant. The first mention of it was found in Indian literature dating back to the 17th and 18th centuries BC. It appeared on the territory of in the ninth century, and in the sixteenth century, hemp fibre became an important part of n exports to other countries. Cannabis plants are grown in India, China, Italy, France, Hungary, and Poland.

In recent years, the area under hemp in Ukraine has decreased from 60,000 ha to 8-10,000 ha in 2010. It is grown in Sumy, Chernihiv, Poltava, Volyn, Cherkasy, Dnipro and Mykolaiv regions. The average fibre yield is 0.6-0.7 tonnes per hectare. The best farms harvest 1.5-1.7 t/ha of fibre.

Biological characteristics, varieties. *Requirements to temperature.* Cannabis seeds begin to germinate at a temperature of $+1...2^{\circ}\text{C}$, but friendly seedlings appear at $+8...10^{\circ}\text{C}$. Seedlings can withstand short-term frosts down to $-4...5^{\circ}\text{C}$. The optimal temperature for hemp growth is $+20...25^{\circ}\text{C}$. A decrease in temperature below $+15^{\circ}\text{C}$, especially in the budding and flowering phase, inhibits the growth and development of hemp.

Moisture requirements. Cannabis plants are a moisture-loving plant. The optimum humidity for plant development is 70-80 per cent RH. The maximum moisture demand is observed in the period from budding to the beginning of seed ripening. The transpiration coefficient of hemp is 400-800.

Light requirements. Cannabis plants are a light-loving plant of short day. With a longer day, the growing season is extended, so when grown in northern regions, southern cannabis varieties have a high yield of stems, but the seeds usually do not ripen.

Soil requirements. High yields of hemp are harvested on fertile soils with a close to neutral soil solution reaction (pH 7.1-7.4). Black soil, river valley soils, and drained peat bogs are the most suitable. It is also possible to grow hemp plants on fertilised dark and light grey podzolic soils.

Nutrient requirements. Cannabis plants are very demanding on soil nutrient content. For the formation of 1 tonne of air-dry weight, plants take out 14-16 kg of nitrogen, 6.1-6.4 kg of phosphorus and 10.1-11.2 kg of potassium from the soil. During the growing season, nutrients are used unevenly. Plants absorb the most nitrogen from the beginning of budding to flowering, although nitrogen fertilisers have a positive effect on growth and development from the three-pair leaf stage onwards.

Cannabis plants absorb phosphorus throughout the growing season, and the critical period is from germination to the formation of 5-6 pairs of leaves and seed formation. Providing plants with phosphorus at the beginning of hemp development eliminates the negative effects of excessive nitrogen doses.

Cannabis plants consume potassium intensively in the first half of the growing season. Its deficiency at this time delays the growth of stems and the development of generative organs, and reduces fibre yields.

Monoecious hemp varieties are zoned in Ukraine: Hlukhivsky 33, Dniprovsky monoecious 6, Dniprovsky monoecious 14, Zolotonosky 15, Zolotonosky monoecious 11, Synelnykivsky.

Conditions for hemp cultivation in Ukraine. Modern breeding varieties of Cannabis listed in the Register of Plant Varieties of Ukraine contain 0.03-0.06 per cent of the narcotic substance tetrahydrocannabinol (THC), while the permissible content under Ukrainian law is 0.15 per cent and under EU law is 0.20 per cent. However, the current Ukrainian legislation provides for the following conditions for hemp cultivation: the farm has the right to grow hemp plants only if it has a licence issued by the Ministry of Agrarian Policy of Ukraine for a period of 3 years; the farm must annually obtain the approval of the Department for Combating Illegal Drug Trafficking of the regional department of the Ministry of Internal Affairs of Ukraine.

Agricultural technology. *Place in the crop rotation.* Hemp plants are sown after potatoes, sugar beets, and corn, under which high rates of organic fertiliser are applied. Seed legumes are a good place in the crop rotation. It is not advisable to plant hemp plants after sunflower because the fields are heavily littered with carrion, which makes harvesting more difficult and worsens product quality.

Hemp plants are grown in special or field crop rotations after row crops, vegetables, perennial grasses, and legumes. Crop rotations with a short rotation period (4-5 years) are common, usually on low-lying soils and drained peatlands.

Soil cultivation. After harvesting early crops in crop rotations (winter crops, legumes), stubble is peeled in layers: the first one is done with disc tools to a depth of 6-8 cm, the second one with ploughshares to a depth of 10-12 cm. In case of severe weed infestation with annual dicotyledonous weeds, herbicides of the 2,4-D group (1.5-

2 l/ha) are used and ploughing is carried out two weeks later. In case of weed infestation with rhizome weeds, immediately after harvesting early plants, double peeling with disc peelers is carried out to the depth of the rhizomes. With sufficient moisture, wheatgrass seedlings appear in these fields in 15-20 days. To completely destroy them during this period, it is necessary to carry out autumn ploughing. When placing hemp after late plants (potato plants, sugar beet), ploughing is carried out immediately after harvesting the place in the crop rotation. The ploughing depth for hemp plants is at least 22-25 cm.

Early in the spring, when the soil is physically ripe, loosening is carried out with plume harrows in combination with heavy tooth harrows. Several operations can be carried out simultaneously. For example, cultivation with simultaneous levelling and rolling of the soil provides a higher yield than pre-sowing cultivation. In areas of sufficient moisture on compacted soils and when applying manure for autumn ploughing, plough the soil with ploughs with skimmers in combination with ring-spur rollers. After that, harrowing is carried out with cultivators.

Fertilisation. Due to the relatively poor development of the root system compared to the aboveground mass, hemp plants respond well to organic and mineral fertilisers.

Organic fertilisers, in particular manure, are of great importance for increasing yields. In the middle zone, 30-40 tonnes per hectare are applied, and in the southern regions - 15-20 tonnes per hectare. Various composts are also used: peat and peat-manure composts at the same rates as manure. In the experiments of the Research Institute of Bast Plants, the use of 20 t/ha of manure increases fibre yields by 100-200 kg/ha, depending on soil and climatic conditions. The aftereffect of manure is manifested on light soils within 3-4 years, and on heavy soils - 6-8 years. On light soils, it is advisable to grow and plough crop lupine for green manure, which is as effective as manure.

The highest yields of high quality hemp are obtained by applying organic and mineral fertilisers. In this case, the dose of mineral fertilisers is reduced by 2 times compared to separate application. Nitrogen mineral fertilisers are the most effective for hemp plants on all soil types, except for vegetated peat bogs.

The following fertiliser application rates are recommended: on sod-podzolic and grey podzolic sandy loam soils - $N_{120} P_{90-120} K_{90-120}$, on grey and dark grey podzolic loamy soils - $N_{90-120} P_{60-90} K_{60-90}$, on podzolic chernozems - $N_{60-90} P_{60-90} K_{60-90}$ on ordinary chernozems - $N_{45-60} P_{45-60} K_{45-60}$, on floodplain soils - $N_{60-90} P_{60} K_{60}$, on vegetated peatlands - $P_{45-60} K_{120-150}$ kg/ha of active ingredient.

On peatlands, it is necessary to apply fertilisers containing trace elements: copper (5-6 kg/ha in the form of copper sulphate), boron (1-1.5 kg/ha of boron-magnesium fertiliser), etc.

Hemp plants absorb hardly soluble phosphorus compounds well, so it is advisable to use phosphate rock on soils with high acidity and low leaching black soils. However, granular superphosphate is considered the best phosphate fertiliser for all soil types.

Manure, composts, phosphate and potash fertilisers are most effective when applied in autumn for autumn ploughing, and nitrogen fertilisers - in spring for

cultivation. Higher yields are achieved by applying granular superphosphate to the rows during sowing (50 kg/ha for continuous and 30 kg/ha for wide-row sowing).

Wide-row crops are fertilised when 2-3 pairs of leaves have formed with nitrogen fertilisers, which are worked into the soil to a depth of 10-12 cm. Fertilising with phosphorus and potash fertilisers is ineffective. Fertilising with slurry (5-7 t/ha) is also useful. Acidic soils need to be lime.

Hemp plants are sensitive to boron, bromine, zinc and copper. The optimal application rates for copper and boron are 300 g/ha, and for zinc and bromine are 100 g/ha. Microfertilisers can be applied in several ways: by direct application to the soil, pre-sowing seed treatment and foliar feeding.

Sowing. For sowing, use cleaned, large seeds with a minimum of 96 per cent purity and 70-90 per cent germination. The higher the germination rate, the higher the yield and the better the fibre quality. When sowing seeds with 70 per cent germination, the fibre yield is reduced to 25 per cent. Hemp seeds reduce germination every year, and after 5 years, they lose it altogether. For example, a seed with a laboratory germination rate of 96-98 per cent in the second year reduces it to 71-76 per cent, and in the third year to 45-58 per cent, in the fourth year to 20-29 per cent, and in the fifth year to 4-6 per cent.

Good results are achieved by pre-sowing heating and treatment with TMTD at a rate of 2-3 kg per 1 tonne of seed.

When growing hemp for green (fibre), seeds and fibre, the best sowing method is narrow-row (7.5 cm) and row (15 cm) sowing. The best conditions for the growth and development of the green hemp plant are created by narrow-row sowing (the fibre yield of southern hemp increases by 23 per cent under such conditions due to more even plant distribution on the area). Pneumatic precision seeders Agrisem, Amazon, or domestic seed drills SZU-3.6 and SZ-3.6 are used for sowing. Sowing with the SZL-3.6 flax seed drill with anchor coulters ensures more even seed placement at the optimum depth, friendly germination, uniform plant development during the growing season and, as a result, an increase in fibre yield by 150 kg/ha.

For seeds, hemp plants are sown in a wide-row method with row spacing of 45 cm in the northern and 45-70 cm in the southern regions. The plants are sown with beetroot (STT-12V), vegetable (CO-4.2) or seed drills with appropriate overlap of the sowing machines.

Hemp plants are an early sowing plant. They are sown immediately after sowing early spring plants, when the soil at the depth of seed placement warms up to +5...8⁰ C. Early crops are more resistant to hemp fleas, suppress weeds better, ripen 10-15 days faster, and are more productive. In addition, harvesting and soaking can be carried out under better climatic conditions.

The optimum seeding rate by narrow-row method for green manure is 4-5 million units/ha or 70-90 kg/ha for monoecious and 90-110 kg/ha for dioecious. When growing for fibre and seeds, it is recommended to sow 2.5-3 million units/ha in narrow-row and row methods. Such crops are almost as good as wide-row crops in terms of seed yield, but provide a higher yield of fibre of better quality.

On seed crops, the elite is sown in a wide-row (45-70 cm) method (0.6-0.9 million units/ha (10-15 kg/ha). Seeds of the first reproduction are sown in larger

quantities - 1.2-1.8, and those of the second reproduction in even larger quantities - 1.8-2.4 million units/ha.

The depth of seeding on heavy soils with sufficient moisture is 2-3 cm, and on lighter soils - 3-4 cm. In the southern regions, seeds are sown 4-5 cm deep.

Crop care. Soil crust on hemp crops is destroyed by pre-emergence harrowing with light or medium harrows, rotary hoes. It is carried out on the 4th day after sowing. To protect against weeds in wide-row crops, mechanised loosening of row spacings is carried out. The depth of the first loosening is 5-6 cm, the second - 7-8 cm, and the third - 5 cm. Deep loosening (12-14 cm) dries the soil and damages the root system of plants. Loosening is most effective in the phase of the first pair of true leaves. On seed plots, weed control should be started after germination, in the phase of the first pair of true leaves, and finished before the rows close, i.e. after 5 pairs of leaves are formed.

To protect crops from annual cereal and dicotyledonous weeds, herbicides Dual Gold (1.6-2.0 l/ha) or Lenacil (1.2-1.5 kg/ha) or their tank mix (Dual Gold 1.3 l/ha + Lenacil 1 kg/ha) are applied before sowing with pre-sowing cultivation or 3-4 days after sowing with pre-sowing harrowing.

In the post-emergence period, Achiba 50 ES (1.5 l/ha), Panther (1.0-1.8 l/ha), Miura (0.8-1.2 l/ha), Targa Super (1.5-3.0 l/ha), Poast (1.5 l/ha), and Nabu (1.5 l/ha) are applied against annual cereal weeds. Spraying of hemp crops is carried out in the phase of 2-4 leaves of weeds.

Insecticides are used to kill pests during the growing season: Sumiton (1.0-1.5 l/ha) - against hemp fleas, corn moth: Zolon (3.0 l/ha) - against leafhoppers, corn moths.

In seed plots, during the first and second loosening of row spacing, the crops are fertilised with full mineral fertiliser (N P K).²⁰²⁰²⁰

Harvesting. When growing on green, the highest yield of fibre of the highest quality can be obtained when harvesting during the flowering period of the flats. In case of dual use, the flax is harvested first, followed by the mother after 35-40 days. The flathead is harvested by hand at the end of flowering, and the mother is harvested when the flower is ripe in the middle part. On seed plots, the mother is harvested separately when 70 per cent of the seeds are ripe or by direct harvesting when 75 per cent of the seeds are ripe. The preferred harvesting method is direct combining with a KKP-1.8 combine. When harvesting separately, the seeds are threshed 3-5 days after mowing. After threshing, the straw is sorted and transported to hemp factories, and the seeds are dried to standard moisture content (11-12 per cent).

Hemp plants can be sold in the form of straw. To obtain the straw, they are soaked in ponds, lakes, rivers, and special reservoirs. During summer soaking in water with a temperature of +18...20⁰ C, 7-8 days are required; during autumn soaking in colder water (+10...12⁰ C), the soaking time increases to 15-18 days. If the water temperature drops to +6...7⁰ C, bacteria do not develop, pectin substances are not destroyed and the urination process stops.

After soaking, the fibre bundles should be easily detached from the fescue. The fescue is dried and partially separated on the MLKU-6 hemp spinner; the long fibre is separated from the fescue on the PTM-1 hemp spinner; and the short fibre suitable for spinning is obtained from the hemp waste on the hemp spinner. The quality of the long

hewn fibre is determined by its number (from 4 to 10).

3.4.3 Cotton plant (*Gossypium hirsutum*)



The cotton plant is the main spinning plant in global agriculture. Cotton fibre is the most important type of plant material for the textile industry. This is due to the high technological qualities of cotton fibre. It is thin, lightweight, but strong enough to tear and bend, easy to dye, and has high hygiene and good thermal insulation properties. Long-fibre cotton fibre is used to make chintz, satin, cambric, knitwear, flannel, papier-mâché and many other fabrics. The shorter fibre is used to make decorative fabrics, linen, blankets, towels and other products. A mixture of cotton fibre and wool is used

to make valuable semi-woollen fabrics. The lint is used to make cotton wool, artificial felts, cellulose, valuable paper, cellophane, artificial silk, film, plastic, varnishes for coating metal parts of machinery, artificial leather and many other products. 1 tonne of raw cotton produces 300-320 kg of fibre and 600-650 kg of seeds. This amount of fibre can be used to produce 3.5-4 thousand metres of² fabric.

The seeds of the cotton plant, which make up about 65 per cent of the weight of raw cotton, contain 20-30 per cent of semi-drying oil (iodine number 102) (the kernel contains 35-40 per cent). The oil is used for food, soap, glycerin, stearin, drying oil, etc. Cottonseed cake is a good concentrated animal feed containing up to 40 per cent protein. However, it should be fed in small quantities because it contains the poisonous substance gossypol. Do not use the cake for fattening pigs.

Ethyl and methyl alcohol, glucose, furfural, lignin, resins, and feed proteins are produced from the seed husks. Cotton stems and bolls are used to make acetic acid, paper, and as fuel. Citric and malic acids and various resins are obtained from the leaves and bark of the stems.

As a row crop, cotton is of great agronomic importance.

The cotton plant is an ancient plant and is the only plant that was cultivated before the discovery of America in both the Old and New Worlds. However, the cotton plant species originating in the Americas differ significantly from those found in Asia: the somatic cells of the American species have 52 chromosomes, while the Asian species have 26. They also differ in fibre length: in the former, it reaches 30-50 mm or more, and in the latter, it is about 20 mm.

Cotton has been grown in Ukraine since 1929. However, in 1954, cotton planting stopped due to low yields and fibre quality. It was more cost-effective to import raw materials from the republics of the Transcaucasus and Central Asia. However, in recent years, cotton cultivation in Ukraine has been resumed (in Kherson region). It is planned

to expand the area under cotton to 3,000 hectares by 2015.

The cotton plant is the world's main spinning plant. The global area under its cultivation is about 35 million hectares, and the gross harvest of raw cotton is 42-45 million tonnes. Cotton is grown in more than 60 countries. The largest sown areas are concentrated in India (7.5 million hectares), the USA (4-4.5 million hectares), China (4.8 million hectares), and Brazil (1.9 million hectares). The global average yield of raw cotton is about 1.5 tonnes per hectare.

Biological characteristics, varieties. All cotton plant species are very demanding on heat. The minimum temperature for seed germination is $+10...12^{\circ}\text{C}$, the optimum temperature is $+25...30^{\circ}\text{C}$. The sum of active temperatures during the growing season is $2800-3600^{\circ}\text{C}$. At temperatures below $+20^{\circ}\text{C}$, plants are inhibited. The cotton plant does not withstand frosts below -2°C both at the beginning of the growing season and in autumn.

Moisture requirements. Cotton is a relatively drought-resistant plant in terms of moisture. Its deeply penetrating root system helps it to use moisture from the subsoil. The transpiration coefficient ranges from 400 to 800. However, high yields are obtained only if the plants are sufficiently supplied with moisture, which is achieved by irrigation. If there is insufficient soil moisture, the capsules fall off. Cotton is the most demanding plant for moisture during the flowering and fruit formation periods. Fibre quality depends on air humidity. Thinner and longer fibres are produced with higher humidity. The total water requirement for a high yield is 5-8 thousand m³/ha.³

Light requirements. The cotton plant is a light-loving, short-day plant. Insufficient lighting inhibits plant development and increases vegetative mass. In case of insufficient light, moisture and nutrient deficiency, buds and ovaries fall off. This is most often observed in weedy, insufficiently fertilised, untimely irrigated and poorly cultivated areas.

Soil requirements. The best soils for cotton plants are grey earth and meadow-bog soils. Soils with a high water table and high acidity (pH 7-8) are unsuitable for cotton. Cotton has high nutrient requirements. A favourable ratio of nitrogen, phosphorus and potassium shortens the plant's growing season by 5-10 days and increases its resistance to disease. For every 1 tonne of raw material, the cotton plant removes 46 kg of nitrogen, 16 kg of phosphorus and 18 kg of potassium from the soil.

Depending on the variety, the cotton plant's growing season lasts 130-150 days. The growing season consists of the following phases: germination, budding, flowering, and ripening. For growing in Ukraine, we recommend the cotton plant variety Dniprovsky 5.

Agricultural technology. Place in the crop rotation. The best place in the crop rotation for cotton is alfalfa. According to the state variety testing stations, the yield in the first 2-3 years increases by 50-60 percent or more compared to the yield of cotton grown in permanent crops.

The value of alfalfa as a place in a cotton crop rotation is that it removes a lot of salts from the soil, enriches the soil with nitrogen, lowers the water table, which prevents re-salinisation, improves its physical properties, and activates the activity of soil microorganisms. Corn, sorghum, and annual legumes are also good options for cotton crop rotation. Mono-plant cultivation of cotton leads to a 30-50 per cent

reduction in yield.

Soil cultivation. If cotton is sown after alfalfa, ploughing is carried out to a depth of 27-30 cm in late October - early November, and after the cotton plant - as the area is released to the same depth. Winter and spring ploughing is less effective.

In the early spring, the area is harrowed and cultivated to a depth of 8-10 cm, and on heavy soils, it is cultivated with chisel cultivators to a depth of 18-20 cm and harrowed in 2-4 traces. After harrowing, the soil surface is levelled.

Fertilisation. The cotton plant is very demanding on nutrients, so when growing it on one field for several years in a row, full mineral fertiliser is applied at the rate of nitrogen 140-160 kg/ha, phosphorus 80-100 kg/ha, potassium 30-50 kg/ha of active ingredient. When sowing cotton after alfalfa in the first two years, the nitrogen application rate is reduced to 50-70 kg/ha. It is better to apply organic fertilisers to the crop in the crop rotation. Post-harvest sowing of green manure plants is effective.

It is advisable to use nitrogen fertilisers separately: 25 per cent of the calculated rate before sowing, 75 per cent in top dressing. Along with nitrogen fertilisers, some phosphorus and potassium fertilisers are also added to the fertiliser. Top dressing is carried out during the budding period.

The pre-sowing application of granular superphosphate or nitrophosphate at the rate of 100 kg/ha gives significant yield increases. They are applied at a distance of 5-8 cm from the row to a depth of 12-15 cm.

Cotton is sown using the dotted method with row spacing of 60-90 cm when the soil warms up to a temperature of +12...15° C at a depth of 10 cm. The seeding rate is 80-90 kg/ha, and the planting depth is 4-5 cm.

Crop care. The first step in caring for the crops is to destroy the soil crust before emergence with rotary hoes. The plant density is formed during the period of formation of two true leaves, leaving 7-9 plants per 1 linear metre of row, or 80-100 thousand plants per 1 ha. Inter-row tillage is carried out as the soil is compacted and weeds appear, as well as after each irrigation, as soon as the soil is sufficiently dry.

During the growing season, it is recommended to maintain soil moisture at 65-80 per cent of the full moisture capacity at all times. Depending on the soil and weather conditions, 4-5 to 10 vegetation irrigations are carried out with an irrigation rate of 600-900 m³ /ha. The most common method of irrigating cotton plants is sprinkling, which reduces water consumption per unit of yield by half compared to furrow irrigation.

An important agricultural measure to increase the yield of cotton plants is to cut off the tops of the plants (*chasing*) when 14-16 fruit branches are formed.

Harvesting cotton plants is a long and labour-intensive process. This is because the bolls take 2-3 months to ripen. It should be borne in mind that the most valuable raw cotton is produced in the bolls that have ripened and opened before the onset of frost. It is from these bolls that the highest yield of high-quality fibre and seeds is obtained. The cotton plant is harvested at several times as the bolls ripen. The raw cotton plant is harvested 2-3 times before and 1-2 times after the onset of frost.

To ensure fast boll ripening and opening, improve the working conditions of harvesting machines, increase their productivity and reduce the harvesting time, cotton plants are defoliated (leaf drying). The best time for defoliation is when 4-5 bolls open

on a plant of fine-fibre varieties and 3-4 bolls open on plants of medium-fibre varieties. Basta (2-3 l/ha) and Reglon Super (2 l/ha) are used for defoliation. As a rule, cotton plants are harvested in rows, for the first time - 8-10 days after defoliation, when 55-60 per cent of the bolls are opened. The next harvest is carried out 12-15 days after the first one, when 25-35 per cent of the bolls are opened.

3.5 Tobacco (*Nicotiana tabacum* L) Family Solanaceae



Tobacco is grown as a raw material for the manufacture of tobacco products, cigarettes, etc. Tobacco is also used to produce nicotinic acid, essential oil and special medicines. Tobacco leaves contain 1-3 per cent nicotine, organic acids, essential oil, carbohydrates, resins, etc. Tobacco originated in America, where it was used for medicinal purposes and for smoking more than 2,000

years ago. It was brought to Europe in the 16th century, and from there to India and Japan.

In , tobacco began to be consumed at the end of the 19th century, and cultivated a little later. The first tobacco plantations were in the areas of present-day Ukraine. In 1717, more than 50 hectares were planted in Okhtyrka and a workshop for the manufacture of smoking products was set up. Then the plant spread to the Naddniprianshchyna region, from where it penetrated into the Crimea.

Distribution and yield. The global tobacco area is about 4.1 million hectares and gross production is 5.9 million tonnes. In Ukraine, tobacco occupies about 20 thousand hectares with a yield of 7-9 centners per hectare. It is grown in the Crimean, Ternopil, Zakarpattia, Ivano-Frankivsk, Khmelnytsky, Chernivtsi and other regions. The best farms harvest high yields (4.5-5.5 tonnes per hectare). It should be noted that tobacco production mainly provides raw materials for the tobacco industry, so the task of tobacco growers is to improve the product range of raw materials, improve their taste, aroma, and technological qualities, and reduce toxicity. Tobacco is a **light-loving plant**. Most of its ecotypes are short-day plants, and some are long-day plants. As a plant of tropical and subtropical climates, tobacco grows well at high temperatures at all stages of development, from seed swelling to maturation. The minimum temperature for its development is 10-13° C, and the optimum temperature is 27-28 °C.

Plants die in spring frosts of minus 2-3 °C. Temperatures above 35 °C have a negative effect on plants. The length of the growing season significantly depends on the temperature regime. Thus, at an average summer temperature of 18 °C, the tobacco

growing season is 175 days, at 22 °C - 130 days, at 25 °C - 120 days, at 26-27 °C - 100 days.

High-quality tobacco products have a temperature of at least 20 °C during leaf ripening, and high-quality tobacco products have a temperature of at least 24-25 °C.

Tobacco is a **water-loving plant**. During the period of intensive growth, plants use more than³ 100 m of water per hectare per day. High yields of quality raw materials are grown at soil moisture content of 60-80 per cent HB. Excessive soil moisture leads to tobacco soaking and fungal diseases. At the beginning of the growing season, tobacco is more resistant to waterlogging.

Tobacco is demanding of **soils**. It grows well on grey and dark grey podzolised soils, and in Crimea on limestone-skeletal and red-brown soils. Deep and humus-rich alluvial black soils are unsuitable for tobacco. Excessive nitrogen content in the soil worsens the technological qualities of tobacco. Plants respond well to the content of phosphorus and potassium in the soil. With a yield of 3 t/ha, nitrogen-50, phosphorus-15 and potassium-97 kg are removed from the soil. Soils with a high content of readily soluble salts, especially chlorine-containing salts, are not suitable for tobacco cultivation.

The formation of the crop and its quality indicators depend on the humus content of the soil. High-quality tobacco raw materials are produced on soils with a humus content of no more than 2 per cent, except for cigar tobacco. Tobacco is a very plastic plant. The growth and development, chemical composition, yield and quality of raw materials depend heavily on environmental conditions and cultivation practices.

There are two main groups of tobacco types in global production: **cigarette and cigar**. Cigarette tobacco is divided into two subgroups: Oriental and American. Based on the type of raw material, cigarette tobaccos are divided into skeletal and aromatic tobaccos, or blends that give cigarettes their flavour.

Agricultural technology. Tobacco is grown in seedlings, and seedlings are grown in greenhouses, warm greenhouses, cold ridges and greenhouses.

Good crop **rotations** for tobacco include winter seed crops, annual grasses, beetroot, silage corn and legumes. It is not grown after tomatoes, potatoes, cucumbers, onions, cabbage, sunflowers, and hemp, as they share many diseases and parasitic weeds. On the Caucasian and Crimean coasts of the Black Sea, tobacco accounts for more than 40 per cent of the sown area. Under these conditions, it should be grown with intermediate plants that enrich the soil with organic matter, prevent soil leaching and act as phytosanitary agents to prevent tobacco diseases.

Soil cultivation. Tobacco responds well to deeper ploughing and requires careful tillage. The main soil tillage consists of stubble peeling and deep ploughing (25-30 cm). On soils with a shallow humus layer, ploughing is carried out to full depth with ploughs with soil deepeners.

In the mountainous regions of Crimea, where there is little rainfall and the soil is coarse-skeletal, plantation ploughing is periodically used (every 4-5 years) to a depth of 50-60 cm. In the mountainous areas on the Black Sea coast, where there is a lot of rainfall and soil erosion is common, deep autumn ploughing, sowing of intermediate plants and shallow (15 cm) ploughing in spring are effective. Very compacted soils are loosened with chisel cultivators to a depth of 16-18 cm or with ploughshares. Pre-

sowing cultivation is carried out 3-4 days before planting to a depth of 8-10 cm.

Fertilisation. Tobacco is an extremely plastic plant and is highly responsive to fertilisation. The highest growth rates are obtained by applying organic and mineral fertilisers. Manure for tobacco is 18-20 tonnes per hectare. After cereal plants, about 45 kg/ha of nitrogen fertiliser is applied to tobacco, and after perennial grasses, no more than 20 kg/ha of active ingredient. For aromatic varieties such as Dubec, Samsun and American, nitrogen fertiliser rates should not exceed 20 kg/ha.

Tobacco plantations use fertilisers: the first one after planting the seedlings ($N_{10} P_{20}$), the second one before buds appear ($N_{10} P_{30}$). Chlorine-containing potash fertilisers should not be applied to tobacco, as they worsen the quality of the raw material.

Tobacco planting. High yields of tobacco are ensured by early planting, especially in Crimea, where the spring is a dry period. Seedlings are planted at a soil temperature of at least 10° C. Tobacco is planted using six-row seedling planters or four-row seedling planters at a seedling height of 12-14 cm. Optimal planting density ensures high yields and good quality of raw materials.

Tobacco care consists of loosening the soil between rows, topping and pinching plants, and controlling weeds, diseases and pests. In 6-7 days after planting, the row spacing is loosened to a depth of 6-8 cm, the second and third times - by 10-12 cm every 12-18 days. Simultaneously with the first inter-row cultivation, the lower leaves are cleaned. Yellowed and old leaves are broken off and destroyed. The second cleaning is carried out 12 days after the first. To grow a high quality tobacco crop, the plants are topped (flowers are picked and pinched) and side branches are removed. On low-fertility soils, topping begins when 10-20 per cent of the plants are in bloom - flowers and 2-4 top leaves are picked; on medium-fertility soils, tobacco is topped when 30-40 per cent of the plants are in bloom. On fertile soils, topping is carried out when 50-60 per cent of the plants are in bloom, with flowers and 1-2 leaves cut off. After topping, lateral shoots grow vigorously, and when they reach a length of 8-10 cm, they are removed. Recently, chemical topping has been carried out, for which recommended preparations are used. Under irrigation conditions, vegetative irrigation is important. It is carried out with an irrigation rate of 300-400 to 600-³ 800 m of water per hectare. To control annual cereal and dicotyledonous weeds, the soil is treated with soil herbicides before planting seedlings. Plants are treated three times against thrips: the first time 10 days after planting and every subsequent decade. Tobacco is protected from damage by wireworms and sawflies. Measures are taken to prevent damage by downy mildew. Tobacco is treated with sprayers, and after the rows are closed, with helicopters.

Harvesting and post-harvest processing of tobacco. Tobacco is harvested when the leaves are fully ripe, gradually ripening from the bottom up. A sign of their technical ripeness is the whitening of the main vein and light colour. The edges of the leaves turn yellow, the leaves are brittle, easily separated from the stem and slightly bent downwards.

Leaves from each tier are harvested separately, and the quality of the leaves from the upper and middle tiers is higher than the lower ones.

Break the tobacco leaves in the morning or in the evening. Those harvested in

the evening contain less moisture and more starch and sugars. The leaves are bundled, transported to warehouses, sorted and immediately strung on cords 5-6 m long at a distance of 2-3 cm from each other. Today, the stringing of leaves is mechanised.

Post-harvest tobacco processing involves drying, moistening, sorting and packaging of raw materials.

The dried tobacco is stored in piles on a dry wooden floor, then sorted in special rooms on sorting lines and semi-automatic presses, packed and shipped to procurement centres. After final processing at the fermentation plants, the tobacco is delivered to the factories.

Varieties. American 26, Aromatic 1, American 14, Galician original, Early ripening, C-9, Ternopil 14.

3.6 Terry (*Nicotiana rustica* L) Solanaceae family



Importance. Mahorka is less widespread in Ukraine than tobacco. It is grown to produce smoking (mahorka) grits, cigarettes, snuff and chewing powder, nicotine preparations, nicotinic (vitamin PP) and citric acids, which are used in the food and textile industries. The seeds contain 35-40 per cent of fatty oil, which is used in the paint and varnish and soap industries. Dry, fermented mahogany leaves contain 5 to 15 per cent nicotine, 15 to 20 per cent organic acids (including 10 per cent citric acid), 10 to 14 per cent protein and 2 to 4 per cent carbohydrates.

History and distribution. Mahorka was introduced to Europe from Florida (USA) in the early 16th century. It began to be grown in Ukraine in the 17th century. Today, commercial cultivation of makhorka in small areas is concentrated in Kyiv, Poltava, Sumy and Chernihiv regions. The average yield of makhorka (stems and leaves) is 15 c/ha, with a potential yield of 30-50 c/ha.

Biological characteristics. Mahorka is a rather thermophilic plant. Its seeds begin to germinate at a temperature of 7-8 °C. The optimum temperature for growth and development is 20-30 °C. At temperatures above 35 °C, the development of makhorka plants is inhibited, and frosts of minus 2-3 °C lead to plant death. Mahorka is a long-day plant that accelerates its development as it moves north, which makes it suitable for growing in different soil and climatic zones. It is highly demanding on **moisture**. Lack of water in the soil causes the leaves to "burn" or die prematurely. At the same time, terry almost does not withstand waterlogging of the soil. The best soils for it are sandy loam and loamy chernozems, dark grey and grey podzolic soils. Mahorka grows well in river valleys with a short period of flooding by spring water.

Agricultural technology. The best places in the crop rotation for makhorka are winter seed crops, annual grasses, legumes, and root crops. Mahorka can grow for 2-3 years in one place, provided that sufficient fertiliser is applied.

After harvesting, the field is tilled in the crop rotation, and when weeds appear, ploughing is carried out with ploughs with skimmers to a depth of 27-30 cm. The best time for autumn ploughing is August - first half of September. Spring tillage is started at the first possible time when the machinery is in the field. Moisture is sealed with cultivators with harrows to a depth of 8-10 cm across the ploughing direction. Pre-sowing tillage is carried out using combined units to the sowing depth. The gap between tillage and sowing should not exceed 0.5-1 hour.

With the seedling method of cultivation, spring tillage includes early harrowing to close moisture and 2-3 cultivations to a depth of 8-10 cm before planting. Organic fertilisers are applied under the makhorka - 35-40 t/ha. On poor soils, the rate of manure application is increased to 50-60 t/ha. Phosphorus (P_{60-90}) and potash (K_{60-90}) fertilisers are applied for ploughing. Chlorine-containing potash fertilisers should not be used because chlorine worsens the flammability of raw materials. Nitrogen fertilisers (N_{20-80}) are applied in spring for cultivation.

There are two ways to grow makhorka: by sowing seeds directly into the soil, and by sapling, or planting seedlings. In Ukraine, both methods are equivalent. Makhorka is sown in early spring, simultaneously with the sowing of early spring plants. The sowing method is **wide-row** with row spacing of 50-60 cm. Sowing **depth** is 0.5-1 cm. The seeding **rate** is 4-5 kg/ha. Seedlings of makhorka are planted in late April - first decade of May. For this purpose, 30-² 40 m of greenhouses or 40-² 50 m of warm beds are required per 1 ha. For² 1 m of greenhouse, 1.5-2 g of seeds are sown, for² 1 m of warm beds, 2-2.5 g. Terry is planted with seedling planters or manually with row spacing of 50-60 cm. The distance between plants in the rows is 25-30 cm. Immediately after sowing, the field is rolled with smooth rollers. As soon as the rows are marked, they are layered to a depth of 3-4 cm. The row spacing is loosened for the second time after 8-10 days and to a depth of 5-6 cm. During this period, the seedlings are also broken through. To facilitate the breakthrough, bouqueting is carried out (the length of the bouquets is 30 cm, the length of the cut

20 cm). During the growing season, row spacings are loosened 3-4 times. In rainy weather, the depth of loosening is increased to 8-10 cm, in dry weather - reduced to 5-6 cm. When grown using the seedling method, care is the same as for tobacco. To protect the plants from damage by scoops, aphids, and thrips, the crops are sprayed with insecticides.

Terry is harvested in one step with whole plants at the stage of technical ripeness of the middle tier leaves, which is characterised by the following features: the leaves become dense and hang down, chlorophyll is partially lost, as evidenced by light spots, the leaf blade becomes very fragile and breaks when slightly bent.

At the time of ripeness, makhorka contains a lot of water - 86-88 per cent. The drying time can be reduced by 10-12 days if the stems are split with a knife 3-4 days before harvest. The cut plants are tied up in the field for several hours and transported to drying rooms, where they are stacked in layers 50-70 cm high and two plants wide (with the leaves in the middle and the stems out). In such layers, the plants warm up quickly and at a temperature of 35-40°C, languishing takes 12-24 hours. After languishing, the plants are hung up to dry. Drying is completed when the moisture content of the raw material is 18-20 per cent. Under normal weather conditions, this

process takes 25-30 days.

Terry varieties: High-growing green 317, Malopasynkovy pechlec 4, Khmelovka 125-s.

3.5. Essential oil crops

Essential oil plants contain volatile aromatic substances - essential oils - in their fruits, seeds, leaves, inflorescences and other organs. In terms of composition and chemical structure, essential oil is a mixture of various organic compounds: vulvovods, alcohols, phenols, aldehydes, ketones and organic acids. Most essential oils are found in plants in a free state. Their content in plants of different species varies widely and depends mainly on the area of cultivation, the phase of development, etc. In dry and warm climates, plants accumulate more essential oil than in cold and humid climates. Most essential oils are found during flowering and ripening. Essential oils are used in a variety of industries, including perfumery, cosmetics, pharmaceuticals, food, soap making, tobacco, canning, etc.

The most common essential oil plants in Ukraine are common coriander, fennel, cultivated anise, caraway seeds, peppermint, clary sage, and lavender. The total area of essential oil plants in Ukraine is about 40 thousand hectares.

3.5.1. Common coriander



Meaning, distribution.

Coriander fruits contain 1.4...2.1% of essential oil, which includes linalool alcohol (60...70%). linalool fractions have the aromas of lily of the valley, rose, linden, violet, lily, etc. After distillation of the essential oil, the fruit retains a fatty oil (18...20%), which is used for wool washing, in the textile industry, and in printing.

Coriander is one of the oldest crops. It is native to the Mediterranean. It was introduced in the early 19th century. It is one of the most important essential oil crops in our country. It is cultivated in the Voronezh, Belgorod, Kursk, Saratov, Samara regions and Krasnodar Territory. The average yield of coriander is 1 tonne of seeds per hectare.

Botanical and biological characteristics. Coriander (*Coriandrum sativum* L.) belongs to the family Apiaceae. It is an annual plant. Coriander fruits are spherical, consisting of two single-seeded fruits. The weight of 1000 fruits is 7...10 g. Ripe fruits crumble easily.

Coriander is a drought-tolerant plant, but due to drought and lack of moisture during the branching-flowering period and in the fruit formation phase, yields are reduced. Seeds begin to germinate at a temperature of 6 °C, seedlings can withstand frosts down to -10 °C; at first, due to slow development, they are strongly suppressed

by weeds. After the formation of 7 ... 9 leaves, the stem begins to grow actively. The growing season lasts 90 ... 100 days. Coriander gives the highest yields on fertile soils.

Varieties. Common varieties are Alekseevsky 1820, Yantar, etc. Features of agricultural technology. The best predecessors of coriander are winter breads, cereal legumes, corn, and potatoes. It is returned to the same field no earlier than in 4...5 years. Winter or spring crops are sown after coriander.

The main soil cultivation is carried out by the type of semi-pair, in the spring, early harrowing and pre-sowing cultivation to a depth of 5 ... 6 cm are carried out. Coriander is sown in early spring in wide rows (45 cm) or by the usual row method with seeding rates of 1.5...1.8 and 2.0...2.5 million germinating seeds per 1 ha, respectively. The sowing depth is 4 ... 5 cm. Caring for coriander crops is reduced to double pre-emergence harrowing and harrowing along the shoots, then 2 ... 3 inter-row tillage is carried out on wide-row crops.

Coriander ripens unevenly, the seeds crumble. Harvesting begins when 30 ... 40% of the fruit is brown. Good results are obtained by timely separate harvesting. Seeds are stored at a moisture content of no more than 12%.

3.5.2. Cultivated anise



Anise (*Pimpinella anisum* L.) belongs to the celery family (Apiaceae). Its fruits contain 1.5...3.5% of essential oil, the main component of which is anethole alcohol (up to 80%). Anise oil is used in medicine, in alcoholic beverages and confectionery production. The seeds also contain fatty oil (16...20%), which is used in soap making for the production of oleic acid. The cake is a concentrated feed. anise is a good honey plant.

Anise is grown in small areas in many countries around the world. Its cultivation is concentrated in the Voronezh, Belgorod and Kursk regions.

Anise is an annual plant. Fruits are flattened-ovoid, small. The weight of 1000 fruits is 3.5 ... 4.0 g. The growing season lasts 120 ... 130 days. The yield is 0.5 ... 1.5 tonnes of seeds per 1 ha.

The most common anise variety is Alvxeevsksh one thousand two hundred and thirty-one. Anise is more demanding on growing conditions than coriander. It needs fertile and weed-free soils.

Anise farming is similar to coriander farming. It is sown in early spring using the usual ordinary row method, or in a wide-row method (45 cm). Sowing rate is 5 million germinating seeds per 1 ha

(With wide-row sowing - 2.5 ... 3.0 million). sowing depth 2 ... 4 cm. In anise crops, it is necessary to carefully weed out not only weeds, but also an admixture of

coriander. Anise ripens unevenly and crumbles easily when standing. Harvesting is started when the fruits of the middle umbels turn yellowish. Anise is harvested in the same way as coriander. During storage, the seed moisture content should not exceed 12%.

3.5.3. Cumin



Importance, distribution.

Caraway (*Carum carvi* L.) is a biennial plant of the Celery family (Apiaceae). In the first year of life, a taproot and a rosette of leaves develop. It bears fruit in the second year of life. The inflorescence is a complex umbel. The fruit is a two-seeded, ribbed fruit. There are 6 tubules in the ribs, which contain fatty oil. The weight of 1000 seeds is 2.3 ...

2.5 g.

Cumin fruits contain 4...7% of essential oil, which includes carvone, used to flavour liqueurs, and limonene, used in perfumery. Cumin seeds contain 14...16% of fatty industrial oil. The seeds are used as a spice in pickles and in baking. Cumin is a good honey plant.

Cumin is undemanding to heat and is a winter-hardy plant. It overwinters in the first year of life in the rosette phase. It does well on fertile soils with sufficient moisture.

Cumin is light-requiring.

Fertilisation and soil cultivation for cumin are the same as for anise. Spring sowing (simultaneously with early cereals) is considered to be the best for caraway seeds, using a wide-row method with row spacing of 45 cm. The seeding rate is 3 ... 4 million germinating seeds per 1 ha, the sowing depth is 2 ... cm. Good results are obtained by pre-sowing air-heat heating, fermentation or stratification.

Caraway crops are cared for by loosening the row spacing to destroy soil crust and weeds. In the first year of life, the plants are lightly hilled in autumn, and in the second year, in early spring, they are harrowed across the rows.

Cumin is harvested when 60% of the fruit is browned by grain harvesters. During storage, the seed moisture content should not exceed 12%.

3.5.4. Fennel

Significance. Fennel fruits are used to extract essential oil (4-6%), which consists of 50-60% anethole. The essential oil and anethole are used in the food, perfumery, cosmetics, pharmaceutical and other industries. Anethole is used to synthesise obepin, an aromatic substance used in perfumery. The fruit also contains

18-20% of fatty oil, which is used for technical purposes. The fennel fruit meal, which contains 18-22% protein, is used as a concentrated feed. Fennel is a honey plant.



'Fennel is considered to be native to the Mediterranean region. Today it is grown in Western Europe, India, Japan and other countries. In Ukraine, it began to be grown in the 1930s. The main fennel plants are concentrated in the Chernivtsi region. The average yield is 5-6 centners per hectare.

Biological characteristics. Fennel (*Foeniculum vulgare* Mill.) belongs to the celery. Fennel seeds begin to germinate at a temperature of 6-8° C, and germination occurs at 20° C. Seedlings can withstand frosts down to minus 8° C. Fennel is a moisture- and light-loving plant. It needs the most moisture from the beginning of stemming to full flowering. Shading and cloudy, cold weather extend the growing season. Dry winds during the flowering period reduce the yield. Fennel grows well and produces high yields on black soil and dark grey podzolic soils. It begins to bear fruit in the first year of life. The growing season lasts 139-147 days. Varieties: Zefir, Crimean, Mertsyshor, Chernivtsi 3.

Features of the cultivation technology. In the crop rotation, fennel is placed after winter and spring cereals, sugar beet, potato plants, annual grasses, etc.

Cultivation of fennel is carried out in the same way as for other essential oil crops of the celery family. Under fennel, it is recommended to apply complete mineral fertiliser in autumn at a dose of N P K₄₀₋₆₀60-8060-80. During sowing, granulated phosphorus superphosphate (10-15 kg/ha P₂ O₅) is applied to the rows.

Fennel is sown simultaneously with early spring cereals in a wide-row method with row spacing of 45-60 cm. The seeding rate is 8-10 kg/ha. They are sown to a depth of 2-3 cm. After sowing, the seeds are rolled with ring rollers.

Crop care includes pre-emergence and post-emergence harrowing and loosening of row spacings. During the phase of the first or second true leaves, bouqueting with beetroot thinners is carried out according to the following scheme: 30 cm cut, 20 cm bouquet.

Fennel is harvested in two stages. Harvesting begins when the fruits are ripe on the first-order umbels. A sign of fruit ripeness is its easy breakdown into two halves. After drying, the swaths are picked up and threshed using converted grain combines. The cleaned and sorted seeds are stored at a moisture content of no more than 12-13 per cent.

3.5.5. Peppermint

Importance, distribution. Peppermint (*Mentha piperita* L.) is a perennial rhizome plant 50 ... 80 cm high in the Lamiaceae family. Mint leaves contain 2.0...3.5% of mint oil, and mint essential oil contains 50...70% of menthol.

It is used in the food industry and medicine. The yield is 1.3...2.0 tonnes of dry mint leaves per hectare. Mint is grown in many countries in Europe, Asia and America. In , it began to be grown at the end of the 19th century, with the most favourable

cultivation areas being the North Caucasus and the Central Black Earth Region. Mint is a moisture-loving plant that is not demanding on heat.



The best soils for mint are lowland sandy loam or light loamy chernozems; it grows well on cultivated peat bogs. Mint can be grown in one place for 2...3 years. The following varieties are common: Kubanskaya 6, Moskvichka. The highest yields are obtained with sufficient supply of all mineral nutrients and the application of manure or compost (30 ... 50 t/ha).

Rhizomes, seedlings and creeping shoots are used as planting material. It is best to plant rhizomes and their segments with 3 ... 4 nodes. Mint is usually planted in early spring with row spacing of 70 cm, laying the rhizomes with a continuous tape in moist soil to a depth of 7 ... 8 cm and immediately closing the grooves. For 1 hectare, 500 ... 600 kg of rhizomes are required. Special planting machines are also used. Mint care includes 4 ... 5 inter-row cultivations with weeding in the rows. On insufficiently fertile soils, nitrogen fertilisation is carried out.

In the first year, the best time to harvest mint is when it is in full bloom, and in the second or third year - in the budding phase. Mint is mowed with haymakers or reapers with lifters. The mowed mass is left for 1...2 days in rolls for drying (humidity of at least 30%), then it is picked up and sent to the plant for processing.

When irrigated, mint can produce two mowings per year. If the mint is left in the second and third years after harvesting, row spacing is cultivated to a depth of 6 ... 8 cm. In autumn, the plantation is mulched with manure (20 ... 30 t/ha), in winter, snow retention is carried out, and in spring it is harrowed. In the spring, after emergence, the row spacing is thinned out with cultivators, leaving intact strips of mint 15 ... 20 cm wide. Subsequently, re-cultivation and weeding in the rows is carried out. On thinned crops, mint is planted with segments of rhizomes or rooted shoots.

3.5.6. Nutmeg sage

Importance, distribution. Musk sage (*Salvia sclaria* L.) is a perennial herbaceous plant of the Lamiaceae family.



The essential oil contained in its inflorescences (0.35%) is used in perfumery, food industry and winemaking. Sage is grown in the Krasnodar Territory. The yield is 0.3...0.4 tonnes of inflorescences per 1 ha. The inflorescence is paniculate-branched, located at the end of the branches. Fruits are dry, consisting of four nuts containing drying fatty oil.

Sage is moderately demanding on heat and moisture. its seeds begin to germinate at a temperature of Yu ... 12 ° C, seedlings tolerate

frosts down to -6 °C. Adult plants tolerate winter well.

In the first year of life, sage forms basal leaves, in the second year it develops densely leafy stems, inflorescences and fruits.

A common variety of sage is Voznesensky 24. Sage is a perennial plant, grown on separate non-cultivated plots for 2...3 years. It is planted after winter cereals and early maturing spring cereals. Manure is applied under the sage. Sage is sown in spring or before winter. Winter sowing is carried out in such a way that the seeds do not have time to germinate before the onset of cold weather. Sowing methods are wide-row (45 cm) and ordinary row (15 cm). The seeding rate for wide-row sowing is 2 million seeds, and for ordinary row sowing - 3...4 million germinating seeds per 1 ha. The weight of 1000 seeds is 3 ... 4 g. The sowing depth on loose soils is 4 ... 5 cm, on cohesive soils - 2 ... 3 cm. Sage crop care consists of harrowing along the seedlings and inter-row treatments.

Harvesting begins when the content of essential oil in the inflorescences is at least 0.12%. For this purpose, inflorescence samples are analysed daily from the beginning of flowering. The best harvesting dates usually occur at the beginning of the browning of seeds in the lower fruits of the inflorescences.

3.5.7 Real lavender

Importance, distribution. Lavender is grown for the production of essential oil contained in flowering inflorescences (1.2-2.3%). The main components of the essential oil are linalyl acetate (50-55%), linalool (10-12%), as well as geraniol, nerol, camphor (10%), etc. The oil is widely used in the food industry, in perfumery and cosmetics production, as a spice, in the manufacture of liqueurs and wines, as an antiseptic and cardiac agent.

Lavender is grown in Asia Minor, North Africa, and the Middle East. In Europe, it has been cultivated since the end of the sixteenth century. In the Crimea, where the main areas of lavender cultivation are concentrated, it began to be grown in 1929.

Biological features. True lavender (*Lavandula vera* DC.) belongs to the Labiate family. It is a perennial evergreen shrub up to 100 cm tall. Lavender is a subtropical plant that has been adapted to harsh climatic conditions since its introduction. Adult plants can withstand frosts down to minus 25° C and below, and seedlings in the phase of 4-5 pairs of leaves can easily withstand frosts down to minus 8 ° C. The optimum temperature for seed germination is 15-20° C. Warm weather is preferred during the growing season, and hot weather during flowering. Lavender is a light-loving plant that does not tolerate shade. The accumulation of essential oil in the inflorescences depends on the intensity of the light.

Lavender is undemanding to the soil and grows well on poor sandy loam and carbonate soils. Heavy, cold soils with high acidity and a high water table are unsuitable for lavender. Lavender is a cross-pollinated plant. The main method of its reproduction is vegetative.

Recommended varieties: Isis, Rannaya, Record, Sineva, Stepnaya.

Features of the cultivation technology. Lavender is planted in specially prepared areas that ensure normal growth and development of plants. The plantations

are used for 15-20 years. The best predecessors are perennial grasses, legumes, winter cereals and silage crops.

The gurnt is prepared as a steam. 'During the preparation of the soil, special attention is paid to clearing the field of weeds and weeds. 'After harvesting the predecessor, the field is peeled by 6-8 cm with disc harrows, after 15-20 days the field is peeled again with ploughshare peelers to a depth of 10-12 cm and, in case of excessive weeds, the herbicide 2,4D (amine salt) is applied. Plantation ploughing is carried out to a depth of 45-50 cm. After the plantation ploughing, the field is levelled and left in this state for the winter, and during the spring and summer of the following year, the soil is cultivated as a black fallow. During this time, 3-4 continuous cultivations are carried out, and a month before planting, the field is ploughed by 25-30 cm.

Lavender responds positively to fertilisation with mineral fertilisers. For plantation ploughing, 30-35 t/ha of manure is applied together with mineral fertilisers ($N_{80-100} P_{80-100}$). The following year, in autumn, a full mineral fertiliser is applied at a dose of $N_{80-90} P_{80-90} K_{80-90}$. When planting lavender, superphosphate is added with irrigation water (P_{10}). Fertilisation of lavender plantations with mineral fertilisers begins in the second year of life with the start of commercial harvesting of inflorescences. It is better to fertilise with nitrogen mineral fertilisers in spring, and with phosphorus-potassium fertilisers in autumn.

Planting material is harvested in autumn from well-developed, mature shoots. Cuttings 8-10 cm long are cut from annual shoots and planted in greenhouses to produce rooted seedlings. Seedlings are planted in a permanent place in October with a lavender planting machine or manually according to the 1.2 x 5 m scheme. During planting, the root collar is buried 5-6 cm below the surface of the soil.

Care for young plantations includes controlling weeds, loosening the soil between rows and replanting seedlings to replace dead plants. 'Herbicides such as 2,4D (3-4 kg/ha) and Lontrel (1-1.7 kg/ha) are used against weeds in the spring at the beginning of lavender growth. On fruiting plantations, 2-3 inter-row loosening is carried out and fertilised with mineral fertilisers. After 6-7 years of use, lavender bushes age and require rejuvenation. To do this, in early spring, before the sap flow begins, the entire aerial part is cut off at a height of 5-6 cm with a lavender rejuvenator POL-1. During rejuvenation, the plantations are fertilised with mineral fertilisers at a dose of $N_{45-60} P_{45-60}$. Agronomic and chemical measures are used against lavender pests (gamma scoop, nematode head, meadow butterfly) and diseases (root rot).

Lavender is harvested during the period of mass flowering in a short time (10-12 days). The lavender inflorescences are cut with the LUM-2 lavender harvester. The cut inflorescences are immediately processed.

3.6. Medicinal plants

The cultivation of medicinal plants as an independent branch of crop production began to develop in Ukraine in the 1930s. Until that time, the pharmaceutical industry's needs for raw materials were met mainly through the harvesting of wild medicinal plants. However, the absence of a well-founded system of plant seed use, ignorance and denial of the peculiarities of the functioning of natural phytocoenoses, of which

useful medicinal plants are an integral part, led to significant depletion and even destruction of the natural environment.

'In this regard, there is an urgent need to preserve a significant number of plant species by including them in agrophytocoenoses, i.e., the transition to the cultivation of cultivated medicinal plants. Today, their number has increased. First of all, belladonna officinalis, valerian officinalis, bluestem, dope, echinacea purpurea, marigold, chamomile dalmatica, etc. are of great importance.

It should be noted that the soil and climatic conditions of the forest-steppe and steppe regions of Ukraine are suitable for growing not only well-known plants of the local flora, but also plants from other continents. To do this, it is necessary to know their biological characteristics of growth and development and to develop a technology for their cultivation.

3.6.1. Belladonna officinalis



Application. All plant organs contain alkaloids (atropine, hyoscyamine, scopolamine). The roots and leaves are used for the preparation of medicines. Preparations from belladonna: tinctures, dry and liquid extracts, decoctions. Complex preparations of analgesic and anti-spasmodic action are also produced.

Botanical characteristics and biological features. Belladonna (*Atropa belladonna* L.) is a perennial, highly poisonous herb of the Solanaceae family. In the first year of development, it forms an erect stem up to

1 m, the second - 1.5 m, which is divided into three branched branches. The alternate leaves are large, green. The root is thick, branched, penetrates

the soil to a depth of 2 m. The flowers are brownish-purple or yellow. The fruit is a two-nested multi-seeded capsule. The seed is dark brown. The weight of 1000 pieces is about 1 g. Blooms from June until the end of the growing season. The growing season lasts 127-156 days.

Belladonna is a heat-loving plant. In areas with warm winters, it overwinters and can be grown for 3-5 years with good care. It is propagated by seeds. The optimum temperature during the growing season is 20-25° C. It freezes without snow cover at minus 15° C. The plant is picky about the fertility of the soil. The best soils are light and medium in texture with a neutral reaction of the soil solution. In the first year of life, belladonna grows slowly and has little fruiting. The recommended variety for growing belladonna is Krasavka.

Features of the cultivation technology. Belladonna is grown after winter and row crops, and should not be placed after solanaceous crops (potato and tomato plants). Fodder crops should not be grown after belladonna, as some plants can grow back, get into the feed and cause poisoning of animals. Cultivation of the soil for belladonna is carried out by the type of semi-pair (stubble peeling, autumn ploughing to a depth of

25-27 cm, 2-3 cultivations). Manure (30-50 t/ha) or complete mineral fertiliser ($N_{45-60} P_{45-60} K_{45-60}$) is applied for ploughing. Vegetation fertilisation with mineral fertilisers is also carried out.

Belladonna is sown in autumn (before winter) or early spring. Two months before spring sowing, the seeds are stratified or germinated in a warm room. The seeding rate is 5-6 kg/ha, and the sowing method is wide-row (60-70 cm). Sowing depth is 1 cm for autumn sowing and 2-3 cm for spring sowing.

Crop care includes 3-4 inter-row loosening, weeding, and vegetative fertilisation (during the regrowth period and after the first harvest) with nitrogen mineral fertilisers. Pesticides are used to control the Colorado potato beetle and flea beetle.

Harvest belladonna when the bulk of the plants are in bloom. The plants are mown at a height of 5 cm from the surface of the boll. The mown mass is dried in dryers at a temperature of 60-80° C or under sheds in sunny, warm weather. Dried raw materials should have a moisture content of no more than 14 per cent. Store before processing on shelves, in bags in a dry, well-ventilated room.

3.6.2. Black pallor



Application. The leaves of the bellflower have long been used in folk medicine. For pharmacological purposes, the leaves containing various alkaloids (atropine, hyoscyamine, scopolamine, etc.) are used. In small doses, bellflower alkaloids act as a sedative and analgesic, in large doses they cause severe agitation, hallucinations, and possible poisoning. Belsenia preparations are included in astmatol and astmatine, and alkaloids are components of some complex preparations.

Botanical characteristics and biological features.

'Black cowpea' is a biennial herbaceous plant of the Solanaceae family. The Latin name is *Hyoscyamus niger* L. The root system is taproot. The stem is straight, 1-1.2 m high. Leaves are large, alternate. Flowers are large, dirty yellow. The fruit is a multi-seeded capsule. The seed is very small, round, brownish-grey in colour. The weight of 1000 seeds is 0.5-1 g. The plant is sticky, with an unpleasant smell, and poisonous. It blooms in June - July, the seeds ripen in August - September.

In the first year of its life, the whitewash forms a rosette of basal leaves, in the second year it flowers and bears fruit. It is propagated by seeds. Seeds germinate at a temperature of 3-4° C. The optimum temperature for plant growth is 20-30° C. Blekta is a light-loving plant, characterised by increased winter hardiness. It needs moisture the most during the first growing season. Most alkaloids accumulate during flowering. Good yields of bellflower leaves are obtained on fertile, structural soils. The best reaction of the soil solution is slightly acidic or neutral.

Features of the cultivation technology. The best predecessors are black fallow or winter cereals. The main cultivation of the crop is stubble peeling and autumn ploughing to a depth of 25-27 cm. When sowing whites before winter, ploughing

should be carried out no later than 25-30 days before sowing the seeds. In the spring, the field is harrowed, levelled and pre-sowing cultivation is carried out by 5-6 cm.

On medium-fertility soils, 30-40 t/ha of manure or only mineral fertilisers are applied for autumn ploughing ($N_{60-90} P_{60-90} K_{60-90}$). Crops in the first year of life are fertilised one and a half months before harvesting with nitrogen mineral fertilisers (N_{30-40}), and in the second year - in early spring with mineral mineral fertilisers at a dose of $N_{30} P_{45} K_{30}$.

Sow the white in autumn and early spring. When sowing in autumn, dry seeds are used. For spring sowing, the seeds are scarified. The sowing method is wide-row with row spacing of 60-70 cm. The seeding rate is 8-10 kg/ha, and the seeding depth is up to 2 cm.

In the first year of life, 3-4 inter-row loosening, 1-2 weeding and fertilisation are carried out on the plantations of white cabbage. In the second year, early sowing harrowing and, if necessary, weeding are carried out.

On crops of the first year of life, the leaves of the whitewort are harvested in late summer or early autumn, when further growth of the leaf blades stops. Plants in the second year of life are usually used for seed. The collected leaves are dried under sheds or in special dryers at a temperature of 50-60° C. Store at a humidity of 16-18 per cent.

3.6.3. Valerian officinalis



Application. In medicine, rhizomes and roots containing 0.5-2% essential oil, alcohols, esters, alkaloids, glycosides, tannins, sugars, organic acids are used. Valerian preparations have a calming effect on the nervous system, in case of neuroses, insomnia, etc. It is widely used for heart diseases.

Botanical characteristics of the seed, biological features. 'Valerian officinalis L. is a perennial herb of the Valerianaceae family. It has a short rhizome (2-4 cm) with numerous cord-like fibrous roots. The stem is erect, hollow. Leaves are opposite, unpaired-pinnate. Flowers are small, pale pink, fragrant, collected in apical inflorescences. The fruit is a small seven' yankee with a pinnate tuft. The weight

of 1000 seven' yankees is 0.4-0.6 g.

As a perennial, Valerian officinalis forms a basal rosette of leaves in the first year of life. Flowering and fruiting occurs only in the second year. It is characterised by high ecological plasticity, which makes it possible to grow in a large part of Ukraine. Valerian grows and develops well at a temperature of 20-25° C. Seeds germinate at a temperature of 5° C, seedlings can withstand frosts down to minus 5-6° C. The plant is quite cold and frost-resistant, drought-resistant. The best soils are chernozems of light texture, and in Polissya - sod-podzolic light fertile loams.

The following varieties of valerian officinalis are included in the register and recommended: Cordiola, Levada, Ukraine.

Features of the cultivation technology. Valerian officinalis is grown in a crop rotation after winter wheat, and in a special crop rotation after plantain.

The cultivation of the gurnt includes peeling with disc peelers and deep ploughing (27-30 cm) for better root growth. Valerian is sown in spring, summer and autumn. The pre-sowing preparation of the soil for spring sowing consists of early sowing harrowing and pre-sowing cultivation to a depth of 5-6 cm with simultaneous harrowing and rolling. For summer sowing, the last cultivation is carried out 10-12 days before sowing, and harrowing is carried out before sowing. For winter sowing, the field is cultivated 1-2 times to a depth of 5-7 cm, harrowed, levelled and rolled.

For autumn ploughing, 30-40 t/ha of manure and mineral fertilisers are applied at a dose of $N_{45} P_{60} K_{45}$. In areas of sufficient moisture, in the second year of life, in spring, the plantation is fertilised with nitrogen-potassium mineral fertilisers ($N_{30-45} K$)₃₀₋₄₅.

Sowing is carried out in early spring or in the second half of July, so that plants with 3-5 leaves are formed before the onset of autumn frosts. Before winter, sow in October - early November so that the seeds do not germinate in autumn. The sowing method is wide-row with row spacing of 45 cm. The seeding rate is 8-10 kg/ha, and the seeding depth is 1-2 cm.

For spring and summer crops of the first year of life, loosen the row spacing and weed in the rows. To prevent damage to valerian by the wireworm, the seeds are treated with TMTD (0.2-0.3 kg/ha) before sowing. In case of massive aphid infestation, the plants are treated with appropriate insecticides. In the second year of life, in the spring, with the massive renewal of vegetation, valerian plants are fertilised and the stems are topped. To do this, the aerial part is cut and removed at a height of 10-15 cm.

Harvest the rhizomes with roots in autumn or early spring before the start of vegetation on second-year plantations. First, the aboveground mass is mowed and removed from the field. Valerian harvester VK-3 is used to harvest the roots. The excavated roots are cleaned from the ground, washed, dried for 1-2 days and dried in special dryers at a temperature of 35-40° C to a moisture content of no more than 15 per cent. The dried roots should be brown on the outside, whitish on the inside, have a valerian smell, spicy, sweetish bitter taste.

Seeds are harvested from plantations in the third year of life, when the plants turn yellow-green. The flower stalks are cut off by hand, dried and threshed with grain combines.

3.6.4. Chamomile officinalis



The essential oil extracted from the flower baskets of chamomile contains hamuzulene, terpene, capric and isovaleric acids. Chamomile products have a positive effect on the nervous system, have antiseptic and anti-inflammatory effects, and have no side effects. Chamomile flowers are also used to produce a highly contact poison, pyrethrin, which is used to control plant and animal pests.

Botanical characteristics of the crop, biological features. 'Chamomile (*Matricaria recutita* L.) is an annual herb of the Asteraceae family. The root is taproot, the stem is erect, 20-60 cm high, the inflorescence is a basket with reed and

tubular flowers. The fruit is an elongated semi' yankee. The weight of 100 sim' yankees is 0.026-0.058 g. Distributed in southern Ukraine, especially in the Kherson region.

It is a temperate plant. Chamomile is undemanding to the soil. It can be grown on different types of soil. Only heavy waterlogged and saline soils are unsuitable for it. The optimal reaction of the soil solution is pH 7.3-8.1. At high humidity during the flowering period, the plants lie down, the number of flowers and their oil content decrease. Seeds germinate at a temperature of 2-4° C. The optimum temperature during the growing season is 19-21° C. For the seed to swell and germinate, 450-470 per cent of its weight in water is required. Therefore, friendly seedlings can be obtained only if the seeds are sufficiently moist in the first 5-7 days after sowing. Chamomile is a light-loving plant. The growing season lasts 70-90 days.

Among the varieties grown, the most common are: Azulena, Kupava, Pearl of the Forest-Steppe.

Features of the cultivation technology. The best predecessors for chamomile are fallow, winter cereals after fallow, fertilised row crops, and oats sown for hay and green fodder. To control carrion after chamomile, spring cereals are grown and sown for green fodder. The main cultivation of the soil is stubble peeling to a depth of 8-10 cm and autumn ploughing to a depth of 22-25 cm. In case of spring sowing in a zone of insufficient moisture, the ploughed field is cultivated 2-3 times in autumn, levelled, and rolled in early spring, after the moisture has been closed with heavy harrows. 'If the field is heavily weeded, then pre-sowing cultivation, looping and rolling are carried out. For autumn ploughing, 10-15 t/ha of manure and mineral fertilisers are applied (N₃₀ P₃₀ K₃₀). In the rosette phase, chamomile is fertilised with nitrogen mineral fertilisers (N₃₀). Granulated superphosphate (P₈₋₁₀) is added to the rows during sowing.

Chamomile is sown in early spring, summer and before winter. Summer sowing (mid-August) is considered the best. Sowing before winter is carried out 7-10 days before a steady cold snap. In spring, chamomile is sown simultaneously with early spring cereals. The seeding rate is 3 kg/ha, row spacing is 45 cm, and the seeding depth is 1-1.5 cm. During the care period, inter-row loosening, weeding, and fertilising are carried out. Summer plants are harrowed in early spring. In the rosette phase, plants are treated with herbicides (2.4D, 1.5 kg/ha).

Chamomile is harvested 3-5 times during the growing season. Harvesting begins at the beginning of flowering. Special scoops-combs are used for harvesting the seeds. The harvested inflorescences are dried under sheds or in special dryers at a temperature not exceeding 45° C.



3.6.5. *Calendula officinalis*

Application. The flowering baskets containing about 3% of carotenoids, 3.5% of resins, up to 4% of mucilage, up to 7% of organic acids and 0.2% of essential oil are used as seeds. Marigold preparations are characterised by anti-inflammatory and bactericidal effects. Infusions and decoctions are used for gargling in

case of sore throat and oral cavity in case of stomatitis. They are also used for gastric and duodenal ulcers, gastritis, liver diseases, etc.

Botanical characteristics of the crop, biological features. 'Calendula officinalis L. is an annual herbaceous plant of the Asteraceae family. The root is taproot. The stem is erect, pubescent, up to 50 cm high. Leaves are alternate, sessile, obovate. Flowers are collected in inflorescences-baskets, orange or yellow in colour. The fruit is a curved seed' yankee. The weight of 1000 pieces is 8-12 g. Blooms from June to late autumn.

Seeds begin to germinate at a temperature of 2-4° C. The optimum temperature for growth and development is 20-25° C. Marigold is a moisture-loving plant. Seedlings from' appear 6-12 days after sowing, and begin to flower in 40-50 days. Systematic harvesting of flowering baskets stimulates abundant flowering. Grows well in lighted areas with moisture.

Features of the cultivation technology. The best predecessors are winter and row crops. Gurnet is cultivated by the half-steam method. To ensure long flowering of marigolds, gunt is fertilised primarily with nitrogen and phosphorus mineral fertilisers. For ploughing, 30-40 t/ha of manure or organic-mineral fertilisers are applied: 20 tonnes of manure, 4 tonnes of superphosphate and 1 tonne of ammonium nitrate. During sowing, 30-40 kg/ha of granulated superphosphate is added to the rows. Marigolds are sown in early spring using a wide-row method (45-60 cm). The seeding rate is 10-12 kg/ha, and the seeding depth is 3-4 cm. The optimal plant density is 12-15 plants per 1 m of row. Crop care includes 2-3 inter-row loosening. 'To control weeds, use the herbicide Treflan (3-4 kg) in pre-sowing cultivation.

Marigold inflorescences are harvested from the beginning of flowering. They are harvested by hand in the opening phase of at least half of the lingual flowers. The baskets are harvested 10-12 times per season. The collected raw materials are dried in the shade under sheds or in dryers at a temperature of 40-50° C. The humidity of the dried raw materials should not exceed 14 per cent.

3.6.6. *Melissa officinalis*



Application. Lemon balm is grown as a medicinal, essential oil and honey plant. Lemon balm leaves contain 0.30-0.35% essential oil, 0.45% ascorbic acid, about 5% tannins, mucilage, resins, etc. The essential oil is widely used in medicine and perfumery. The oil has sedative and bactericidal properties. In folk medicine, lemon balm is used to treat heart and colds.

Botanical characteristics of the crop, biological features. 'Lemon balm (*Melissa officinalis* L.) is a perennial herb of the Lamiaceae family. It has a branched rhizome that penetrates the soil to a depth of 30 cm and a dense network of lateral roots. The stem is erect, up to 80-100 cm high. Leaves are petiolate, ovate, toothed-serrate. Flowers with a white, yellow or pink

corolla. The fruit is a chestnut-brown nut. The weight of 1000 pieces is 0.5-0.7 g. The seed germinates at 10-12° C, the optimum temperature for growth and development is 20-25° C. It is a moisture-loving plant that requires a lot of moisture during the growing season. Lemon balm does not tolerate waterlogging. It is a light-loving plant, picky about soil fertility. Lemon balm is propagated by seeds, parts of the bush, cuttings, and rhizome cuttings. When grown from seeds in the first year of life, the plants form only a basal rosette of leaves.

Features of the cultivation technology. The best predecessors for lemon balm are fertilised winter crops, legumes, and tilled crops. For autumn ploughing, 20-30 t/ha of rotted manure is applied, and in spring for cultivation - mineral fertilisers at a dose of N₃₀₋₄₅ P₆₀₋₉₀ K₄₅₋₆₀. In spring, the seeds are sown in a well-warmed soil in a wide-row method with a row spacing of 60 cm. The seeding rate is 6-8 kg/ha, the seeding depth is 0.5-1 cm, followed by mulching with a thin layer of humus or peat. Seedlings are planted according to the 60x15-25 cm scheme. With the vegetative method of propagation, the grass is mowed in the year of planting, and when sown with seeds - in the second year of life. When caring for lemon balm, the aisles are loosened, fertilised and watered. Feeding is carried out in early spring and after the first mowing. Apply N₃₀₋₄₅ K₃₀₋₄₅. During the growing season, the plantation is watered 3-4 times.

Lemon balm is harvested before flowering, which ensures a relatively higher yield of essential oil. The mown mass is processed or, if necessary, dried at a temperature not exceeding 35° C. During the growing season, lemon balm is mown three times (in July, August, and October). The lemon balm plantation is used for 5-6 years. Seeds are harvested from seed plots.

3.7 Spinning crops

Yarn crops are grown for fibre, which is used to produce various household and technical fabrics. 'The world's agriculture grows spunbonded fibre crops, which are divided into two groups. The first group includes cotton, whose fibre is formed in the seeds, and the second group includes long-staple flax, hemp, kenaf, rope, and jute, whose fibre is formed in the stem in the form of bast.

The seeds of spikenard crops contain oil, which is used for food and for various technical purposes. The oilseed production waste - oilcake and meal - is a valuable concentrated feed for animals. Ukraine grows flax and hemp.

3.7.1. Long-staple flax

Importance. Flax is one of the best spinning crops. It is cultivated mainly for its natural fibre and seeds, which are used to extract oil. The stem of a long-stemmed flax contains 18...33% fibre (oil flax contains almost half as much). Linseed fibre has high technological properties and is one of the main raw materials in the textile industry. It is 2 times stronger than cotton fibre, 3 times stronger than wool fibre and slightly inferior to silk yarn. Flax products are diverse. flax products are beautiful, durable, lightweight, elastic and hygienic. On average, 1 kg of flax fibre produces 10 m² of batiste, 2.4 m² of linen or 1.6 m² of tarpaulin. The country's textile industry produces a wide range of household and technical goods from flax: towels, underwear, clothing, blankets, tarpaulins, belts, sailcloth, sacking, packaging materials, twine, threads, ropes, etc. Technical fabrics resist rotting well and wear out slowly.

For the manufacture of fine fabrics, dress and shirt material, long hewn fibre is used, which can be obtained from flax straw or triste. Linseed straw is divided into 13 grades depending on its quality (5.00, 4.50, 4.00, 3.50, 3.00, 2.50, 2.00, 1.75, 1.50, 1.25, 1.00, 0.75, 0.50), and tress into 11 grades (4.00, 3.50, 3.00, 2.50, 2.00, 1.75, 1.50, 1.25, 1.00, 0.75, 0.50). Flax fibre is in great demand both in Ukraine and abroad. The rational rate of consumption of household linen fabrics per capita per year is 4.2 m². linen fibre is one of the best components when used in combination with chemical fibre.

The short fibre of oilseed flax is significantly inferior in quality to the fibre obtained from the primary processing of long-staple flax, but it is quite suitable for the manufacture of tow, non-fabric materials such as twine, rope, etc. The n Federation is the world's leading producer of flax fibre, but the production of household linen fabrics lags behind the ever-growing demand.

The oil content of flax seeds is 35...39%, that of oilseed flax - 42...44%, and they contain up to 23% protein. The seeds produce oil, which is used mainly for technical purposes. Its ability to dry quickly, forming a strong, thin and elastic film, is used to make high-quality drying oils, as well as varnishes and enamels. Linseed oil ranks first in the world among technical oils in terms of production. It is widely used in the electrical, paper and soap-making industries, as well as in medicine and perfumery. A small amount of linseed oil is used for food. Waste from oilseed production (cake and meal) is a valuable high-protein feed containing 6...12% fat, up to 30% crude protein, 4.3 g of calcium, 8.5 g of phosphorus, and 2 mg of carotene. 1 kg of flaxseed cake contains 1.15 feed units. When flaxseed trusts are processed into fibre, short fibre is obtained, which is used mainly for the production of coarse fabrics (sacking, packaging, bast) and tow. Bonfire wood (stem wood) contains up to 64% cellulose and is used as a raw material for the production of pressed building boards, technical cardboard, ethyl alcohol, acetone and other materials. Flaxseed is one of the medicinal plants used in pharmaceutical practice to produce medicines. Flax is a labour-intensive crop. The flax harvest contains 70...75% flax straw (with high yields of about 80%), 10...15% seeds (up to 30% in seed crops) and 10...15% chaff. The average yield of the flax straw harvest is 70%.

In prehistoric times, primitive man used wild flax for fibre and oil. flax thickets were discovered by academician N.I. Vavilov in northern Spain. Flax was known in India, China, Egypt and the Transcaucasus 4...5 thousand years before Christ. The art of cultivating this crop and producing the finest linen fabrics in Egypt was lost over time.

Since time immemorial, long-flax has also appeared in . In the third to fifth centuries flax was cultivated in what is now the Yaroslavl and Kostroma regions, in the sixth to tenth centuries in the Pryladozhye and the Nenets region, and by the tenth century linen fabrics, yarn, fibre and oil were produced not only to meet their own needs but also for sale abroad. In the XII...XV centuries, this culture was most widespread in the Pskov and Novgorod lands. The Pskov region is called the cradle of flax growing in . The first rope factory was built in the 16th century. In 1711, Peter the Great issued a decree to expand flax cultivation. At the same time, state-owned linen mills were set up to produce wide linen cloths for sails and other needs. By the

end of the 17th century, flax fibre was a leading export commodity. Pskov, Novgorod, and Kashin flax were especially famous. In the early 20th century, our country was the main supplier of flax fibre.

More than 60% of the world's flax area is concentrated in the CIS countries. Poland, Romania, France, the Czech Republic, Slovenia, and the Netherlands also have significant flax areas. The global area under oilseed flax is approximately 1 million hectares. The largest areas are concentrated in Argentina, the USA, Canada and India. In the CIS, oilseed flax occupies 7-10% of the world's area. Long-staple flax is grown in humid and temperate climates, while oilseed flax is grown in drier and warmer regions. The sum of temperatures during the growing season of flaxseed (75...90 days) in flax-growing zones is 1400...2200°, and up to 240 mm of precipitation falls from sowing to harvest. the sown area of flaxseed in the CIS is 0.8 million hectares. Its main crops are located in the Non-Chernozem zone (60%) - Tver, Smolensk, Yaroslavl, Nizhny Novgorod, Vologda, Pskov, Kirov and other regions. More than 65% of the total oilseed flax area is concentrated in the Central Black Earth Region, the Volga region, and Western Siberia.

The average yield of flax fibre is 0.4 t/ha, and the potential yield is 1.6 t/ha or more. Botanical description. The genus *Linum* of the flax family (Linaceae) includes more than 200 species distributed in temperate and subtropical regions of all parts of the world. these are mainly annual, less often perennial herbaceous plants.

The most important crop is common flax (*Linum usitatissimum* L.), which is highly diverse. Academician M. I. Vavilov has done a great deal of work on differentiated botanical, systematic, geographical and phylogenetic studies of cultivated flax. According to the modern classification, common flax is divided into five subspecies, of which the following three subspecies are of the greatest importance: the Mediterranean subspecies - subsp. *mediterraneum* Vav. et Ell. Plants are undersized (up to 50 cm). Flowers, capsules and seeds are large. Weight of 1000 seeds 10 ... 13 g. Cultivated in Mediterranean countries; intermediate subspecies - subsp. *transitorium* Ell. plants of medium height (50 ... 60 cm). Flowers, capsules and seeds are of medium size. Weight of 1000 seeds 5 ... 6 g. Distributed as an oilseed crop in southern Ukraine, Crimea, Transcaucasia and Kazakhstan; Eurasian subspecies - subsp. *eurasicum* Vav. et Ell. plants of different height and branching. Flowers, capsules and seeds are small. Weight of 1000 seeds 3 ... 5 g. The most common subspecies in culture. Cultivated in Europe and Asia. The Eurasian subspecies is divided into four groups of varieties, among which the following are most important. Elongated flax (*elengata*) is an annual plant. The root system is taproot, poorly developed and accounts for 8...10% of the plant's mass, up to 80% of the roots are located in the topsoil, 10...15% - in the layer of 20...40 cm. The productive part of the plant is a thin, straight, light green smooth stem covered with a waxy coating.

The stem has the shape of an elongated cone - widened at the base and narrowed at the top. Its height is 60 ... 120 cm or more. In dense crops, long flax is a tall single-stemmed plant. In its upper part there is a short inflorescence - an umbellate raceme with 2 ... 10 fruits - seed pods. In some crops, 10 seed pods or more are usually formed on a plant.

Leaves are 36...40 mm long, 2...4 mm wide, lanceolate, sessile, arranged alternately in a helical line, green, with a slight waxy bloom, die off during flax ripening. Flax flowers are regular, five-petalled, usually with blue, pink or white petals. Plants with blue petals are more productive. There are five stamens with anthers. Flax is a self-pollinating plant, but it is possible that it is also pollinated by migratory insects, mainly bees.

On clear, hot days, the flower blooms at 5 ... 6 am, by 9 ... 11 am the flower petals fall off. On cloudy days, flowering begins and ends 1 ... 2 hours later. On the whole plantation, flowering lasts an average of 6 ... 10 days.

The fruit of flax is a spherical small box 6.1...8.3 mm long and 5.7...6.8 mm wide. It is five-nested, each nest is divided by an incomplete, usually unpubescent partition into two half-nests containing one seed each.

In production crops, the number of normally developed seeds can be less than 10 (depending on the growing conditions). Ripe capsules remain closed, and only when left to stand on the root do they crack and the seeds fall out. In case of prolonged wet weather and delayed harvesting, they can germinate in the capsules. The seeds are flat, ovoid, with a slightly curved and narrowed nose. Healthy seeds have a brown colour of various shades - from light to dark brown, have a friability, their surface is smooth and glossy. The weight of 1000 seeds is 2.8...6.0 g. Although the colour and size of seeds are hereditary traits, they are affected by growing conditions. Flax, or cattail (*v. brevimulticaulia*), is a low-growing (30 ... 50 cm) plant with a strongly branched stem at the base and

The seeds are larger than those of long-flax. It is cultivated for oil in Central Asia and the Caucasus. Intermediate flax, or intermediate flax (*v. intermedia*), is a medium-sized plant (50...70 cm), 1...2-stemmed. It has more bolls than long flax (11 ... 25). It is cultivated mainly for oil and fibre in the Central Black Earth zone, the Volga region, the North Caucasus, and Kazakhstan. Creeping flax (*v. Prostrata*) is a plant with many stems that creep before flowering. By the time flowering begins, the stems are raised and reach a height of 1 m or more. It is cultivated as a winter crop on small areas in the Transcaucasus. These forms of flax determine the directions in its culture: two-sided for fibre and seed (*dovguntsya*) and seed (*kudryashov*).

Mezheumki occupy an intermediate position, being closer to *Kudryashov*. All flax varieties can be used in breeding work.

Technological properties of flax fibre. Bast fibres are located in the parenchymal tissue of the stem bark in the form of fibrous or bast bundles consisting of a large number of individual cells called elementary fibres. Elementary fibres are elongated cells with pointed ends, 15 ... 40 mm long. The average fibre thickness is 20...30 μm . The fibres are firmly bonded by pectin into a fibrous bundle. The transverse size of the elementary fibres varies from 4 to 30 μm ($\mu\text{m} = 0.001 \text{ mm}$). Each bundle contains 10...50 fibres. Located on the periphery of the stem, they form a ring of varying density consisting of 20...40 bundles, which are also connected by pectin to the surrounding tissues. Short elementary fibres (4 ... 5 mm) are found in all parts of the stem, but their number decreases from the clump to the apical part. The length of the fibres from the coma to the apex increases, in the coma part of the stem it reaches 50...60 μm , in the

middle part - 85...95, in the apical part - PO...130 μm . The shape of the elementary fibres in cross-section is different - from oval to polygonal.

The number of fibres in a bundle and the number of bundles are often highest at about 1/3 of the stem height from the base. The elementary fibres are connected in a bundle so that the ends of the individual fibres are at different heights, which determines the strength of the bundle.

Fibre bundles are connected to each other by elementary fibres passing from one bundle to another. The main characteristics of a good quality fibre are sufficient length, high strength, elasticity, weight, ribbing, tone, and uniformity. The longer the elementary fibre is, the larger the gap (cavity) in it, the more multifaceted it is in cross-section, the more fibres in the bundle, the higher the quality of the fibre. The quality of flax fibre is determined by the number (a complex indicator of fibre quality), which shows the number of skeins of yarn of a certain length (254.5 m) per unit weight of fibre (453.6 g). Along with the main properties of the fibre (strength, flexibility, thickness, colour, etc.), the following are also taken into account: fire content, imperfections, flammability, weight, ribboniness.

The quality of long fibre is determined by GOST. The higher the fibre number, the less fibre is used to make 1m² of fabric.

There is a distinction between the total length of the plant - from the point of attachment of the cotyledon leaves to the bottom of the upper boll - and the technical length - from the point of attachment of the cotyledon leaves to the first lateral branching. The diameter is measured in the middle of the stem. Stalks with a total length of more than 70 cm and a diameter of 1.0...1.5 mm have higher quality fibre.

The anatomical structure of the stem depends not only on the characteristics of the variety, but also on the conditions and methods of cultivation of long flax. Therefore, the combination of economic characteristics of this crop can be used to judge the conditions for growing long flax to a large extent.

Features of biology. Moderate temperatures in spring and summer with interspersed rains and clear weather are favourable for long flax. Flax seeds begin to germinate at a temperature of 5 °C. Flax seedlings can withstand frosts down to -5 °C. The sum of active temperatures for the sowing - germination period is 60 °C, germination - beginning of flowering - 418 ... 440, from flowering to early yellow ripeness - about 410 °C. The most favourable air temperature in the germination phase of flax is 9 ... 12 °C, for further growth and development 16 ... 18 °C. At air temperatures above 22°C in combination with dry weather, plant growth is inhibited, stem branching increases and fibre quality deteriorates. To achieve technical ripeness, the duration of the growing season with a temperature of 10 °C and above should be 75 ... 90 days.

Flaxseed is more demanding on heat than long-flax. The optimum temperature for seed germination is 12°C. The greatest need for heat is experienced by oil flax during flowering - seed ripening (20...22°C). The sum of active temperatures during the growing season is 1600...1800° (for boron flax - 1100...1500° C).

Long flax is quite demanding on soil moisture. Both excess and lack of moisture in the soil during the entire growth period reduces flax yields. For the seeds of long-flax to swell, 160% of water by weight is required, while curly flax and mezheumki

require 140%. Starting from the herringbone phase to flowering, the need for moisture increases, and plant growth and development are normal with productive moisture reserves in the layer of 0...20 cm 30 mm or more. Preservation of moisture in the soil is one of the most important conditions for the formation of a high yield of good quality. it is undesirable to place flax in areas with a close groundwater level. excessive precipitation after flowering and during ripening causes flax lodging and contributes to the development of various fungal diseases. Flax is a long-day plant with moderate requirements for sunlight intensity. strong lighting causes increased branching of the stem, which reduces the yield of long fibre. In conditions of excessive shading, flax lays down and forms rather loose fibre bundles. The elementary fibres have a rounded shape, a large internal cavity and slightly thickened shells with a sharp layering, i.e. flax of reduced quality is obtained. the net productivity of photosynthesis in long flax during the period of rapid growth - budding reaches 10 ... 14 g per 1 m² of leaf area per day. The process of photosynthesis proceeds normally with increased solar radiation at the beginning and in the second half of the growing season and at relatively low light during the period of rapid growth.

The best sunlight regime is created when the leaf area before the budding phase for early-ripening varieties is 35...40 thousand m², for late-ripening varieties - 40...50 thousand m² per 1 ha. In the Non-Chernozem zone of the n Federation, cultivated sod-podzolic medium and light dusty loams with a low degree of podzolisation are considered to be the best for long-flax, with a slightly acidic soil reaction (pH 5.6...6.0). Light soils (sandy loams and sands) are of little use for long flax. It also does poorly on heavy clay and acidic peat soils. On soils of homogeneous fertility, the plant develops its root system more evenly and forms an even stem. The microrelief of the soil is essential. The most favourable is a levelled field with the following indicators: a contour of at least 20 hectares, a humus content in the layer 0 ... 20 cm of about 2%, RNS 0 L 5.6, easily hydrolyzable nitrogen 10 mg, the content of P 2 0 5 15 ... 20 and K 2 0 13 ... 17 mg per 100 g of soil (according to Kirsanov), soil bulk density 1.2 ... 1.3 g / cm³. However, in flax-growing areas, a significant part of the fields has a small contour, low content of phosphorus, potassium, nitrogen in the soil, high acidity and weediness.

The best soils for oil flax are weed-free black soils. Saline soils, heavy clay soils, and marshy areas are not suitable for flax cultivation. Flax is characterised by the following stages of development: germination, herringbone, budding, flowering, and ripening.

Under "favourable conditions, seedlings appear on the 6th...7th day after sowing, the plant has cotyledon leaves with a small bud between them. Field germination is on average 70% of the number of germinating seeds sown. In the herringbone phase, on the 18th-20th day after germination, the plants reach a height of 6-10 cm, having 5-8 pairs of true leaves covered with a waxy coating.

These two phases are characterised by slow growth of the stem in height and intensive development of the root system. then comes a period of rapid growth of plants in height (3 ... 5 cm per day), which lasts 12 ... 20 days before budding, after which the growth of plants in height is significantly weakened (1.0 ... 0.5 cm per day), and by the

end of flowering almost stops. During this period, the bulk of the fibre yield is formed. The flowering phase begins 40...50 days after germination and usually lasts 6...10 days.

The ripening stage of flax is divided into green ripeness, early yellow ripeness, yellow ripeness and full ripeness. Green ripeness occurs approximately 2 weeks after flowering, early yellow ripeness - 25...30 days after mass flowering, yellow ripeness - 35...40 days after flowering. full ripeness occurs a few days after yellow ripeness.

The growing season of long flax averages 75...85 days, and in cold, rainy weather it is extended (100 days or more). Under production conditions, the stage of ripeness is determined by the length of the stem, which is free of leaves, and the colour of the seed pods and seeds.

The green ripeness phase - the stem is freed from leaves by 1/4 of the length, 15 ... 20% of flowers and 80 ... 85% of the set capsules remain on the plants.

Early yellow ripeness phase - leaves fall off 2/3 of the stem length, only the uppermost ones remain green, 65...75% of yellow-green seed pods are pale green with a yellow nose, the rest of the pods are green, yellow with seeds of the same colour and brown with brown seeds. In this phase, flax is harvested for fibre.

Yellow ripeness phase - leaves are yellow, remain only in the upper part of the stem, 50% of the capsules are yellow, seeds are yellow, the other half of the capsules are brown and yellow-green.

The phase of full ripeness - the stem is free of leaves, all the capsules are brown, the seeds in them are brown, when the capsules are shaken, they rustle.

Long flax is very demanding on the supply of mineral nutrients, as it has an underdeveloped root system. In addition, it uses most of the nutrients in a very short period of time. Before flowering, flax consumes up to 84% of nitrogen, 63...80% of phosphorus and 70...90% of potassium, and in the herringbone phase - respectively 16...36, 6...15, 11...12% of the total amount of these elements required for the formation of the crop. The removal of nutrients per 1 ton of the main product (fibre) is, kg: N - up to 80, P 20 - 15 ... 40, K 20 - 60 ... 100.

With a lack of nitrogen, the growth of all flax organs is delayed, and the leaves turn light green. At the same time, with an excess of nitrogen in the soil, the growing season is extended, the diameter of the stem increases, and the plants lodge, which causes poor shape and loose fibres in the bast bunches.

With a significant lack of phosphorus, flax stem growth is suspended and seed yields are reduced. Normal supply of phosphorus to plants helps to accelerate their development (especially the root system), the formation of fruiting organs, and has a favourable effect on the anatomical structure of elementary fibres and bast bundles. Violation of phosphorus nutrition of plants at an early age cannot be eliminated in the future. Lack of potassium in the first 3 weeks after germination causes a slowdown in the formation of fibrous substances, and after budding - a deterioration in the quality and reduction of fibre yield, a decrease in plant resistance to fungal pathogens. flax is also very sensitive to a lack of boron in the soil.

Varieties. The following varieties of flax are approved for use in the Federation: Aleksey, Krom, Pskov 359, Smolensky, Smolich, Soyuz, Tomsky 17, Tomsky 18, Torzhoksky 4. Oilseed flax variety Legur. Agricultural technology. In the crop rotation, long-flax is placed so that its sowing on the same field is repeated after

5 ... 6 years. With a permanent culture, flax fatigue occurs - a decrease or complete loss of flax yield due to the accumulation and development of pathogenic fungi in the soil - pathogens of fusarium, anthracnose and polysporosis, bacteria, viruses, various toxic substances.

Flax fatigue is also caused by one-sided soil depletion, lack of certain nutrients, heavy weed infestation, and damage to flax by pests and diseases. In connection with these features, as well as the reduced natural soil fertility in some flax-growing areas in 7 ... 8-field crop rotations, flax is placed on a layer of perennial grasses with a hay yield of 2 ... 4 tonnes/ha. Perennial grasses (clover) are not always the best flax predecessor. D.N. Pryanishnikov, noting the positive effect of clover, emphasised that flax is sown after clover because little fertiliser is applied. Fertilised winter cereals, spring wheat, and vetch-oat mixture are recommended. In farms with a high culture of farming, flax crop rotations with fewer fields can be used. The sod-podzolic soils of the flax growing zone are characterised by high acidity and require liming. excessive acidity delays the development of the flax root system, reduces the absorption of phosphorus and other nutrients, which leads to a violation of protein and carbohydrate metabolism of plants, and increases the damage to crops by fungal diseases.

In the flax crop rotation, fields with an SOC of 0 L 4.5 or less are limed first, and lastly, fields with an SOC of 5.1...5.5. At the same time, flax belongs to the group of crops that react negatively to increased lime rates. Due to the disturbance of the ratio in the soil between calcium and boron, flax can be affected by bacteriosis or experience physiological wilting. The place and time of lime application in the flax rotation is important for the main crop, flax. lime is applied under the cover crop or in the fallow, taking into account the acidity of the soil.

In a crop rotation with flax, organic fertilisers are recommended to be applied at least 2...3 times per rotation. Manure or peat compost should not be applied directly under flax in order not to cause lodging of plants, variegation and weediness of crops. Like all small-seeded crops, flax is particularly demanding on pre-sowing soil cultivation. Before sowing, it must be carefully levelled and rolled. the final operations of pre-sowing tillage are carried out with combined units. On soils well prepared for sowing, the field germination rate of flax seeds is at least 70%, which ensures a high yield.

Physiologically unripe, small, injured and diseased seeds with a dark shade have low germination and low germination energy. Long flax is most often affected by fusarium, polyspora, rust, anthracnose, and bacteriosis. Seed treatment, if their moisture content does not exceed 12...13%, is best done 2...6 months before sowing. Use TMTD, 80% a.i. (2 ... 3 kg/t), with the addition of microfertilisers. Seeds should be evenly covered with the preparation, increased doses of the treatment reduce seed germination and damage flax seedlings. Early seed treatment is more effective as a result of the long-lasting effect of the product on pathogens.

Long-flax is sown in the middle of spring, when the topsoil warms up to 6 ... 8 °C. According to popular belief, if the linden buds swell, the time for sowing flax comes. In the central flax growing regions, flax sowing begins and ends in the first or second decade of May. At late sowing dates, bast cells have a looser structure and lower mechanical strength; fibres are thin-walled, oval-rounded, with weakly expressed

boundaries, a reduced number of elementary fibres, and an increased percentage of fibres with lignified midrib.

At the optimum sowing time, the seeds germinate together, the plants are less thinned out, are not damaged by frost, and are less affected by fusarium, rust, anthracnose and pests, especially the flax flea.

A widespread method of sowing long flax is narrow-row sowing, with row spacing of 7.5 cm. Both sparse and excessively thickened flax stalks deteriorate the economically valuable morphological characteristics of plants and ultimately reduce the yield of flax products. To obtain flax crops with high, weakly branched, thin stems, with a high content of high-quality fibre suitable for mechanised harvesting, it is necessary to have 1500...1600 plants per 1 m² by the end of the growing season. During the growing season, the self-seeding rate of flax crops averages 10% of the number of plants at full germination. Seeding rates for long-flax are 18...25 million, and for seed crops 15...18 million germinating seeds per 1 ha.

In wet years, flax plants can lie down at higher seeding rates, which makes harvesting and primary processing more difficult.

Thickened crops are also undesirable on poor soils, where flax grows stunted. However, on heavily weeded, heavy, floating soils, where fewer plants remain at harvest time, the seed rate should be increased by 10...15%.

During combine harvesting with straw spread on the flax bed for curing, it is most effective to sow red fescue (*Festuca rubra*) under flax - 10...12 kg/ha. By the time of spreading, red fescue forms a dense stand of grass up to 20 cm high, providing reliable isolation of the strips from the ground and optimal conditions for straw curing. When sowing grasses, flax becomes a cover crop. Grass seeds are sown together with flax seeds and mixed thoroughly before sowing.

The best seed sowing depth on heavy soils is 1.5...2.0 cm, on medium and light loams 2.0...2.5 cm, on light sandy loam soils no deeper than 3 cm. With deeper sowing, the density of seedlings decreases, with very shallow sowing, seed germination is delayed due to a lack of moisture in the upper soil layer.

The care of commercial flax crops involves post-sowing rolling, destruction of soil crust, weed and pest control, flax fertilisation, prevention of losses from childhood diseases, and treatment with desiccants to dry the plants on the root.

The protection of flax crops from the most dangerous pest - flax flea beetle - is of great importance in caring for flax crops. the use of insecticides in the fight against flax flea beetle is economically feasible already in the presence of 10 ... 20 beetles per 1 m² in the germination phase. For these purposes, decis extra, 12.5% c.e. (0.06 l/ha) is used.

Flax is heavily suppressed by weeds, while at the same time it is very sensitive to most herbicides. The response of flax to herbicide depends on the growth rate and the thickness of the wax layer on the stem surface. The most common weeds in flax crops are white quinoa, wild radish, bindweed, chickweed, Zyabrev's pickleweed, odourless chamomile, field thistle, creeping wheatgrass, field horsetail, field thistle, field thistle.

Weeds whose seeds ripen together with the seeds of cultivated plants, do not crumble, and are similar in shape and weight to flax seeds are called specialised weeds

- flaxseed, flax bindweed, flax bindweed, flax bindweed, etc. There are also parasitic weeds, such as flax bindweed and others. Crops infested with annual dicotyledonous weeds are sprayed with herbicide 2M-4X 750, 75% a.i. (0.5 ... 0.6 l/ha), at a plant height of 5 ... 8 cm and an air temperature of 15 ... 17 ° C. During this period, the leaves are located at an acute angle (10 ... 30 °), covered with a waxy coating. The duration of chemical treatment is no more than 10 days. On seed crops, desiccation with magnesium chlorate (10 ... 15 kg/ha) is used to accelerate flax ripening by 5 ... 10 days in the phase of early yellow ripeness. In this case, the drying time of flaxseed is reduced by one and a half times, and the productivity of the combine increases. However, the effectiveness of desiccation depends on weather conditions.

Harvesting flax is the most labour-intensive and responsible job, which largely determines not only the safety of the crop but also the quality of flax products. Harvesting and primary processing of flax accounts for up to 70% of all costs in flax production. When growing long-fibre flax in commercial crops, both fibre and seeds are produced, so it must be harvested at a time when the largest amount of fibre with the best quality and seeds suitable for sowing and processing into oil can be harvested. This period is called the technical maturity of flax.

The optimum harvesting time for flax crops in terms of fibre quality, physical and mechanical properties, and spinning ability is the early yellow ripeness phase. harvesting is carried out in a short time - 10 ... 12 days. On seed crops, the optimal harvesting time is the yellow ripeness phase, and the seeds are harvested in 5...6 days.

If a farm starts harvesting commercial crops in the yellow ripeness phase, which lasts 5-7 days, there is a risk of harvesting part of the crop in the full ripeness phase. When the flax is fully ripe, the fibre becomes brittle, coarse, produces a lot of waste during processing, and the stems are harder to cure.

Green flax harvested in the flowering phase is characterised by poor separability of the bast, a high percentage of defects, and a 25% reduction in fibre yield. In addition, unripe (green) seeds are usually not viable. For any harvesting method, it is important to correctly determine the flax's root ripeness. In production conditions, the stage of ripeness is determined by the length of the stem, freed from leaves, the colour of the bolls and the seeds contained in them.

If it is difficult to determine the stage of ripeness by eye before harvesting, 1000 plants are selected evenly along the diagonal of the selected plot. Then they are laid out in a ribbon and 50 plants are selected for analysis. Separate all the bolls, sort them by colour, examine the seeds and determine the percentage of green bolls with underdeveloped and green seeds; yellow-green bolls with pale green seeds and a yellow nose; yellow bolls with yellow seeds; brown bolls with brown seeds.

In the early yellow ripeness phase, at 65...75% of the yellow-green seed pods, the seeds are pale green with a yellow nose. Flax that has fallen down is harvested at the earliest possible date, the deadline being the end of the flowering phase. Flax that has fallen down and is contaminated reduces the productivity of harvesting machines. Flax harvesting is carried out using different technologies depending on climatic conditions, specialisation of the farm (seed or non-seed), yield level, availability of technical means, and methods of primary flax processing.

The most efficient way to harvest flax is by combine harvesting. The main requirements for the quality of combine harvesters are: chaff purity - not less than 99%, mechanical damage to stems (breakage) - not more than 5, seed loss - not more than 5, seed damage - not more than 1%, stretching of stems in the belt - not more than 1.2 times the total length of the stem, stretching of sheaves - not more than

1.3 times, binding tightness - 85%, sheaf lint - no more than 3%. Flax is a crop that requires careful treatment of both stalks and seeds, so flax harvesting machines need to be carefully adjusted. The flax heap obtained during the threshing of stalks by combines consists of bolls, seeds (up to 25%), tangles and other impurities (10...16%), and the moisture content of the heap reaches 60...65%, including seed bolls -40...50%. Therefore, the flaxseed is immediately dried in dryers and then processed to separate and clean the seeds. Harvest preservation and quality depend on the drying and processing modes of flaxseed. When storing raw flaxseed heap for 2...3 hours, it is self-warming, which leads to an increase in infection and seed spoilage.

Before harvesting, not only the density of the flax stalks is determined, but also the density of the spreading belt. The thickness of the belt is determined by multiplying the working width of the flax harvester sections by the number of stalks per 1 m². The thickness of the belt is determined by taking samples in different places.

At the rate of spreading flax straw to obtain straw 1...3 times, the belts are rotated during the curing process (on the 3rd...6th day), the second time in the middle of curing (on the 12th...16th day after shaking), the third time before lifting the straw to ensure that the lower layer of stems in the belt dries faster and the curing process in the upper and lower layers of straw is more even.

The flax bale is unloaded onto the platforms of the dryer compartments, bringing its layer to 0.4...1.7 m, depending on the humidity and type of dryer. The temperature of the coolant should not exceed 45 °C

(For sowing seeds - 40 °C). The heap is dried to a seed moisture content of 8 ... 12%. Seeds may lose their germination due to the death of the embryo under the influence of heating temperature exceeding the maximum permissible temperature. As soon as the heap is dry, it is blown for 2 ... 5 hours with cold air to equalise the moisture content across the layer thickness and reduce microdamage to the seeds during threshing. The dried heap is threshed with constant control over the quality of threshing. During drying and processing of the heap, the germination rate of seeds may not be reduced by more than 2%, their crushing may not exceed 1%, and irrecoverable losses may not exceed 3%. Seeds are cleaned and sorted in a timely manner.

The primary processing of flax is very diverse in terms of the types of products sold (straw, trestle, long and short fibre, seeds). It includes the preparation of trestle from straw, trestle drying and tapping. Currently, 80...85% of trestle is prepared on flax farms by spreading straw on straw bale and up to 20% at flax mills. Dew-dried straw produces straw straw, water-air straw produces straw straw, and water-vapour straw produces straw straw. Flaxseed products, in which the bast bundles are separated from the accompanying tissues (parenchyma, epidermis), are called trista. The main well-studied method of producing trista is dew lobe flax stalks, in which the straw is spread in a thin layer on the floor. The required humidity of the stems is achieved through

rainfall and precipitation. At the same time, pectin substances are destroyed by microorganisms.

The main microorganisms involved in the production of stannous trust are lower fungi and bacteria, the main ones being the fungi *Cladosporium herbarum* Zink, *Alternaria tenuis* Nees, etc., as well as anaerobic bacteria and yeasts - *Vass. Subtilis*, *V. megaterium*, *V. mycoiotes*, etc. The source of microflora is soil. The main factors of dew lobe are heat, moisture, aeration and light. Under the influence of ultraviolet rays and light, the stems acquire whiteness and shine. Flax straw curing is positively influenced by a flat relief and constant air exchange. The optimal conditions for pectin-degrading microorganisms are a temperature of 14...20°C without sharp fluctuations during the day, straw moisture content of 40...60%, and a flax height of 8...10 cm above the soil. The best time for strawing is the first decade of August.

The batch of flaxseed straw intended for sale must be of the same breeding variety, homogeneous in terms of growing conditions, as well as in terms of the degree of curing (trust). Straw and straw must be tied into sheaves with a diameter of at least 13 and 17 cm, respectively, placed with the clod in one direction and levelled along the clod. Straw and trestle contamination is allowed no more than 10% (normalised 5%), moisture content - 25% (normalised 19%).

When preparing flax seeds from seed crops, their purity, moisture content and germination are taken into account, and from non-seed crops (with normal appearance) - only purity and moisture content.

The long fibre obtained on the farms is sorted and bundled into bales of 3...4 kg with a flax length of at least 70 cm before being sold. Features of oilseed flax agricultural technology. Narrow-row sowing with a seeding rate of 12 ... 15 million germinating seeds per 1 ha. In 3...4 days after sowing, pre-emergence harrowing is carried out with light harrows, the soil crust is destroyed with a rotary hoe, herbicides are used in the herringbone phase, and crops are sprayed with chemicals in case of massive pests.

Oil flax is harvested when 60...70% of the bolls are ripe in a two-phase method or by direct harvesting in the full ripeness phase. The cutting height of the stems is 12 cm. The windrows are picked up in 6 ... 7 days. The greatest economic effect is achieved with the in-line harvesting method. The flax bale is immediately cleaned. After processing and drying, the seeds are stored with a moisture content of no more than 12%.

3.7.2. Hemp

Meaning. Hemp is processed for fibre and seeds. Its stalks contain up to 27% fibre, which is used to make cloth, strong sea and river ropes, fishing gear, tarpaulin, twine, ropes and other products. short fibre is used to make twine and is also used as a packaging material. The branches are used in construction.

Hemp seeds contain 35% drying oil, 18...23% protein, about 20% starch, 15% fibre and 4...5% ash. hemp oil is close to the best grades of edible oil in terms of taste. It is widely used in confectionery, canning and fish production, as well as for the manufacture of high-quality grades of drying oil, oil paints, etc.

The seeds are a valuable feed for many types of poultry, and the cake, which contains 30% protein and 10% fat, is a concentrated feed for farm animals (1 kg of cake replaces 3 kg of barley in terms of protein content). About 65% of the weight of the hemp trust is wood (bast), which is used to make battens for the furniture industry, paper and plastic.

Hemp was widely cultivated as early as the ninth century, and hemp was one of the most important export commodities. In European countries, hemp began to be cultivated only in the XVI century. The main areas of hemp sowing are located in the middle lane, in the Krasnodar and Stavropol Territories. The average yield is about 0.7 t / ha of fibre per 1 ha, in advanced farms they get 1.2 ... 1.4 t / ha. Botanical description. Hemp is an annual herbaceous plant, belongs to the Cannabinaceae family.

There are three types of hemp: common (sowing), Indian and weed. Only common hemp (*Cannabis sativa*L.) is grown for fibre and seeds. Geographical forms of common hemp are divided into three groups: northern, Central and southern. Northern hemp has long been grown in the northern and northwestern regions of the European part, including the Arkhangelsk region. Due to its cold tolerance and short growing season (the sum of active temperatures is about 1400°C), this crop can be harvested satisfactorily here.

Common hemp is an annual dioecious plant. Plants bearing male flowers are called flat plants or zamashka, and plants with female flowers are called mater. Poskoni plants have thinner stems, fewer leaves and mature earlier. The ratio of male and female plants in the crop is approximately the same, but the share of the mother plant accounts for 2/3 of the total fibre yield. The root system is taproot, and the roots are poorly developed compared to the aerial part, which determines the increased demand for soil fertility. The roots penetrate to a depth of 2 m, but the bulk of them develop in the soil layer up to 40 cm.

The stem is 0.75...5.0 m high, covered with glandular hairs, and has 6...7 internodes. The anatomical structure of the hemp stem is similar to that of flax. The fibre yield in the seedling is 20...25%, in the mother 15...20% of the stem weight. Hemp leaves are petiolate, palmately divided. The leaves of pokoni have a smaller number of lobes. The inflorescences of the mother are spike-shaped, while those of the father are small loose clusters located on the lateral branches and in the upper part of the stem. The fruit is a grey-green bivalve nut. The weight of 1000 seeds is 18...25 g, they remain viable for up to 3...4 years.

Features of biology. Hemp is a long-day plant. Seeds begin to germinate at a temperature of 1 ... 2 ° C, but for the emergence of friendly seedlings, a temperature of 8 ... 10 ° C is required. the duration of seed germination is 3 ... 25 days. seedlings can withstand short-term frosts down to -5 ... - 6 ° C, adult plants die during frosts. Hemp grows most intensively at an air temperature of 18 ... 20 ° C. The greatest need for moisture occurs during the budding - flowering period. Waterlogging of the soil negatively affects the development of hemp at the beginning of the growing season. Cultivated lowland soils and drained peat bogs with a groundwater level not higher than 0.75 m, black earth soils most fully meet the requirements of hemp. the reaction of the soil solution should be close to neutral (pH 6 ... 7). Hemp is not recommended for heavy clay and sandy soils.

At a fibre yield of 1 t/ha, hemp takes out of the soil, kg: N - 150 ... 200, P 20 ... 35 ... 40, K 20 - 100 ... 120. plants consume nutrients most intensively in the following periods: nitrogen - from the beginning of budding to flowering, phosphorus - from germination to the formation of 5 ... 6 leaves and during seed formation, potassium - in the first half of the growing season. At the beginning of the growing season, hemp plants grow slowly, and the root system, on the contrary, develops intensively. more intensive growth is observed in the period from budding to flowering (daily growth of 5 ... 6 cm). At first, the flathead grows faster, then the mother grows faster. The flowering of pokonie begins 4 ... 5 days later than the mother and lasts 12 ... 15 days. The average hemp plant takes 8...10 days from sowing to germination, flowering begins on the 45th...59th day, maturation of poskoni on the 65th...70th day, of mother hemp on the 65th...115th day, and of southern hemp on the 135th...150th day.

Varieties. The cannabis varieties approved for use are Zinita, YUSO 14, and YUS031.

Features of agricultural technology. On podzolised medium-cultivated, grey forest soils, manure (30 ... 60 t / ha) and mineral fertilisers are applied depending on the level of soil fertility. On peaty soils, it is recommended to apply microfertilisers. Hemp can be cultivated for a long time in one field (on Konoplyanik).

Large seeds with a germination rate of at least 85% and purity of at least 97% are used for sowing. Against diseases, the seeds are pre-treated with TMTD, 80% a.i. (2 kg/t). Hemp is sown in the early stages simultaneously with early crops or immediately after them, when the soil at a depth of 10 cm warms up to 8°C. With early sowing, plants are less damaged by pests.

The seeding rate is set according to the purpose of cultivation. For green and dual-use applications, a conventional row seeding method is used with a seeding rate of 4.0...4.5 million germinating seeds per 1 ha. The optimal seeding rate for monoecious hemp is 3...4 million germinating seeds per 1 ha. When using hemp for seeds, wide-row sowing is used with row spacing in the middle hemp cultivation zone of 45 cm, and 45...70 cm in the southern zone. When growing elite seeds of the first and second reproduction, the seeding rate of monoecious hemp is 0.9 million, of the third reproduction - up to 2 million germinating seeds per 1 ha, the sowing method is ordinary.

Hemp is sown with a converted seeder. The sowing depth on loamy soils is 3...4 cm. Crop care involves pre-emergence harrowing, and in wide-row crops - inter-row cultivation, fertilisation, herbicide application, desiccation and defoliation. Pre-emergence harrowing is carried out with light or medium harrows on the 4th day after sowing. On wide-row crops, the row spacing is loosened 2...3 times. Simultaneously with cultivation, fertilisation is carried out. In the southern zone, hemp crops are irrigated (irrigation rate is 1800 ... 3500 m³ / ha). The first watering is carried out at a plant height of 20 ... 25 cm, the second - at the beginning of flowering, the third - at the beginning of seed filling.

Hemp plants are highly leafy, which complicates harvesting and increases the time required to dry the stems and prepare the truss. On wide-row crops, seeds do not ripen at the same time, so defoliation is carried out 5-6 days before harvesting to

remove leaves and dry the plants on the root, sprayed with chemicals. defoliation of green crops is carried out at the beginning of the flowering of the pokoni, using magnesium chlorate (7.5 kg/ha), the working solution consumption is 100 litres per 1 ha.

Before the stem lobe, the leaves are stripped off with a hemp thresher. Desiccation of seed hemp is carried out when 50 ... 75% of the seeds in the inflorescences are ripe. Desiccation contributes to a more complete threshing of the seeds and a reduction in their moisture content. The quality of hemp products (straw from seed or green crops, trust) is regulated by standards. To prepare trusses, hemp plants or farms use a lobe with the addition of chemical accelerators, bacterial starter cultures, or steam the stems under pressure.

3.7.3. Cotton

Significance. Cotton is one of the most important spinning crops in the world. Its fibre is used as a raw material for the textile industry. The oil obtained from the seeds is used for food, and the cake is used as high-protein feed for livestock. 1 tonne of raw cotton produces 320...340 kg of fibre and 560...580 kg of seeds. This amount of fibre can be used to make 3500...4000 m² of fabric, and the seeds can be used to make 112 kg of oil, 270 kg of cake, 170 kg of onions and 8 kg of lint (short fibre fluff).

Cotton fibre is used to make various fabrics, threads, and cotton wool. Cotton is a good honey plant. Its stalks are used as fuel and for cardboard production. After the seeds are processed into oil, a meal containing 35...40% protein is obtained.

It is a high-protein feed, but the meal contains gossypol, which can be harmful to animals in large doses. Cotton is the oldest crop. Cotton fibre was known in India 3000 years before Christ. A little later, cotton farming began to develop in China. Then it spread to Iran (Persia), Arabia, Egypt, and Central Asia. In South America (Mexico, Peru), cotton was grown in ancient times. Cotton growing on this continent developed independently of the Old World countries. Cotton is grown in tropical and subtropical zones. Its sown area in the world is about 32 million hectares. In the former Soviet Union, cotton was grown on an area of 5.67 million hectares (1980). The main cotton-growing countries in the world include India (7.7 million hectares), China (5.1 million hectares), the USA (5.4 million hectares), Brazil (1.2 million hectares), and Pakistan (2.8 million hectares). The seeds together with the fibre are a product called raw cotton. The average fibre yield from raw cotton is 33...35%. The yield of raw cotton in Uzbekistan and other Central Asian countries that were formerly part of the Soviet Union was 2.5...2.7 t/ha, and the best farms received 4 t/ha or more. Botanical description. Cotton belongs to the genus *Gossypium*, to the family Malvaceae. This genus includes many species, of which 5 species are used in culture. In world agriculture, two species are mainly cultivated: common or Mexican cotton (medium-fibre cotton), *Gossypium hirsutum* L., and Peruvian cotton (fine-fibre cotton), *Gossypium peruvianum* Gav.

Cotton is a perennial plant, but it is cultivated as an annual crop.

Cotton root is taproot, penetrating to a depth of 1.5...2.0 m. Within 1 month after germination, the root grows very rapidly. The stem is straight, strong, lignified in the lower part, covered with hairs. An adult plant is a bush 80 ... 180 cm or more high with

many lateral shoots, usually called branches. Branches are formed from buds located in the leaf axils. Two types of branches are formed on a cotton plant: growth branches (monopodial) and fruit branches (sympodial). Monopodial branches develop in the lower part of the stem, extend at an acute angle and lengthen continuously at the expense of the apical growth point. On them and on the main shoot above the monopodial branches, sympodial (fruit) branches are formed in the leaf axils.

They grow intermittently, developing sequentially from several buds. Flowers and then fruits develop on the sympodial branches. There are varieties that do not have side branches.

Flowers and fruits are located on short stalks of 1 ... 3 in the leaf axils of the main shoot. This type of branching is called zero branching. If the plants form shortened sympodial branches with one internode, ending in one or more capsules, then this type of branching is called marginal branching.

If the sympodial branch ends in a growth bud, then the branching type will be unsaturated. branches of the non-limiting branching type with intermittent growth are divided into 4 subtypes: the first with internodes 3 ... 5 cm long, the second - 6 ... 10, the third - 10 ... 15, the fourth - 16 ... 25 cm.

The length of the internodes determines the compactness or spreading of the bush, its productivity, and the duration of the cotton growing season.

At normal density, 1 ... 3 monopodial (growth) branches are formed on one plant. Sympodial branches are formed sequentially and continuously.

Cotton is a plant with an indeterminate (continuous) type of growth; 20 or more sympodial branches can form on one plant. However, late-formed fruits do not have time to ripen. In addition, the most valuable part of the crop is formed on the lower branches. Therefore, after the formation of 12 ... 18 sympodial branches (depending on the growing conditions), further stem growth is interrupted by minting, removing the apical buds. Cotton leaves vary in shape and size. The first three leaves are entire, the rest are dissected. on fruit branches, the leaves are located opposite the buds.

The flower has a large corolla of five petals fused at the bases. The colour of the petals is yellow, creamy. flowering of one flower lasts one day. Cotton is mainly a self-pollinator.

The fruit is a 3 ... 5-nested box. When ripe, it cracks, the flaps open. One box contains 25 ... 50 seeds with fibres. The weight of raw cotton from one boll is 4 ... 6 g or more. The development of bolls lasts 50 ... 60 days. The seeds are ovoid. On the surface of the seed there are long fibres and short fibres (underfloor). The weight of 1000 seeds is from 80 ... 150 g and more. Fibre and its technological properties. Fibre is a strongly extended epidermal cell of the seed skin. Dead seeds with short fibres are called bolls. Uluca is formed when the plant is diseased and the level of agricultural technology is low. The fibre is usually white, in some forms it can be coloured - cream, green, brown.

The quality of a fibre is determined by its technological properties, which include: fibre length, tensile strength, tint (metric number, linear density), twist, breaking length, maturity, and fibre yield. Fibre length is the distance in millimetres between the ends of a fibre in a straightened state. Medium-fibre cotton varieties have a fibre length of 31...36 mm, and fine-fibre varieties have a fibre length of 38...42 mm.

Modal length (mass length) is the average length of the majority of fibres in a given sample in millimetres. Staple length is the average length of all groups of fibres exceeding the modal length in millimetres. Tensile load (strength) is a measure of the force withstood by a fibre before it breaks, measured in Newtons (N).

The strength of the fibre ranges from 0.043 to 0.049 N in medium-fibre grades and from 0.046 to 0.052 N in fine-fibre grades. The metric number (linear density) describes the tone of the fibre. It indicates the total length in metres of fibres per 1 g of weight. The fineness is expressed in tex (m/g). The breaking length (relative breaking load) is equal to the product of the strength of the fibre and its metric number, measured in metres, or $H \times \text{tex}$. This is the length of a fibre in thousands of metres or kilometres at which it breaks under the action of its mass. For medium-fibre cotton, the breaking length is 25...27 km, and for fine-fibre cotton, it is 33...36 km. Fibre tortuosity is measured by the number of turns per 1 mm of fibre length (10 ... 12 turns). Fibre maturity is the degree of fibre deposition in the fibre walls, expressed by the maturity coefficient. A coefficient of 0 corresponds to a dead fibre, 5 to an overripe fibre, and 2...2.5 to a normal fibre.

The fibre yield is the ratio of fibre weight to raw cotton weight, ranging from 30 to 40%. The range of cotton fibre is divided into seven types (Table 57). The first three types of fibre are obtained from fine-fibre cotton. This is the most valuable long, thin, strong fibre. The other four types of fibre are obtained from medium-fibre cotton. Varieties of this type are more early maturing and productive than fine-fibre cotton and occupy the bulk of the area. Type IV fibre is used to make strong sewing threads and fabrics, type V is used to produce mass fabrics (linen, dress, etc.), and type VI is used for melange production, for mixing with wool. Type VII fibre is considered the worst quality.

Biological features. In the process of development, cotton goes through the following phases: germination, formation of true leaves, budding, flowering, and ripening (opening of the bolls). From sowing to germination at favourable temperature and humidity, it takes 5-6 days, from germination to the appearance of true leaves - 8-12 days, from the beginning of the appearance of true leaves to budding - 25-30 days, from the beginning of budding to flowering - 25-30 days, from flowering to the beginning of ripening - 50-60 days.

In total, medium-fibre varieties take approximately 125...150 days from sowing to the beginning of ripening, and fine-fibre varieties take 145...160 days. Depending on the conditions, the length of the growing season can be 10...15 days longer or shorter.

The appearance of buds and opening of flowers on the semipodal branches of cotton occurs every 5...7 days (long flowering cycle), and from bottom to top from branch to branch - every 2...3 days (short flowering cycle).

The blooms spread upwards from branch to branch faster than along the branches, so the space within the bush that is covered at any given time is conical. The blooms spread through the bush in cones.

More than 100 buds can be formed on individual bushes, but most of the fruit elements (about 60 ... 70%) fall off. Cotton is a typical short-day crop that does not withstand negative temperatures. When cold weather returns in spring, seedlings are

sparse and cotton has to be reseeded. Seedlings die at frosts of 1...-2°C, and adult plants at 3...-5°C. The optimum temperature for cotton development is 25°C, during flowering 26...30°C. The sum of active temperatures for early ripe varieties is 3000°C, mid-season - 3400°C, late ripe - 4000°C.

Cotton is particularly demanding on moisture during flowering and boll formation. In the Central Asian countries that were once part of the Soviet Union, cotton is cultivated only under irrigation.

To form 1 tonne of raw cotton together with the entire vegetative aboveground mass, cotton requires on average, kg: N -50 ... 60, P 20 ... 30, K 20 ... 30, Ca 10 ... 15, Mg 5 ... 10, C 100 ... 120. Nitrogen deficiency causes small leaves and yellow-green colour, plants become stunted, form few bolls. An excess of nitrogen enhances vegetative growth, and ripening is delayed. A lack of phosphorus causes stunting and poor development of the root system, red veins appear on the leaves, the development of bolls is delayed, and the quality of the crop decreases.

If there is a lack of potassium, brown spots appear on the leaves, the leaves curl and crumble. The incidence of wilt increases, and the quality of the crop decreases.

In Central Asia and the Caucasus, cotton is grown on sulphurous and grey-earth meadow soils. Meadow soils are among the best for cotton, and meadow-boggy soils are also quite suitable after they have been reclaimed.

Cotton is relatively salt-tolerant, plants can withstand salt concentrations at which other crops are inhibited and die. However, to obtain a high yield on saline soils, it is necessary to carry out leaching irrigation. Fields with a close groundwater table are not suitable for cotton; it is better if the groundwater is deeper than 3 m from the soil surface.

Varieties. They are divided into two groups: medium-fibre, which belong to the common cotton species, and fine-fibre (Peruvian cotton). More than 20 varieties of both types have been developed and recommended for production in the Central Asian republics.

Agricultural technology. Cotton can be grown in one place for a long time, but with a permanent culture, infection accumulates, pests and diseases, especially wilt, spread. Cotton stalks and roots are removed from the field, and numerous irrigations and inter-row treatments lead to accelerated decomposition of organic matter and reduced soil fertility.

Alfalfa plays a special role in crop rotations with cotton. Under the influence of alfalfa, the supply of organic matter and nutrients increases, the water and physical properties of the soil improve, salinity decreases, and the soil is freed from weeds and pathogens of cotton infection, especially wilt.

In addition, alfalfa is considered a high-quality fodder crop.

Cotton is grown mainly in 10- and 9-field rotations with three fields of alfalfa. Before sowing the alfalfa, the land is planned, washed, etc. After ploughing alfalfa, cotton is sown for 4 years. To improve soil fertility and increase cotton yields, intercrops (mustard, rapeseed, percoche, rye, peas, etc.) are sown using the green mass for livestock feed and for ploughing as green fertiliser in the 4th to 6th year after alfalfa ploughing. Cotton consumes a large amount of nutrients to form a crop. Mineral and

organic fertilisers are used, but it is recommended to apply organic fertilisers only in the 3rd...4th year after ploughing alfalfa - 30...40 tonnes of manure per 1 ha.

The rates of nitrogen, phosphorus and potassium depend on the type of soil, the location of the cotton field in the crop rotation and the planned harvest. Soil cultivation depends on the predecessor. after the cotton crop is harvested, the stalks are harvested. if the stalks are infected with wilt, they must be removed by the roots and taken off the field. On fields that are not infected, the stalks are chopped and ploughed. If cotton is sown after alfalfa, before ploughing, the soil is peeled to a depth of 5-6 cm to cut the roots to prevent their regrowth, or special devices are made for the upper body of the plough.

Immediately before sowing on uninhabited soils, harrowing with low tilth is used (low tilth is levelling the soil with a small amount of tilth). When the soil is compacted, it is loosened with a chisel cultivator with harrowing.

For sowing, conditioned seeds are used, pubescent and bare. At cotton mills, the seeds are treated with a chemical, and immediately before sowing, they are moistened on the farms (500...700 litres water per 1 tonne of seeds). Moistened seeds germinate for 12 ... 18 hours. Bare seeds are not moistened. It is very important to sow cotton at the optimum time. It is sown when the soil temperature is stable at 12 ... 14 ° C. The method of sowing cotton is wide-row, with row spacing of 60 or 90 cm. Frequent-nest sowing is used with distances between nests of 10 ... 30 cm. With the dotted method, seeds are sown every 10 cm, 1 ... 2 per nest. In this case, uniform placement of plants and a given density of 100 ... 150 thousand plants per 1 ha without thinning of seedlings are ensured. The seeding rate depends on the row spacing, sowing pattern, and conditions during the sowing period. For bare seeds, it should not exceed 25 ... 30 kg/ha, and for dropped seeds - 60 ... 70 kg/ha.

Medium-fibre varieties are grown at a density of 100...120 thousand plants per hectare, and fine-fibre varieties at 120...150 thousand plants per hectare. Depending on the variety and planting scheme, the density can be increased to 150...170 thousand plants per hectare.

To destroy the soil crust, the crops are harrowed across the rows with tooth harrows before emergence. after emergence and before the rows close, inter-row cultivation is carried out. Depending on the number of irrigations and weed infestation, 4...7 cultivations are carried out. Herbicides are used against weeds. Diseases such as wilt, root rot, gommosis cause great damage to cotton, and pests such as spider mites, thrips, aphids, cotton bollworm, and caradrina are common. Agricultural practices to combat wilt and other diseases include cotton-alfalfa crop rotation, as well as mandatory harvesting and removal of cotton stalks with roots from the field. Cotton crops are treated with chemical and microbiological preparations only after inspection and determination of the number of pests. Pheromone traps are used against the cotton bollworm. To combat the winter moth, a trichogram is released at least three times. Cotton crops are sprayed with acaricides against spider mites.

The growth of cotton plants and the formation of new sympodial branches can continue until the onset of frost, so the plant contains bolls of varying degrees of development, as well as flowers and buds that do not have time to form full-fledged

bolts before the frost. A large number of late-forming fruit elements prolongs the growing season and diverts nutrients from previously formed capsules.

To stop the formation of new branches and to reduce the drop of flowers and capsules, remove the tops of the growth branches and the main shoot. This technique is called minting. The timing of plant minting depends on the development of the cotton. It is carried out with special devices for a cotton cultivator in two steps. During the first pass, the tops of the tallest plants are cut to the level of the middle ones, and during the second pass (7...10 days after the first), the tops of the rest of the plants are cut. Mechanised chasing is combined with the last cultivation or furrow cutting.

For cotton, as well as for other crops, the optimal root layer moisture content is higher than the RHW (60% RHW). During the growing season, depending on the type of soil and the depth of groundwater, cotton is watered 2...12 times.

The irrigation rate ranges from 600 to 1000 m³ / ha, and the irrigation rate - from 3 to 8 thousand m³ / ha. Irrigation is carried out along furrows, the length of which, depending on the slope and permeability of the soil, is 80 ... 150 m, the speed of the water jet supplied to the furrows is from 0.2 to 1 l / s.

With 60 cm wide row spacing, the depth of irrigation furrows is 12...18 cm, and with 90 cm wide spacing, it is 15...22 cm. When watering cotton, rigid and semi-rigid irrigation pipelines, flexible hoses and siphon tubes are used. When using sprinklers, water consumption is reduced by 2 ... 3 times.

Ripening of cotton bolts on the bush takes more than 2 months. To use machine harvesting, it is necessary to accelerate the maturation of the bolts and cause artificial leaf fall. To do this, defoliation is carried out - cotton is treated with chemicals to cause the leaves to fall off quickly.

If there is insufficient leaf fall after defoliation, the plants are desiccated, which is the drying of the plants at the root. Cotton gins are used to harvest raw cotton. Machine harvesting of raw cotton is carried out in two stages as the bolts open. The first collection begins 8...10 days after defoliation. By this time, 50 ... 60% of the bolts are opened and at least 80% of the leaves fall off. The second harvest is carried out 12 ... 15 days after the first. Harvesting of dried apricots (opened capsules) is carried out by dried apricot harvesting machines.

After the first and second harvests, the fallen raw cotton is picked up from the ground by mechanical pickers. Manual picking of raw cotton is carried out in fields that are not suitable for machine picking or on seed crops.

After all the raw cotton has been harvested, the stalks are removed by a ginning machine. The stalks are uprooted, placed in windrows, and then transported off the field.

3.7.4. Kenaf

Significance. Kenaf is a valuable bast fibre plant. The stems contain up to 24 per cent of strong, soft and hygroscopic fibre. The fibre is used to make tarpaulin, sacking, packaging, carpet and furniture fabrics, twine, ropes and other products. The seeds contain 18-20% of technical oil, which is used in the leather, paint and varnish, and soap industries. The seed cake is used for animal feed. Kenaf fescue is a raw material for making building boards and paper.

Kenaf is native to South America. This plant is grown in many countries, including China, India, Indonesia, Sudan, Brazil, and others. Kenaf has been cultivated in Ukraine since the mid-nineteenth century. Kenaf is not grown in Ukraine.

Biological features. 'Kenaf (*Hibiscus cannabinus* L.) is an annual herbaceous plant of the Malvaceae family. It is a heat-loving plant. Seeds begin to germinate at a temperature of 13-15° C. Friendly seedlings with' appear at 20-22° C. It does not withstand frosts down to minus 1-1.5° C both at the beginning and at the end of the growing season. The most favourable temperature for the growth and development of kenaf plants is 23-25° C.

Kenaf is a moisture-loving plant. The optimum soil moisture at which kenaf grows and develops well is 80 per cent HB. Therefore, it is grown in areas with sufficient rainfall, or only under irrigation.

In terms of light, kenaf is a short-day plant. Therefore, stunted and weak plants develop in excessively thickened crops.

Kenaf requires fertile soils. The best soils are grey soils, meadow soils and meadow-bog soils. Saline and marshy soils are unsuitable for it.

The growing season of kenaf lasts 120-160 days.

Features of the cultivation technology. The best predecessors for kenaf are winter cereals, grain corn and legumes. Cultivation of the crop consists of peeling, autumn ploughing with ploughs with skimmers to a depth of 28-30 cm, early sowing and harrowing, one or two cultivations with simultaneous harrowing. Before sowing, the field is levelled and harrowed.

Kenaf is very demanding on nutrients. With a yield of 100 c/ha of stems, it removes 120-150 kg of nitrogen, 60-80 kg of phosphorus and 120-150 kg of potassium from the soil. Kenaf responds well to fertilisation with organic mineral fertilisers (15-20 t/ha). Mineral fertilisers are applied in the following approximate doses: nitrogen 180-200 kg/ha, phosphorus 150-170 kg/ha, potassium 90-100 kg/ha. These doses of mineral fertilisers are designed to produce 180-200 centners per hectare of stalks. Organic mineral fertilisers and 50 per cent of phosphorus and potassium mineral fertilisers are applied for autumn ploughing. 'Nitrogen and half of the calculated doses of phosphorus-potassium mineral fertilisers are used at sowing and in top dressing: the former 15-25 days after emergence, and the latter during the budding phase. During sowing, phosphate mineral fertilisers are applied to the rows.

Before sowing, the seeds are treated with TMTD (2 kg/t). Kenaf is sown when the soil warms up to 13-15° C. The best method of sowing for growing kenaf for green manure is belt sowing (60x15 or 48x12), and for seeds - wide-row sowing with row spacing of 60-70 cm. The seeding rate for green manure is 35-40 kg/ha, and for seeds - 15-20 kg/ha. Kenaf seeds are sown to a depth of 3-5 cm.

'Care of kenaf crops begins with pre-sowing harrowing to destroy the crust and control weeds. When' emergence occurs, the first inter-row cultivation and thinning of plants on seed crops is carried out, leaving 150-180 thousand per 1 ha. Kenaf plants are watered during the growing season (2-4 waterings before flowering and 1-2 waterings during flowering). The irrigation rate is 800-1000 m³ of water per 1 ha. Three irrigations are carried out on seed crops. After each irrigation, the row spacing is

loosened when the soil dries. Inter-row cultivation is completed when the plants close in the rows.

Sowing begins to harvest kenaf for greening when at least 50 per cent of the plants have flowered. Kenaf stalks are mowed with the ZhK-2.1 harvester and processed with the LS onion separator. The green bast is spread on the stubble to dry. 'After that, the bast is sorted, bundled and delivered to harvesting centres. Kenaf for seeds is harvested with ZhK-2.1 harvesters when 4-5 lower bolls are browned. The cut stalks are sheared into sheaves at'. After drying, the stems are threshed. The threshed seeds are dried, sorted and stored at a moisture content of no more than 12 per cent, and the stems are processed into fibre.

3.8. Tobacco, terry, hops

Among the narcotic plants grown in Ukraine, the most common are tobacco and makhorka, which contain nicotine, one of the most poisonous alkaloids. When oxidised with chromic acid, nicotine is converted into nicotinic acid, which is used to synthesise pharmaceuticals.

3.8.1. Tobacco

Importance. Tobacco is grown to produce leaves, which are used primarily as a raw material in the manufacture of cigarettes, cigars, cigars and pipe tobacco.

Tobacco leaves contain: nicotine 1...3%, essential oils about 1, resins 4...7, proteins 7...10, carbohydrates 4...13, ash 13...15%. Resins and essential oils determine the smell and aroma of tobacco.

The birthplace of tobacco is America. The Indians of South and Central America used tobacco leaves for smoking long before Europeans discovered the continent. Tobacco is grown in many countries around the world. The global area under tobacco cultivation is more than 4 million hectares. More than half of the world's tobacco production is in China, the US, India and Brazil. About 60 thousand hectares are under tobacco cultivation, with the main crops located in the North Caucasus. The yield of tobacco leaves averages 1.5...2.0 t/ha, in some farms it reaches 3.0...3.5 t/ha (with a yield of 87% of the highest varieties). Botanical description. Tobacco (*Nicotiana tabacum* L.) is an annual plant of the Solanaceae family. The root of tobacco is taproot, penetrating to a depth of 1.5...2.0 m. The stem is erect, pubescent, 1.0 ... 1.8 m or more high.

The leaves are large, petiolate or sessile, entire, oval, ovate or elliptical, pointed, with a smooth or wrinkled surface. There are 25 ... 50 leaves on one plant. The number of leaves and their size vary greatly depending on the variety and growing conditions.

Leaves and stem are covered with short adhesive hairs. The inflorescence is paniculate, corymbose. The flowers are pedicellate, five-petalled, with bracts. Tobacco is a self-pollinating plant, but cross-pollination is also possible. The fruit is a two-nested oval-shaped multi-seeded box, brown, cracking when ripe. The seeds are oval, dark brown, small. The weight of 1000 seeds is 0.05 ... 0.12 g.

The tobacco industry is usually divided into two groups of tobacco: cigarette and cigar tobacco. Cigarette tobacco is divided into Oriental and American. Oriental snuff is widespread in our country, with varieties of tobacco that are divided into aromatic

(flavouring, added to tobacco raw materials in small quantities) and skeletal, which form the basis of smoking products.

Features of biology. Tobacco is a typical short-day plant. Seeds begin to germinate at a temperature of 10 ... 12 ° C. The most favourable temperature for plants is 25 ... 30 ° C. At temperatures above 35 ° C, tobacco growth stops. For young plants, frosts of -2 ... - 3 ° C are destructive. However, in autumn, tobacco tolerates short-term low temperatures well. It is a moisture-loving plant. The greatest amount of moisture is required when planting seedlings and rooting them, as well as during the period of leaf formation and rapid plant growth. Lack of moisture at this time leads to a decrease in leaf size, premature ripening, and a decrease in yield and tobacco quality.

Excessive moisture, especially on heavy clay soils, can lead to plant soaking. Tobacco is a light-loving plant. In case of insufficient light, its development is delayed and the quality of raw materials decreases. The most suitable structural soils for tobacco are light in particle size distribution and low in humus, while excessive humus affects the smoking quality of tobacco. Chloride compounds of sodium and especially calcium reduce its flammability. Tobacco does not grow well on heavy clay soils, as well as on saline and marshy soils.

In tobacco culture, there are two periods: the first is the cultivation of seedlings from seeds in greenhouses or on soil beds, and the second is the cultivation of tobacco from seedlings in the field. The period of seedling formation lasts 45...50 days or more, depending on the variety, and ends when the plants have 5...6 true leaves. The second period (from transplanting seedlings into the field to the onset of technical maturity of the leaves of the upper tier) lasts 80 ... 120 days. After transplanting the seedlings into the field, the plants take root within 10...15 days. This is followed by the phases of stemming, budding, flowering, seed formation and ripening. Leaves of tobacco are formed in a row. The technological properties of the leaves depend on the variety, tiering, and growing conditions.

Varieties. The varieties approved for use are Trapezoid 15 and Trapezoid 162.

Features of agricultural technology. The best predecessors of tobacco in the crop rotation are winter cereals, sugar beet, corn, annual legumes and cereal grasses. On soils with low fertility, tobacco is placed after cereal legumes and on the turnover of a layer of perennial legume-grass mixtures. Tobacco should not be cultivated after sunflower, hemp and melons, as they share pests and diseases with tobacco. If the crop rotation is highly saturated with tobacco, it may be re-planted in a year, after which other crops are sown in the field for 3 to 4 years.

On average, tobacco consumes 1 tonne of leaves, kg: N - 60, P 205 - 17, K 20 -46, CaO - 67. Nitrogen fertilisers should be used in moderate amounts, as excess nitrogen in the soil can affect the quality of tobacco raw materials.

Tobacco is grown only by seedlings. Seedlings are grown in heated and sunny greenhouses (nurseries), in film greenhouses, and in soil beds. Nurseries are placed on flat areas with a slight slope to the south or southwest, well-lit by the sun, away from tobacco fields, dryers and tobacco storage facilities to avoid infection of seedlings with Ryabukha, mosaic and other diseases. Nurseries for tobacco are prepared in the same way as for vegetable crops. The timing of sowing tobacco seeds in nurseries depends

on the timing of planting seedlings in the field. It takes 35...65 days to produce ready-made seedlings, depending on the type of nursery and weather conditions. For example, in the North Caucasus, seedlings are obtained in heated greenhouses on the 45th day, in sunny greenhouses on the 55th day and in soil beds on the 60th day after sowing. The seeding rate for tobacco seeds is 0.6 g per 1 m² of greenhouse, 0.8 g on warm beds, and 1 g/m² on cold beds. Care of tobacco seedlings includes watering, airing, feeding, weeding and pest and disease control. Seedlings are watered with small portions of water, but often to prevent the surface of the nutrient mixture from drying out. For seedlings, the preferred temperature from sowing to germination is 22 ... 28 °C, after germination 18 ... 25 °C. In greenhouses with technical heating, the temperature is regulated by heating, and in other greenhouses - by ventilation and covering them with mats for insulation. Weeds on seedlings are destroyed as they appear. thickened seedlings are thinned out. If the nurseries are dry, they are watered before weeding and thinning.

Seedlings suitable for planting should have a well-developed root system, a dense, flexible stem with 5...6 true leaves. Before sampling, the seedlings are hardened. To do this, 8 ... 10 days after the seedlings are watered every 1 ... 2 days, and 2 ... 3 days before transplanting, watering is stopped. The yield of seedlings is 2500 in greenhouses with a warming layer, 2000 in sunny greenhouses and 1500 plants per 1 m² in soil beds.

For 1 hectare of planting, 40 ... 60 m² of nurseries are required, depending on the variety. Seedlings are planted in the field when the temperature of the topsoil reaches 10 ... 12 °C and the danger of frost has passed. In most tobacco growing areas, planting of seedlings begins in the third decade of April and ends in the third decade of May. The density of tobacco plants depends on the cultivation area and the characteristics of the variety. Small-leaved varieties are planted according to the 50x12 scheme with 150 ... 200 thousand plants per 1 ha, medium-leaved varieties - 60 x 20 ... 24 cm with 80 ... 90 thousand and large-leaved varieties - 70 x 30 and 90 x 20 cm with 45 ... 55 thousand plants per 1 ha. Tobacco is planted using a seedling planting machine.

As with all wide-row crops, inter-row treatments are used to control weeds. special care methods include stripping, topping and pinching tobacco. stripping removes the lower seedling leaves, which are then destroyed. Cleaning promotes better development of the leaves of the following tiers. Creaming (removal of inflorescences) is carried out from the beginning of flowering 3 ... 4 times simultaneously with pinching (removal of side shoots). These tobacco care techniques help to increase yields, as plastic substances are not spent on further development of inflorescences and lateral shoots, but are used by the leaves.

The maturation of tobacco leaves does not occur simultaneously. The oldest lower leaves ripen first, followed by the middle leaves, and the top leaves are the last to ripen. Most varieties have five levels of ripening.

Tobacco leaves are harvested manually. Within 1.5 ... 2.0 months, 5 ... 10 breaks are made. The number of breaks usually coincides with the number of ripening levels. During one break, 3 ... 7 leaves are removed from one plant.

The harvested leaves are put into bundles and immediately sent to drying sheds, where they are sorted, strung on cords 5-6 metres long and dried. Tobacco is dried in two phases: catching and fixing (actual drying). Curing is carried out in drying sheds on special frames on which cords with strung tobacco leaves are hung. During languishing, which is most complete at a temperature of +25...+30°C, the plants still breathe and evaporate moisture. In the leaf tissues, proteins break down, starch is converted into sugar, and chlorophyll is destroyed. The nicotine content in the leaves decreases, while the aromatic substances increase. Moisture loss during languishing reaches 6...7%, and dry matter loss - 10...16%. As a result of languishing, the leaves turn yellow and their quality improves. Catching usually lasts 3 ... 4 days.

After languishing, fixation is carried out - the final drying of tobacco in the sun for 15 ... 20 days or in fire dryers at a temperature of 40 ... 42 °C at the beginning of drying and 48 ... 50 °C at the end. Dried leaves are sorted according to the standard into five varieties, tied into bales and delivered to procurement points. The moisture content of marketable raw materials in bales should not exceed 19%. From the procurement centres, the tobacco is sent to fermentation plants to improve its quality and make it resistant to mould, from where it is supplied to tobacco factories.

3.8.2. Terry



Importance. Mahorka is grown to produce smoking (fly) cereal, snuff and chewing tobacco. The dry leaves of this plant contain 5...15% nicotine and 15...20% organic acids, including 10% or more citric acid.

Terry stalks contain somewhat less of these substances. A significant part of the terry raw material is used to produce nicotinic (vitamin PP) and citric acids, which are used in the food and textile industries. Terry seeds produce fatty oil (35...40%) used in the production of paints, varnishes and soaps.

Mahorka is grown in the regions of the Central Black Earth zone, in Western Siberia, Chuvashia and Tatarstan. the area under Mahorka is about 10 thousand hectares. Botanical description. Makhorka (*Nicotiana rustica* L.) is an annual plant of the Solanaceae family.

The root of the terry is taproot, highly developed. The stem is erect, ribbed, with a loose core, up to 1.2 m high. The leaves are petiolate, heart-shaped or ovate, with a wrinkled surface, light or yellow-green in colour. 12...20 leaves are arranged on the stem. The leaves and stems are covered with short, capitate hairs that emit a strong, specific odour. The inflorescence is a panicle. The flowers are green or yellowish-green, pentagonal, with bracts. The mahogany plant is self-pollinating, but cross-pollination is also observed. The fruit is a bivalve multi-seeded capsule. The seeds are small, brown or creamy. The weight of 1000 seeds is 0.25 ... 0.35 g.

Features of biology. Mahorka is a long-day plant. Its development accelerates as it moves north, which makes it possible to grow this crop even in the Arctic. However, compared to other long-day crops, it is more thermophilic.

Terry seeds begin to germinate at a temperature of 7 ... 8 ° C. The most favourable temperature for growth and development is 20 ... 25 ° C. Terry is sensitive to low temperatures and is damaged by frosts of -2 ... - 3 °C. The culture requires constant sufficient moisture supply, even with short-term water stress, the quality of raw materials deteriorates. The best soils for terry are loamy chernozems, sandy loam and loamy sod-podzolic soils.

Varieties. The most common varieties are the following: Malopasynkovy Pekhlets 4, AC 18/7. Features of agricultural technology. The best predecessors of makhorka are winter breads, corn, root crops, cereal legumes, perennial grasses and vegetable crops. Terry should not be planted after melons, potatoes, hemp and sunflower, which have common diseases and pests. Terry is a good predecessor for many field crops.

The plant is demanding on the level of soil fertility. to form 1 tonne of dry leaves and stems, terry consumes, kg: N - 24, P₂O₅ - 10, K₂O - 35. A good yield of dry leaves and stems is considered to be 3.0 ... 3.5 t / ha.

There are two ways to grow makhorka: by seedlings (hanging) and by sowing seeds in the field (sowing). Seedling culture is of great importance for the northern regions, requiring increased costs for growing seedlings and planting them. However, low-lying areas flooded by hollow water and insufficiently structural soils can be used for it.

Sowing is best done in elevated areas with light structural soils. Terry seedlings are grown in the same way as tobacco seedlings, in greenhouses or on soil beds. The seeding rate in greenhouses is 1.5 ... 2.0 g / m², on warm beds 2.0 ... 2.5 and on cold beds - 2.5 ... 3.0 g / m². Before sowing, the seeds are pickled in a weak solution of formalin and germinated at a temperature of 25 ... 28 ° C for 3 ... 4 days. When sowing, they are mixed with clean sand in a ratio of 1: 40. To plant 1 ha of terry, depending on the variety, 30 ... 45 m² of greenhouses or 45 ... 60 m² of warm beds are required.

Seedling care consists in maintaining the most favourable temperature (18 ... 20 ° C), thinning the plants, 2 ... 3 times feeding, watering and hardening. Seedlings ready for planting have 5 ... 6 true leaves and reach a height of 8 ... 12 cm. It takes 30...35 days to grow seedlings in greenhouses, and 40...45 days in beds.

For makhorka, it is most effective to plant seedlings in the early stages, after spring frosts, when the topsoil warms up to 10 °C. In the Central Black Earth Zone, planting of seedlings begins in the second decade of May, and in the northern regions of the Non-Black Earth Zone and Siberia - in late May - early June.

Seedlings are planted with a seedling planting machine or manually with row spacing of 60 ... 70 cm and plant spacing of 25 ... 30 cm. For large-leaved varieties of makhorka, a density of 60 ... 70 thousand plants per 1 ha is adopted, for medium-leaved varieties - 70 ... 80 thousand and small-leaved - 80 ... 90 thousand per 1 ha.

Mahorka is sown in the early stages, simultaneously with the sowing of early grain breads. For sowing, germinated seeds are used in a mixture with dry seeds in equal amounts. germinated seeds germinate in 5...7 days after sowing, and dry seeds in 15...18 days. This makes it possible to get good seedlings in the event that early seedlings from germinated seeds are severely affected by frost. Mahorka is sown in a wide-row method with row spacing of 60 ... 70 cm using special or grain seeders with

depth limiters. The seeding rate is 2 ... 3 kg/ha, the sowing depth is no more than 1 cm. In case of soil crust formation before emergence, it is destroyed with rotary hoes. The first loosening of row spacings is carried out at the beginning of emergence to a depth of 5 ... 6 cm, the second - in 8 ... 10 days after the first to a depth of 6 ... 8 cm.

The bouqueting of terry begins when two true leaves appear. With a wide-row sowing with row spacing of 60 cm, the cut width is 20 cm, the length of the bouquet is 10 cm, and the distance between the centres of the bouquets is 30 cm. After 2 ... 3 days, the bouquets are thinned out, leaving 3 ... 5 well-developed plants in them. The final breakthrough is carried out 10 ... 12 days after bouqueting, when the plants have 5 ... 6 leaves, one best plant is left in each bouquet. Simultaneously with thinning, the first feeding is given.

The planting density of terry-seedlings is the same as for hanging: 60 ... 70 thousand plants per 1 ha for large-leaved and 80 ... 90 thousand for small-leaved varieties. After thinning, the row spacing is loosened (2 ... 3 times) and the plants are fed. before the first or second inter-row treatment, 2 ... 3 lower leaves are removed from the upright and seedlings (terry cleaning).

Creaming (removal of inflorescences) should be carried out during budding, and pinching should be carried out when the lateral shoots grow by 5 ... 7 cm. Makhorka is harvested in one step with whole plants at the onset of technical ripeness, which is characterised by the fragility of the leaves and their sagging. Ripe leaves give off a strong peculiar smell. If harvesting is delayed, makhorka can be damaged by autumn frosts.

For faster drying of the ripe terry 3 ... 4 days before harvesting, the stems are cut from top to bottom (layered), leaving the lowest part of them 5 ... 6 cm long untouched so that the plants do not lie down. Flaking shortens the drying period by 10...12 days and reduces the loss of dry matter. Terry is harvested manually in dry, sunny weather. it is cut down to the root, leaving no small stumps. the cut plants are left in the field for drying, which is completed when the terry leaves become soft and do not break when bent.

From the field, the terry is transported to drying rooms, where it is languished at a temperature of 30...40°C for 20...24 hours. For languishing, the terry is stacked outwards in stacks with a width equal to two plants and a height of 50 ... 70 cm. After

languishing, the terry is dried for 25 ... 30 days in well-ventilated rooms to a standard humidity of 35% and delivered to the procurement centre.



3.8.3. Hops

Significance. Hop growing is a very important branch of crop production. Hop cones are an indispensable raw material for the brewing industry. In addition to carbohydrates, proteins, oils, and ash

substances that are found in any plant, hop cones contain a range of substances that are not found in the organs of other plants.

The lupulin glands of hop cones contain bitter substances, alpha acids, resins, tannins, polyphenols, and essential oil. These substances give beer a pleasant bitter taste, colour, aroma, and contribute to its foaming and foam stability, as well as storage stability.

Hop cones are also used to make liquid yeast for the baking industry in the baking of wheat bread and in the production of soft drinks. Hops are also used in pharmacology and cosmetics. Hop stalks can be used to make strong coarse fibre.

Hops grow in the wild in Europe, Asia Minor, and North America. As a cultivated plant, hops are grown in the Czech Republic, Slovakia, Austria, Poland, the Netherlands, England, Germany, the USA, and Canada. The global area under hop cultivation exceeds 60 thousand hectares.

In Ukraine, hops are grown on an area of 8-9 thousand hectares. Hop production is concentrated in Zhytomyr, Khmelnytsky, Vinnytsia, Kyiv, Chernihiv, Volyn and Rivne regions. Average yields of hop cones in Ukraine reach 10-12 centners per hectare.

Biological characteristics. Hops belong to the hemp family (Cannabaceae L.). In production, common hops (*Humulus lupulus* L.) are widespread. This is a dioecious or monoecious plant, with underground organs (main rhizome or uterus, lateral rhizomes and roots) being perennial, and stems being annual. Hops are propagated vegetatively by cuttings harvested during the spring pruning of the mother plants.

Hops are picky about growing conditions. It belongs to temperate plants, grows and develops well at a temperature of 20-25° C, and can easily withstand severe frosts and spring frosts. Young plants can tolerate frosts down to minus 3-5° C. High temperatures inhibit plants and reduce their productivity. The sum of effective temperatures from the beginning of the growing season to harvesting is 2000-2800° C.

Hops are picky about moisture, which is due to the intensive formation of a large vegetative mass. It grows best where the annual rainfall is 500-600 mm.

Hops are a light-loving plant. Under shady conditions, light, loose cones with a low content of bitter substances are formed. In years with insufficient sunshine during the ripening period, the quality of hop cones deteriorates.

Hops are not very demanding on the soil. However, the highest yields are obtained when plantations are located on fertile deep soils with a poorly compacted subsoil and deep occurrence of soil water. The best soils for hops are podzolised black soils, grey and dark grey forest and soddy-low-podzolic soils. Heavy and light sandy and marshy soils are of little use for hops. The optimum reaction of the soil solution is pH 5.5-6.5. Hops have increased requirements for the content of nutrients in the soil.

The growing season for hops - from the beginning of spring growth to the ripening of cones - lasts 100-120 days, depending on the variety and growing conditions.

The following hop varieties are zoned in Ukraine: Alta, Zagrava, Clone 18, Regent, Slov' yanka, Zmina, Kumyr, Promin, Polissya, Granit, etc.

Growing technology. Hops are a perennial plant. It is grown on one site for 12-15 years. Therefore, the right choice of areas for hop planting is extremely important.

Hops are planted in flat areas with a slight slope (up to 5°) to the south, southwest and southeast. Unsuitable for hops are gurnts where the gurnt water lies at a depth of 1.5-1.8 m. To protect the hops from the prevailing winds, hop houses are planted near forests, orchards or forest belts. When hops are planted in open areas, they are surrounded by protective strips of fast-growing trees at a distance of 20 cm from the edges of the plantation.

Hops are placed on 30-50 hectares of land, which are divided into separate plantations of 2-3 hectares, with 3-4 m wide roads between them. On each hectare, 140-150 posts 8-9 m high are buried to form trellises. Galvanised wire is stretched over the tops of the posts, from which wire supports are stretched to each bush.

In the areas allocated for hops, reclamation measures are carried out in advance, windbreaks are planted, etc.

Cultivation of gurnt. The main cultivation of gurnt for hops involves cultivating it to the depth of the root layer. It includes peeling, deep loosening, ploughing, and replanting. After the stubble predecessors, peeling is carried out with LDG-10, LDG-15 peelers or disc harrows to a depth of 6-8 cm. After 15-20 days, the area is deeply loosened

(60-100 cm) with the ShP-000 and ShUN-2.6 after fertilising with mineral fertilisers in one or two directions.

On dark grey, grey podzolic and black soil soils with a humus layer of 50 cm, a year before hop planting, plantation ploughing is carried out to a depth of 50 cm using PPN-50 and PPU-50A plantation ploughs.

On sod-podzolic soils with a shallow topsoil, the trench method of hop preparation is used. To do this, organic mineral fertilisers are applied in a dose of 100-120 tonnes, phosphorus fertilisers - 150 kg and potash fertilisers - 180 kg of d.p. per 1 ha before cutting the trenches into a 3-4 m wide strip. The mineral fertilisers are mixed with the gurnt by discing. The mixture of the fertile layer of gurnt and organo-mineral fertilisers is moved to the side by a bulldozer with a D-607 rotary blade. After that, trenches 50-60 cm wide and 60-70 cm deep are cut with rotary excavators in the direction of the future hop rows and the prepared organic-mineral mixture is poured into them. The area prepared in this way is planned out, the remaining mineral fertilisers and lime are applied, and continuous ploughing is carried out to the depth of the humus layer. Before planting hops, the area is deeply loosened with a cultivator.

Fertilisation. High yields of hop cones are obtained only when the plants are provided with nutrients. With a yield of 18-20 c/ha of cones, hops take out up to 200 kg of nitrogen, 60-80 kg of phosphorus, and 200 kg of potassium from the soil.

In the second and subsequent years after planting hops, organic and mineral fertilisers are used. On soils with a humus content of up to 1%, 50-60 t/ha of organic mineral fertilisers are applied, with 1-2% - 40-50 t/ha, with 2-3% - 30-40 t/ha, and above 3% - 20-30 t/ha. Organic mineral fertilisers are applied in autumn for ploughing. When organic mineral fertilisers are applied a year later, their dose is increased by 50 per cent.

The doses of nitrogen fertilisers are set according to the humus content of the soil and the planned yield. For example, 120-160 kg/ha are applied to soils with a humus content of 2-3%, with a cone yield of 10-15 c/ha, 170-200 kg/ha with 15-20

c/ha, and 210-240 kg of nitrogen active ingredient per 1 ha with 20-25 c/ha. Half the dose of nitrogen fertiliser is applied in autumn for ploughing. The other half is applied in the spring for top dressing.

The doses of phosphorus and potassium fertilisers are calculated for the planned yield, taking into account the availability of these nutrients in the soil. For example, on soils with an average supply of phosphorus and potassium, with a cone yield of 10-15 c/ha, it is recommended to apply 90 kg/ha of phosphorus and 120 kg/ha of potassium. On medium and heavy soils, phosphorus and potassium mineral fertilisers are applied in autumn when ploughing hop row spacings, while on light soils, half of the phosphorus-potassium mineral fertilisers are applied in autumn and the other half in spring and as top dressing. Hops are fed during intensive growth and before flowering. Feeding is carried out simultaneously with hilling.

Planting. Hops are planted with seedlings and cuttings. However, seedlings are the best planting material. Compared to cuttings, they take root better and produce a higher yield of cones in the first year. In the autumn, holes measuring 45x45x45 cm are dug in the fertilised areas with BM-204 and BKGO-67 machines, which are covered with the top fertile layer of humus mixed with 5-7 kg of humus or compost and annual seedlings grown in schools or hop cuttings are planted. Hops are planted in rows according to the 2.1x1 m, 1.6x1.6 m, and 2.5x1 m schemes. For mechanised planting of seedlings, the MLU-1 seeding and planting machine is used.

Care. In the first year of the hop's life, before emergence, the row spacing is loosened to break up the crust. When about 75 per cent of the seedlings germinate, new seedlings are planted to replace those that have not germinated. During the growing season, 4-5 row spacing loosening with cultivators is carried out with simultaneous harrowing by 10-12 cm. When the height of the hop plants reaches 40-50 cm, they are planted on T- or V-shaped wire supports, creating the optimal number of plants (14-16 thousand productive stems).

In the second year of the hop's life, the ridges are ploughed up in early spring, and the lateral rhizomes and underground stems of the previous year are cut off on the queens. This operation is carried out before the emergence of seedlings (I-II decades of April). The height of stem cutting depends on the condition of the plants: on highly developed plants - above the first and second pair of eyes. For mechanised pruning of queens, use the PKX-1 seed tiller on a plough with a ripper.

Damaged plants are uprooted and replaced with new cuttings or seedlings. The cut stems and uprooted plants are removed from the plantation and burned.

After pruning the hops, herbicides are applied and the soil is loosened between the rows. The following herbicides are used against weeds: basagran (4.2 l/ha), dual (2.5 l/ha), treflan (1.5-2 kg/ha), etc. During the growing season, row spacing is loosened 5-6 times from 6-8 to 16-18 cm. Hop plantings are hilled twice. The first hilling is carried out when the height of the plants reaches 3-4 m, and the second - when the plants reach the top of the trellis. It is better to huddle hops after rain. In dry years, the second hilling is not carried out. Each hilling is carried out once with hop fertilisation. The first feeding is carried out with full mineral fertiliser (N₉₀ K₄₅ P₄₅), and the second - with phosphorus-potassium fertiliser (P₄₅ K₄₅).

The following insecticides are used to control alfalfa weevil on hops: aktara (0.1-0.14 kg/ha), durbsan 480 (2-2.5 litres/ha), and stefesin (1 litre/ha). When spider mites, aphids, and sawflies appear on the plants, hops are treated with B-58 new (1.5 kg/ha), Confidor (0.6 l/ha), Mitak (3 kg/ha), 57% fufanon (1 kg/ha), etc.

Against diseases, hops are sprayed with allate (3.0-5.0 kg/ha), cuproxate (3.0-5.0 kg/ha), copper chloride (3.2-4.0 kg/ha). Zinc sulphate (3 kg/ha) is used against viral diseases.

Harvesting. Hops are harvested when they are technically ripe, when the cones are dense, golden-green or light green in colour, have a specific hop aroma and when they accumulate the most alpha acids. In the main hop-growing regions, hop harvesting begins in the second half of August and ends by 15 September. Delayed harvesting worsens the quality of the cones due to the shedding of lupulin grains. Hops are harvested using hop harvesting machines ChKh-4L, LKh-2, KhMP-1 or manually.

Harvested hop cones are divided into two categories: basic (cones of light yellow-green to golden-green colour) and limiting (cones of yellowish-green, green-yellow, yellow with brown spots, brown). At the post-harvest processing points, the cones are dried with heated air (up to 30° C) for 12-14 hours with their moisture content brought to 25-30%. After that, the cones are dried in the drying chambers of special dryers (PCB-750K) at a temperature of 40-50° C with the moisture content brought to 9-10%. The dried cones are placed in dry and dark rooms for curing. After curing, the cones, laid out on wooden racks with a layer of 1.5-2 m, are humidified with air to a moisture content of 11-13 per cent. To preserve the cones' qualities, they are sulphited in a drying chamber with sulphur dioxide from burnt sulphur. The hop cones processed in this way are packed in bags and shipped to hop breweries.

In autumn, the stems are removed from the supports and taken out of the hop houses. Organic (40-50 t/ha) and phosphorus-potassium fertilisers are applied to the plantations, and ploughing is carried out with hop ploughing for the winter.

Conclusions to Section 3

1. Technical crops important to industry and humanity include those for textiles (cotton), biofuels (corn, sugarcane), and materials (rubber), as well as other food staples processed industrially (wheat, rice, soybeans, sugarcane). These crops are crucial for products like clothing, fuel, and sweeteners, and some also serve as important food sources or animal feed. Provides fibers for the global textile industry, used for making clothing and other fabrics. Latex from these plants is used in manufacturing tires, gloves, and other rubber products.
2. Cultivated for its fibers, which are used in various industrial applications. Used for biomass and in carbon capture and storage initiatives. Widely used for producing bioethanol. A major source for producing both sugar and biofuels. While primarily used for animal feed, they are also processed for industrial uses and biodiesel. For food and industrial processing. Major staple crops with significant industrial applications, including food processing and the production of ethanol. Processed for sugar, with by-products like bagasse used for energy. Processed into a wide variety of products beyond animal feed. A fundamental food source globally, often grown and processed on an industrial scale.
3. Industrial crops are plants cultivated for industrial purposes, such as producing raw materials, biofuels, fiber, and chemicals, rather than direct human or animal consumption. Examples include crops used for oils like sunflowers and corn, fiber crops like cotton and flax, and energy crops for bioethanol and biodiesel production. These plants are processed industrially to create a wide range of products from textiles and cosmetics to plastics and pharmaceuticals.
4. Plants grown for their seeds, which are processed for edible or industrial oils. Examples include sunflower, soybean, and linseed. Plants that provide fibers for various uses, such as cotton for textiles or hemp for rope and fabric. Crops cultivated specifically for producing renewable energy, like corn for bioethanol. These include plants used for medicinal, aromatic, or cosmetic purposes, such as tobacco, hops, and herbs. Crops like sugarcane and sugar beet are used for producing sugar and other industrial by-products.
5. Plants like corn and sugarcane are used to create biofuels such as bioethanol and biodiesel. Fiber crops provide materials for textiles, paper, and other industrial products. Various industrial crops are used to extract oils, essential oils, and other compounds for cosmetics, lubricants, and pharmaceuticals. Some crops, like corn and soybeans, are also used as industrial crops for animal feed or processed food products, though they are also consumed directly.

Questions for discussion and self-assessment to Section 3

1. General characteristics of root crops.
2. Botanical and morphological characteristics of sugar beets.
3. Significance and biological characteristics of sugar beets.
4. Technology of sugar beet cultivation.
5. Significance and biological characteristics of potatoes.
6. Botanical and morphological characteristics of potatoes.
7. Chemical composition of potato tubers.
8. Potato cultivation technology.
9. Botanical and morphological characteristics of oil crops, sunflowers.
10. Characteristics of vegetable oil.
11. Sunflower cultivation technology.
12. Poppy. Significance, biological characteristics, and cultivation technology.
13. Blue mustard. Significance, biological characteristics, and cultivation technology.
14. White mustard. Significance, biological characteristics, and cultivation technology.
15. Winter rapeseed. Significance, biological characteristics, and cultivation technology.
16. Essential oil crops, their significance in the national economy, and areas of distribution.
17. Coriander. Significance, biological characteristics, and cultivation technology.
18. Peppermint. Significance, biological characteristics, and cultivation technology.
19. Types of programs for computerized crop yield forecasting.
20. Characteristics of fiber crops, their importance and areas of distribution.
21. Long-staple flax. Importance, areas of distribution and biological characteristics.
22. Technology of growing long-staple flax.
23. Stages of ripeness, timing, and methods of harvesting long-stemmed flax.
24. Primary processing of long-stemmed flax.
25. Preparing legume seeds for sowing. Controlling pea weevils (bruchus).
26. Protection of sunflowers from diseases and pests. Desiccation of sunflowers.
27. Control of sugar beet pests.
28. Control of sugar beet diseases.
29. Post-harvest ripening of seeds.
30. Cleaning, sorting, and calibrating seeds.
31. Pre-sowing preparation of crop seeds.

APPROXIMATE LIST OF TEST TASKS

Question 1. Match the following bread groups with their representatives

1. Real breads	A. Rye
2. Millet breads	B. Barley
	V. Rice
	D. Millet
	Д. Sorghum plants
	E. Winter wheat
	J. Oves

Question 2: Match the following plants with the types of fruit

A. Box	1. Buckwheat
	2. Millet
	3. Rapeseed
B. Nut	4. Sunflower
	5. Safflower plants
	6. Peanuts
C. Bibe	7. Poppy
	8. Flax
	9. Soybeans
D. Pod	10. Triticale
	11. Sugar beet
E. Semenka	
I. Zernivka	

Question 3: Match the following plants with the amount of moisture required for seed germination

1. 1.	A. 25-30 per cent
2. Millet, sorghum plants	C. 100-110 per cent
3. Sugar beet	C. 160-170 per cent
4. 4. peas, soya	D. 55-60 per cent

Question 4. From the list below, select the correct statements that describe the flowering and pollination of the named plants:

A. Buckwheat	1. Different heights of anthers and pistil stigma in the flower
B. Barley	2. Pollinating your plant with pollen.
C. Corn	3. Pollination with pollen from the flowers of another plant.
D. Winter wheat	4. Differential maturation of male and female flowers generative organs.
	5. Male flowers ripen earlier

	6. Pollination by pollen from the same unopened flower. 7. Female flowers ripen earlier

Question 5. Which of the following plants are typical cross-pollinating plants?

1. Barley, 2. Corn, 3. Hemp plants, 4. Rice, 5. Beans, 6. Sunflower, 7. Flax, 8. Buckwheat.

Question 6. Which of the following plants are anemophilous due to their adaptation to pollen transfer?

1. Sainfoin, 2. Corn, 3. Alfalfa, 4. Sorghum plants, 5. Beans, 6. Sunflower, 7. Vetch, 8. Buckwheat, 9. Rye.

Question 7. Select the correct and arrange the phases of growth and development of cereal plants in order of their passage

1	Bushing
2	Output to the tube
3	Flowering
4	Spikelets
5	Stairs
6	Ripening
7	Yellow ripeness
8	"Fir tree"

Question 8. Seed germination capacity (SGC) is calculated by the formula.....

(write the correct answer in the answer sheet using the formula)

Question 9. From the list below, select the statements that describe the achievements of the scientists presented.

1. I.I. Tumanov 2. M.I. Vavilov	A. Author of the classical textbook "Plant Industry", the law of homologous series and hereditary variability; the doctrine of the world centres of origin of plants, the immunity of plants to diseases and pests; collected the world's richest collection (over 350 thousand) of plant specimens from 68 countries.
	C. Author of twelve stages of organogenesis of the plant life cycle, which occur in a certain sequence, allowing to have an idea of the peculiarities of plant development in advance, before the onset of a certain phase, and to take the necessary measures to strengthen or weaken them

	C. Author of the theory of hardening of winter cereals, researcher of the physiology of plant adaptation to low temperatures.

Question 10. Match the plants to the row spacing when sowing them:

1. 15 cm 2. 45 cm 3. 70 cm 4. 7.5 cm	A. Peas
	B. Rapeseed
	C. Sugar beet
	D. Corn for green fodder
	E. Corn for seed and silage
	G. Sunflower
	3. Plants of flax longifolia
	K. Grechka
	L. Potatoes

Question 11: Correlate the recommended planting density of sunflower for the harvesting period with the following growing regions

1. Southern Steppe	A. 40-41 thousand plants/ha
2. Central Steppe	B. 30-35 thousand plants/ha
3. Forest-steppe	C. 50-55 thousand plants/ha

Question 12. Match the average seeding rate with the plants:

1. 3.5-4.5 million UAH/ha 2. 22-23 million USD/ha 3. 0.9-1.5 million USD/ha 4. 50-60 thousand/ha	A. Peas
	B. Winter wheat
	C. Corn for seed
	D. Sunflower
	Д. Plants flax longifolia
	J. Grechka
	3. Potatoes

Question 13. Indicate which letters on the plants in the figure represent the following plants

1 - Soybeans 2 - Peas 3 - Beans 4 - Lupine	

Question 14. Calculate the actual seeding rate, if the recommended seeding rate for winter wheat plants in the Forest-Steppe is 5 million/ha of germinating seeds, the weight of 1000 seeds is 45 g. The seed germination rate is 96 per cent.

(write the correct answer in one number in the answer sheet)

Question 15. Scientifically based alternation of agricultural plants and steam in time and on the territory is called

(write the correct answer in one word in the answer sheet)

Question 16. Indicate which numbers on the plants in the figure indicate the eaten parts of the wheat plant grain

A - rudimentary leaves;
B - growth point (growth cone);
B - embryonic stem;
D - bangs;
D - fruit shell;
S - seed coat;
A - aleurone layer;
K is the endosperm itself;
L - coleoptile;
M - embryonic root;
H - root cap.

Question 17. - plant resistance to a range of adverse wintering conditions.

(write the correct answer in one word in the answer sheet)

Question 18. Indicate what organic matter is valued in potato tubers?

1	Proteins;
2	Fats;
3	Starch;
4	Sucrose;
5	Fibre.

Question 19: Which plant of group 2 breads has two types of inflorescences?

1	Millet
2	Sorghum plants
3	Rice
4	Corn

Question 20. Select from the list the characteristic biological features of tobacco:

1. Withstands shading.
2. Light-loving.
3. Moisture-loving

4. A plant of the steppe regions

Question 21. State the main method of growing tobacco:

1. 1. Seedless.
2. 2. Seeds.
3. Seedling.
4. 4. Vegetative.

Question 22: Tobacco is harvested at technical maturity at:

1. Brown the main vein of the leaf.
2. Whitening of the main leaf vein.
3. The light colour of the leaves.
4. 4. Dark green colour of the leaves.

Question 23: Indicate the moisture content at which the drying of terry leaves is stopped.

1. 14-16 per cent
2. 16-18 per cent
3. 18-20 per cent
4. 20-22 per cent

Question 1. Set of accordance between the adopted groups and types of wheat

1. Hulled wheat 2. Nude wheats	A. Aestivum
	B. Spelta
	C. Turgidum
	D. Monococcum
	E. Dicoccum
	F. Sphaerococcum

Question 2. Group crops depending on the types of inflorescences, that characteristic them

1. Spike 2. Panicle 3. Brush	A. Flax
	B. Wheat
	C. Corn
	D. Soy
	E. Barley
	F. Oat
	G. Mustard

Question 3. Set accordance between the adopted crops and to botanical families:

1. Lentil	A. Poaceae
2. False flax	B. Fabaceae
3. Buckwheat	C. Polygonaceae
4. Corn	D. Brassicaceae

Question 4. From a list choose correct statements which characterize the rootage of the adopted crops :

A. Buckwheat B. Rye C. Corn D. Pea	1. Rootage cored
	2. A rootage is well developed
	3. A rootage is characterized by high by physiology activity
	4. Rootage sod
	5. Part of chums in general mass of plant folds 10 %
	6. A rootage has a different amount, depending on a ripeness, tiers of key chums

Question 5. What from the brought crops over do belong to the typical selfed crops?

1. Barley, 2. Corn, 3. Hamps, 4. Rice, 5. Kidney bean, 6. Sunflower, 7. Flax, 8. Buckwheat

Question 6. What from the brought crops over after adaptation to transference of pollen does belong to entomophillous?

1. Wheat, 2. Corn, 3. Flax, 4. Sorghum, 5. Kidney bean, 6. Sunflower, 7. Potato, 8. Buckwheat, 9. Rye.

Question 7. Choose correct and dispose the phases of height and development of flax on the order of their passing

1	Yellow ripeness
2	"Fir-tree"
3	Sprout
4	Buding
5	Early ripeness
6	Flowering
7	Bushing out
8	An output is in a tube

Question 8. From the brought list over choose statements which characterize achievement of the presented scientists.

1. F.M.Kuperman 2. M. I. Vavilov 3. I.I. Tymanov	A. Author of theory of tempering of winter-annual grain-growing, researcher of physiology of adaptation of plants to transference of subzero temperatures.
	B. Author of twelve stages of organogenesis of life cycle of plants, which flow in a certain sequence which enables in advance, to the offensive of certain phase, to have imagination about the features of development of plants and accept necessary measures in relation to their strengthening or weakening
	C. Author of classic textbook "Plant-grower", to the law of homological rows and inherited changeability; studies about the world focus of origin of cultural plants, about immunity of plants to illnesses and wreckers; collected the

	richest in the world collection (over 350 thousands) of standards of cultural plants from 68 countries of the world.

Question 9. Set accordance between the average norm of sowing and crops :

1. 3,5-4,5 mln.sh.seeds./he 2. 22-23 mln.sh.seeds./he 3. 0,9-1,5 mln.sh.seeds./he 4. 50-60 thousands/and	A. Pea
	B. Wheat
	B. Corn on grain
	C. Sunflower
	D.Long-stalk Flax
	E. Buckwheat
	F. Potato

Question 10. Set accordance between the oriented terms of sowing and crops :

1. on September, 1-25 2. 1-2 °C on the depth of seed bedding 3. 10-12°C on the depth of seed bedding 4. 6-8°C on the depth of seed bedding	A. Pea
	B.Winter wheat
	C. Sugar beets
	D.Sunflower
	E.Long-stalk Flax
	F.Buckwheat
	G.Oat

Question 11. The gravimetric (actual) norm of sowing (HВ) is calculated on a formula.

(in the form of answers enter a faithful answer a formula)

Question 12. Calculate sowing fitness of winter wheat seed, if the purity of seed is 98,6 %, laboratory germination ability- 97 %.

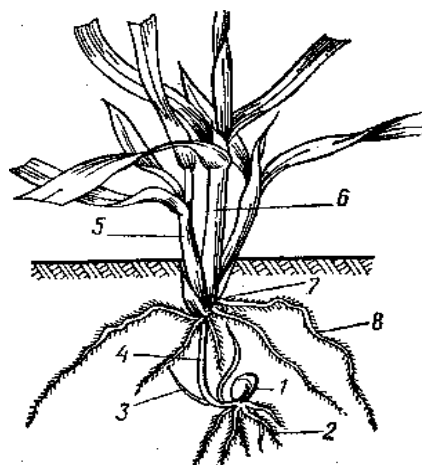
(in the form of answers enter a faithful answer a number)

Question 13. – it is a number, which shows the amount of water, necessary for synthesis of dry matter unit of certain crop

(in the form of answers enter a faithful answer in few words)

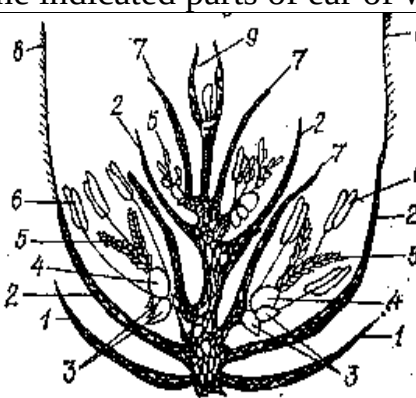
Question 14. Specify, what numbers on picture are mark the indicated parts of plant of wheat

- A. lateral escape from an embryonic knot
- B. Tillers (side shoots)
- C. Tillering node
- D. Main escapeof
- E. Underground stem
- F. Is key secondary roots
- G. It is a weevil
- K. Embryonic roots



Question 16. What numbers on picture are mark the indicated parts of ear of wheat

- A. ear scales;
- B. external scales of flowers;
- C. lodicule;
- D. ovary;
- E. snout;
- F. stamens;
- G. internal scales of flowers;
- K. awns;
- L. underdeveloped flower



Question 17..... :- it is a process of formation of lateral shoots and secondary roots on the underground knot of cereal grain-crops

(in the form of answers enter a faithful answer in a word)

Question 18. Choose the best predecessor of winter wheat in the area of Steppe

1	Sunflower
2	Clean fallow
3	A Maize for grain
4	Occupied fallow

Question 19. Specify, in how many years it is recommended to return a sunflower into previous place?

1	8-10 years
2	7-8 years;
3	5-6 years;
4	4-5 years;

Question 20. Specify crops from the list below which suitable for oil production?

1. Potato. 2. Rape. 3. Soya. 4. Mustard. 5. Pea. 6. Vetch. 7. Corn. 8. Oat.

Question 21. What processes do determine tempering of plants of winter crops ?

1	Piling up is in the knots of bushing out of fats
2	Piling up is in the knots of bushing out of albumens
3	Piling up is in the knots of bushing out of ash
4	Piling up is in the knots of bushing out of sugars and other organic matters

Question 22. Specify correlation of bringing of N of:P:K on rich in nitrogen soils at growing of long-stalk flax

1	3:1:1
2	1:2:3
3	1:3:4
5	3:1:2

Question 23. Specify, what factor leguminous plants fix atmospheric nitrogen due to?

1	Activity of nodules bacteria
2	Activity of the ground bacteria
3	Activity of the ground mushrooms
4	Finished off bringing
5	Photosynthetic activity of sheets

Question 24. Specify, on what fertilizers negatively buckwheat reacts and potatoes?

1	Nitric ammoniac;
2	Nitric nitrate;
3	Potassium, that does not contain a chlorine;
4	Phosphoric;
5	Potassium, that contain a chlorine.

Question 25. To group crops after the features of germination

1. Crops which take away seed-lobes on the surface of soil	A. Vetch
	B. Lentil
	C. Soya
	D. Chickpeas
2. Crops which do not take away a seed-lobe on the surface of soil	E. Pea
	F. Lupin
	G. Kidney Bean

Question 26. Set accordance of group of pesticides to their description

1. Desiccants	A. Preparations against fallen of plants
2. Fungicides	B. Preparations for a fight against illnesses
3. Herbicides	C. Preparations for the acceleration of ripening of seed
4. Retandrolums	D. Preparations for a fight against weeds

Question 27. Sowing unit of seed of sugar beets presents

1	50 thousand
2	100 thousand
3	150 thousand
4	200 thousand
5	75 thousand

Question 28. Specify the middle depth of bedding of knot of bushing out at a winter wheat

1	1-1,5 cm
2	5-6 cm
3	3-4 cm
4	1,8-2 cm

TERMS AND DEFINITIONS IN CROP PRODUCTION

Agrotechnical methods of pest control include scientifically based rotation of plants in crop rotation, use of healthy seed material, autumn tillage, optimal sowing dates, seeding rates, stem density, seeding depth, harvesting dates and methods.

Agrophytocenosis is an artificial plant community created on the basis of agrotechnical measures and constantly maintained by humans (sowing and planting of cereals, vegetables, fruit and industrial plants), which has poor dynamic qualities, including low environmental plasticity, but is characterised by high yields (productivity) of one or more plant species or varieties.

Soil aeration is the exchange of gas between soil air and the atmosphere, which enriches the soil air with oxygen and the active layer of the atmosphere with carbon dioxide.

Nitrogen fixation is the process of binding molecular nitrogen in the air and converting it into organic nitrogen compounds with the help of microorganisms that inhabit the soil environment.

Allelopathy is the effect of one plant on another as a result of the former's release of various substances called colines.

The bioclimatic productivity potential is the maximum amount of output that can be obtained from a hectare of crops given the available heat and water resources of a particular Plant science zone.

Biological yield is the amount of main and by-products grown, determined by the method of trial sheaves (before harvesting from the sown area), or by the calculation and balance method (after harvesting).

Biological control is the monitoring of the morphophysiological and physiological state of plants and the phytosanitary situation in crops during the growing season in order to timely adjust the conditions of air (carbon) and mineral nutrition of plants, use crop protection products to achieve optimal realisation of the plant (variety) productivity potential.

The biological method of weed control is the suppression and destruction of weeds with the help of specialised insects, fungi and bacteria.

Biological method of plant protection is the use of living organisms or their products to reduce the number and harmfulness of pests and create favourable conditions for the activity of beneficial species in agrocenoses.

Weeds are wild plants that invade agricultural land and inhibit the growth and development of plant life.

Soil buffering capacity is the property of soil to resist changes in the physical state and reaction of the soil environment.

Gross yield is the conditional total weight of economically useful plant products harvested from the entire sown area.

The vegetation period is part of the plant ontogeny, during which vegetative organs are formed.

Vegetation cycle is a period in the ontogeny of plants during which, under agrometeorological conditions, one generation of offspring lives and reproduces.

Vegetation is a set of processes of active plant life with inherent signs of growth

and development in terms of biological properties during the vegetation cycle.

Freezing of plants is an unfavourable agrometeorological phenomenon during the period of winter dormancy of overwintering plants, which is determined by their internal damage or death at temperatures lower than the critical temperature at the depth of the tillering node.

Soaking is an unfavourable agrometeorological phenomenon of winter crops and perennial grasses dying from prolonged exposure to rain and melted surface water.

A production trial of a technology is a field trial carried out in production conditions to test scientific recommendations and assess the effect of technology elements on the crop and its quality.

Winter plant loss is a phenomenon that occurs when there is a sharp and active increase in heat during the period of vegetation recovery and, at the same time, a moisture deficit in the topsoil. In this case, the secondary root system does not have time to use moisture from deeper soil layers, and the plants die. This phenomenon is more common in late spring.

Plant bulging is the process of forcing the tillering nodes of winter plants onto the soil surface, accompanied by root breakage.

Plant damping off is a type of plant death caused by unfavourable temperatures during winter dormancy of overwintering, mostly overgrown plants, due to intensive respiration under a significant layer of snow and significant consumption of nutrient reserves.

Vegetation recovery is the self-restoration of active plant life under the influence of changing agrometeorological conditions.

Water consumption is a set of processes of water use by plants in field crops to ensure physiological functions during the growing season.

Total water consumption is the amount of water used for transpiration and physical evaporation by the soil during the growing season.

Sustainable wilting moisture is the amount of soil moisture at which irreversible signs of plant wilting begin to appear.

The tillering node is a morphological sign of the developmental phase, a section of the main mother shoot from which lateral shoots separate.

Hybridisation is the process of producing hybrids based on the combination of genetic material from different cells in one cell.

Herbicides are chemicals used to kill unwanted vegetation.

Heterosis is a phenomenon when the first generation of hybrids obtained as a result of unrelated crosses has increased viability, productivity, growth, resistance to pests, diseases, etc.

Hydrothermal coefficient (HTC) by G.T. Selyaninov is an agrometeorological indicator of atmospheric moisture and is determined by the ratio of precipitation for a period with an average daily air temperature above 10⁰ C to the sum of average temperatures for the same period, reduced by a factor of 10.

Seed placement depth is the distance between the field surface and the place where the seeds of field plants are placed in the soil.

Soil crust is a highly compacted surface layer of soil. In some cases, the crust lags behind in the form of tiles, in others it is a monolithic, solid layer that gradually

passes into the lower loose layers. The thickness of the crust can be from 1-2 mm to 50-80 mm. It impedes the emergence of seedlings and plant respiration.

Soil and climatic productivity potential is the maximum amount of output that can be obtained from a hectare of crops as a result of the integrating effect of heat and water resources and the potential soil fertility of a particular Plant science zone.

Plant density is the number of plants per 1 m² of sowing.

Two-phase harvesting means harvesting with the main products separated in two stages.

Determinant varieties - the advantages of this form are increased flower fertility, higher leaf and root supply, fast rate of initial fruit formation, separate passage of the phases of linear shoot growth and fruit filling, increased heat resistance and resistance to lodging.

Ecological feasibility of the technology - the use of agrotechnical measures and chemicals as elements of the technology does not adversely affect the environment.

The economic threshold of harmfulness is the amount of pest or plant damage at which yield losses can be > 3-5 per cent, and the use of chemical protection measures increases the profitability of plant production and reduces the cost of the crop.

The economic threshold of weed damage is the number of weeds per 1 m² of row crops or the percentage ratio of the number of crops and weeds in a continuous crop.

Elements of technology are interrelated agrotechnical, land reclamation, and organisational measures that make up the cultivation techniques, namely crop rotation systems, soil cultivation, fertilisation, chemical and biological plant protection in the agrophytocenosis of sowing and the farming system as a whole.

Epiphytosis is a massive plant disease caused by the activity of a phytopathogen.

Desiccation of crops is the pre-harvest chemical drying of plants on the stump, which accelerates their ripening and facilitates machine harvesting.

Seed teasing is a change in the shape and size of seeds with the gradual addition of fillers, adhesives and/or protective and stimulating substances (pesticides, plant growth regulators, microelements), which ensures accurate sowing to the final plant density and protection against pests.

Effective temperature is an agrometeorological indicator, a positive air or soil temperature reduced by the value of the biological minimum in a certain period of plant development.

Potential weed infestation - the possible level of weed infestation of crops due to the content of viable seeds in the topsoil.

Winter drought is the cessation of water supply to the above-ground part of the plant when there is no snow cover in the fields and the air temperature rises to 0°C or higher during the day or when there is intense solar radiation, which causes increased evaporation of moisture by the leaves and their drying out. As a result of leaf dehydration, the above-ground organs dry out, then the tillering nodes, and the plants die. Winter drought is often accompanied by bulging and blowing out of plants.

Winter hardiness of plants is the ability of overwintering plants in a state of anabiosis to withstand adverse agrometeorological phenomena of the winter period

without significant damage (low temperatures, ice crust, damping off, bulging, soaking, frosts alternating with thaws).

The conventional row sowing method is row sowing with row spacing of 10 to 25 cm.

Sowing sparseness is a deviation of the sowing density from its optimal value towards a decrease in the number of plants per area.

Leaf area index is a conditional indicator of the ratio between the total surface area of all plant leaves and the area occupied by these plants.

Seed inlay is the coating of seeds with an aqueous suspension containing protective and stimulating substances (pesticides, plant growth regulators, microelements), a film-forming agent and a colourant.

An integrated protection system is a complex technological process that is carried out by a sequence of measures using chemical and biological pest control methods, chemical and some special measures to protect plants from diseases and chemical weed control methods.

Water consumption coefficient is a conditional indicator of the amount of water consumed by plants to create a unit of production and is determined by the ratio of the mass of water used for transpiration and evaporation from the soil during the plant's growing season to its yield.

The FAR efficiency is a conditional indicator based on the ratio of the energy content in the phytomass of plants during the growing season to the amount of photosynthetically active radiation received during the same period.

Feed unit is a unit for assessing the nutritional value of feed. One feed unit is the calorific value of 1 kg of oat grain.

Rolling is a surface tillage method of soil cultivation with rollers to compact the top layer, crush clods and partially level the field surface in order to improve soil capillarity and seed contact, create conditions for shallow and uniform seed placement, reduce diffuse evaporation, and destroy soil crust.

The critical period is a part of the Plant science season in which the values of agrometeorological factors differ significantly from the optimum and are close to the tolerance limit.

Cultivation is a measure of surface or shallow soil cultivation for the purpose of loosening, partially moving, levelling the topsoil, incorporating fertilisers and destroying vegetative weeds.

A catch crop is a field plant that is sown under the cover of another plant and then grown as the main crop.

A vapour-forming plant is a plant harvested for green mass or hay before the first half of summer.

A cover plant is a field plant under which a seed plant is grown.

Post-harvest intermediate plant is an intermediate plant that is grown in the current year after the main crop is harvested for seed.

Intermediate post-cutting plant is an intermediate plant that is grown in the current year after harvesting the main plants for green fodder, silage or hay.

A row crop is a field plant sown in a dotted or strip method with row spacing or inter-row spacing that allows for soil cultivation for inter-row crop care.

A continuous sowing plant is a field plant sown in a spread or row method with row spacing of 7.5 to 25 cm.

Ice crust is a layer of ice formed as a result of alternating thaws and frosts and adhering tightly to the soil surface. The death of plants from suffocation occurs during prolonged exposure to crushed ice (for 30-40 days or more) due to impaired gas exchange - increased carbon dioxide concentration and lack of oxygen. Damage to plants from the ice crust also occurs as a result of direct mechanical impact - tearing of roots and tillering nodes.

Frost resistance of plants is a sign of biological adaptation, a genetically determined property of overwintering plants to withstand the effects of negative temperatures while maintaining the ability to vegetate and reproduce.

Mulching is the covering of the soil surface with various materials to reduce moisture evaporation, regulate the temperature regime, prevent structural damage, and control weeds.

Seeding rate is the number or weight of seeds sown per hectare, taking into account their economic suitability.

Soil cultivation is the mechanical impact on the soil by the working bodies of machines and tools to create the best conditions for growing plants.

Single-phase harvesting means harvesting with the main products separated in one stage.

Plant ontogeny is the process of individual development of a plant organism according to the hereditary code from the moment of its inception to natural death.

A fallow is a plant that grows on the field from seeds lost during the ripening and harvesting of a previous plant.

The cross-sowing method is a line sowing in two cross directions.

A field trial of a technology is an experiment carried out in the field to determine the effect of technology elements on crop yields, quality of crops and soil fertility.

A place in the crop rotation is a field plant or a clean fallow that occupies the field before the next plant is sown.

Sowing is a field sown with seeds of agricultural plants.

Potential yield is the maximum amount of production that can be obtained from a hectare of crops with the full realisation of the genetic potential of the productivity of an agricultural plant or variety in specific soil and climatic conditions.

Crop programming is the targeted creation of conditions for crop development in order to obtain the planned yield.

Photosynthesis productivity is the intensity of biomass accumulation by plant communities per unit area over a certain period.

Weed resistance is a trait acquired through the selection process and characterises the resistance of certain weed species to certain herbicides when they are systematically applied.

Retardants are synthetic substances of various chemical natures that inhibit stem growth and give plants resistance to lodging.

Plant growth is an irreversible increase in the size and mass of plants during their development in the vegetation cycle.

Plant development is the process of forming habitus, organs and offspring from the plant's inception to the termination of its individual existence.

The spreading method of sowing means sowing the seeds without rows.

Crop production is a complex of interrelated agrotechnical, land reclamation and organisational measures aimed at efficient land use, preservation and improvement of soil fertility, and obtaining high and sustainable crop yields.

Crop rotation is the interval of time during which crops and pairs of crops pass through each field in the sequence provided for by the crop rotation scheme.

Green manure is a predominantly high-protein green mass grown on the field that is ploughed into the soil to enrich it with organic matter and nitrogen.

Symbiosis is a form of long-term coexistence of organisms of different species, in which both organisms (symbioses) benefit from coexistence.

Crop protection system is a complex of interrelated agrotechnical, chemical and biological measures and methods aimed at protecting crops in the agrophytocenosis of sowing from pests (weeds, diseases, harmful organisms) and lodging.

Fertiliser application system is a set of scientifically based measures for applying local, organic, mineral fertilisers and green manure to crops in crop rotation to increase soil fertility and plant productivity.

Seedling is a chemical and biological treatment of cereal crops to dry the stems in order to accelerate ripening and improve grain quality. The physiological essence of seniculation is the effect on plants of ammonium ions contained in the fertiliser, which accelerate the aging and ripening processes. This effect is manifested in the weakening of the synthesis process and increased hydrolysis of high molecular weight compounds into simple and mobile ones, which contributes to their more vigorous and complete outflow into the seeds.

Sowing is a technological process in which seeds are sown on an area and buried in the soil to a certain depth.

Crop rotation is a scientifically based alternation of agricultural plants and pairs in time and territory, or only in time.

Seed scarification is an artificial surface damage to the seed coat to improve the absorption of moisture necessary for swelling and germination. Seeds of clover, alfalfa, sweet clover and other plants are scarified, in which the seed has a palisade layer of cells in the shell that is difficult to penetrate for water and therefore germinates slowly.

A plant variety is a set of plants created as a result of breeding and possessing certain (defined) morphological, physiological, economic characteristics and properties that stably retain their characteristic features in a number of subsequent generations.

Varietal technology is a set of agrotechnical cultivation techniques that necessarily take into account the biological characteristics of not only the plant but also the variety.

Soil maturity is the physical state of the soil surface, which characterises its readiness for mechanical cultivation.

Stratification is one of the methods of preparing seeds for sowing, in which the seeds are placed in a humid, cold environment for a certain period of time.

Strip sowing is a row sowing method in which two or more rows forming a strip are alternated with wider row spacing.

Sowing dates - calendar sowing dates, taking into account the biology of the plant and the soil and climatic conditions of the growing area.

Sown area structure is the ratio of sown areas of various field crops and pure fallow land, expressed as a percentage of total arable land.

The sum of active temperatures is an indicator of the amount of heat and is determined by the sum of the average daily positive air temperatures between the dates of its crossing of 10° C in spring and autumn.

The sum of effective temperatures is an indicator of the need of plants for a certain amount of heat for development during interphase periods or during the growing season. It is determined by the sum of daily differences between the average daily air temperature and the biological minimum temperature.

Alternative technology is a set of agrotechnical production measures, technical means and operations for growing agricultural plants based on the maximum possible use of bioclimatic and soil-climatic potentials and local resources as fertilisers and ameliorants, and does not allow the use of any agrochemicals, such as mineral fertilisers and pesticides.

Basic technology is a system of agrotechnical measures developed and recommended for a specific zone in order to obtain sustainable yields, taking into account their economic and environmental feasibility.

Agrotechnology of agricultural plants is a system of organisational, economic, agrochemical and agrotechnical measures based on the knowledge of the regularities of crop formation in relation to agrometeorological and soil-climatic conditions in order to manage the processes of formation of plant productivity elements in sowing and obtaining high sustainable yields of agricultural plants and reducing the gap between potential and actual plant productivity.

Zonal technology is a basic varietal technology that takes into account the bioclimatic potential of the growing area, biological characteristics of the variety, soil fertility, and place in the crop rotation.

Intensive technology is a dynamic system of agrotechnical measures based on biological control over the formation of potential, biological yield of individual plants and agrophytocenosis as a whole, introduction of high-yielding varieties, development of a new fertiliser system that ensures high efficiency of fertiliser nutrients based on reliable information on soil nutrient reserves and plant nutrition conditions, effective differentiated plant protection system against weeds, pests, diseases, lodging, aimed at maximising the

Resource-saving technology is a zonal technology that is adjusted to a certain extent by the technical and energy capabilities of the production and the producer.

Transpiration is the physiological process of evaporation of vapourous moisture into the atmosphere by plants during their life.

Biological harvest is a crop product that is in the field at the time of harvesting.

Yield is a conditional indicator of the mass of production of an economically useful organ of a grown plant species per unit area.

The chemical method of plant protection is the use of chemically synthesised

pesticides that can cause the death of various types of pests or disrupt their development.

The wide-row sowing method is a row sowing with row spacing of at least 45 cm.

Stem density is the number of stems per 1 m² of sowing.

state standards DSTU 4138-2002, DSTU-2240-93 shall have the following meanings:

agricultural plants - seed, fodder, oilseeds, oilseeds, essential oils, industrial, spinning, vegetable, medicinal, flower, fruit, berry plants, grapes, potatoes used in agricultural production;

seeds - plant organs used for reproduction;

planting material - plants and their parts considered suitable for reproduction of whole plants;

Seed production and nursery farming is a branch of crop production that deals with the propagation of seeds and planting material, respectively, the preservation and improvement of their varietal, sowing and yield qualities (properties), and also carries out varietal and seed control;

categories of seeds: *original seeds (O)* - seeds of primary seed production units, which are sold for further reproduction and obtaining elite seeds; *elite seeds (ES)* - seeds obtained from the sequential reproduction of original seeds in elite seed production units and other farms listed in the State Register of Seed and Planting Material Producers; *reproduction seeds (P_n)* - seeds of the first and subsequent reproductions;

hybrid seed - F₁ - the first, F₂ - the second generation of seeds obtained from crossing genetically distinct plants (parental forms of hybrids);

batch of seeds and planting material - any quantity of seeds and planting material of uniform quality, the quality of which is certified by the relevant document;

Varietal qualities - a set of indicators that characterise the seed's belonging to a particular variety;

Seed quality is a set of seed quality indicators that characterise its suitability for sowing;

conditioned seeds - seeds whose varietal and sowing qualities meet the requirements of regulatory documents;

substandard seeds - seeds that do not meet the quality requirements of regulatory documents;

The Register of Plant Varieties of Ukraine is the State Register of Plant Varieties suitable for distribution in Ukraine;

The State Register of Seed and Planting Material Producers is a list of seed and nursery producers who are entitled to produce and sell seeds and planting material;

Seed marking - a symbol, word, trademark, symbol or picture placed on the packaging, attached to it, or embedded inside it;

testing (field testing) - assessment of the quality of varietal crops and plantations;

Varietal control is an activity aimed at determining varietal purity, establishing whether seeds and planting material of agricultural, forestry, ornamental and decorative

plants, as well as medicinal plants belong to the relevant plant variety by testing crops and plantations, soil control and laboratory varietal control;

Seed control - state and on-farm control over the varietal and sowing qualities of seeds and planting material;

soil control is an activity to determine varietal purity, seed infection by diseases, and the degree of male sterility in sterile analogues of varieties, lines and simple interline hybrids, carried out by sowing seeds in the soil and then evaluating the plants;

laboratory varietal control - determining whether the seed belongs to the appropriate variety and determining the varietal purity of the seed by conducting laboratory analysis;

insurance seed fund - an untouched, periodically renewed stock of seeds in farms in case of crop failure or natural disaster;

state reserve seed fund - seeds to provide districts that do not produce their own seeds or have limited capacity to produce them;

passport - a document certifying the right to enter a business entity into the State Register of Seed and Planting Material Producers;

seed certificate - a document certifying the varietal and sowing qualities of seeds and planting material.

batch of seeds - a certain amount of seeds of homogeneous quality, certified by the relevant documents, as stipulated by DSTU 4138-2002.

control unit - the maximum quantity of seeds of a separate batch or its part, for determining the quality of which one average sample is taken. the norms of the maximum weight of batches and samples of seeds are given in table 1.

spot sample - a small sample of seed taken from one point of the batch in one step. the size of spot samples is determined based on the size of the average sample to be obtained.

pooled sample - a set of all collected point samples after establishing their homogeneity.

average sample - the amount of seeds of uniform quality stipulated by DSTU 4138-2002, allocated for laboratory analysis.

working sample - a part of the average sample of seeds provided for by dstu 4138-2002, allocated for the determination of certain quality indicators.

Seed quality indicators, which can be used to give a complete description of the available seed material, are divided into three groups: varietal, sowing, and yield.

Varietal properties are a set of indicators that characterise the seed's belonging to a particular variety or hybrid. Varietal (genotypic) properties of seeds affect the yield mainly through changes in plant productivity, while sowing and yield properties affect field germination, survival and productivity of plants. Varietal properties of seeds are determined by the genotype of the variety to which they belong. They are characterised by the degree of purity, which is expressed as a percentage. The State Standard of Ukraine defines the following **categories of varietal purity**:

- **original (OO)** - seeds obtained by scientific institutions in the primary seed production stages through the sequential selection of pedigree plants and evaluation of their descendants for the purpose of reproduction and preservation of the variety;

- **Elite (EN)** - propagated seeds of the best descendants of pedigree plants selected in nurseries of primary links, which most fully transmit the hereditary characteristics and properties of the variety and meet the requirements of the state standard for elite in terms of varietal and sowing qualities;

- **Reproductive (RH₁₋₃ and RH_n)** - seeds of the first and subsequent reproductions.

Seeds of these categories include the corresponding planting material of potato, grape, fruit, nut, berry, ornamental, medicinal, and forest plants, taking into account the peculiarities of their reproduction.

In accordance with the OECD Varietal Certification Schemes and the European Union Directive L0402– EN, the following categories of seeds are used in cereal seed production:

- **pre-basic seed (PBS)** - seed from primary seed production units (seed nurseries for testing progeny, propagation nurseries) intended for obtaining basic seed;
- **basic seed (BS)** - seeds of superelite and elite varieties (lines, populations), as well as hybrids that are parental forms for other (complex) hybrids, intended for production of certified seed;
- **certified seeds (CS)** - seeds of the first (CS₁), second (CS₂) and subsequent generations (CS_N) (starting from the third) varieties, as well as seeds of the first generation of hybrids (F₁) obtained from hybridisation sites.

The yield properties of a seed are determined by its biological state, which depends on the growing conditions (meteorological conditions, agricultural practices, soil fertility), storage and preparation of the seed for sowing.

Sowing properties are a set of seed quality indicators that characterise its suitability for sowing. Seed quality is characterised by its purity, content of impurities of plants and weeds, germination, viability, germination energy, weight of 1000 seeds, microflora infestation, pest damage, and some other indicators. Most of them are determined by district (city) state seed inspections using standardised methods of analysis.

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ADDITIONAL INFORMATION

Addition 1
Purity Seed Designation (PSD) numbers and seed pellicularity depending on botanical species

View	Family	PSD	Film density
1	2	3	4
Abelmoschus	Malvaceae	10	
Abies	Pinaceae	51	C
Abutilon	Malvaceae	16	
Acacia	Fabaceae (Leguminosae)	50	
Acer	Aceraceae	52	C
Achillea	Asteraceae (Compositae)	1	
Adonis	Ranunculaceae	4	
Aeschynomene	Fabaceae (Leguminosae)	23	C
Aesculus	Hippocastanaceae	10	
Ageratum	Asteraceae (Compositae)	4	C
Agrimonia	Rosaceae	3	C
Agropyron	Poaceae (Gramineae)	28	C
Agrostemma	Caryophyllaceae	10	
Agrostis	Poaceae (Gramineae)	34	C
Ailanthus	Simaroubaceae	52	C
Alcea	Malvaceae	16	C
Allium	Alliaceae	10	
Alnus	Betulaceae	53	C
Alopecurus	Poaceae (Gramineae)	34	C
Alysicarpus	Fabaceae (Leguminosae)	20	
Alyssum	Brassicaceae (Cruciferae)	11	C
Amaranthus	Amaranthaceae	10	
Amberboa	Asteraceae (Compositae)	4	C
Ammobium	Asteraceae (Compositae)	1	
Amorpha	Fabaceae (Leguminosae)	22	
Anagallis	Primulaceae	10	
Anchusa	Boraginaceae	18	C
Andropogon	Poaceae (Gramineae)	42	C
Anemone	Ranunculaceae	4	C
Anethum	Apiaceae (Umbelliferae)	15	C
Angelica	Apiaceae (Umbelliferae)	15	C
Anthoxanthum	Poaceae (Gramineae)	29	C
Anthriscus	Apiaceae (Umbelliferae)	15	C
Anthyllis	Fabaceae (Leguminosae)	11	
Antirrhinum	Scrophulariaceae	10	C
Apium	Apiaceae (Umbelliferae)	15	C

Continuation of addition 2

1	2	3	4
Aquilegia	Ranunculaceae	10	
Arabis	Brassicaceae (Cruciferae)	11	
Arachis	Fabaceae (Leguminosae)	11	C
Arctium	Asteraceae (Compositae)	4	
Arctotis	Asteraceae (Compositae)	4	C
Armeria	Plumbaginaceae	2	C
Arrhenatherum	Poaceae (Gramineae)	35	C
Artemisia	Asteraceae (Compositae)	1	
Asclepias	Asclepiadaceae	10	C
Asparagus	Asparagaceae	10	
Aster	Asteraceae (Compositae)	4	
Astrebla	Poaceae (Gramineae)	41	C
A triplex	Chenopodiaceae	2	
Atropa	Solanaceae	10	
Aubrieta	Brassicaceae (Cruciferae)	11	
Aurinia	Brassicaceae (Cruciferae)	11	C
Avena	Poaceae (Gramineae)	33	C
Axonopus	Poaceae (Gramineae)	36	C
Beckmannia	Poaceae (Gramineae)	34	C
Begonia	Begoniaceae	10	
Bellis	Asteraceae (Compositae)	1	
Beta	Chenopodiaceae	46	C
Betula	Betulaceae	53	C
Borago	Boraginaceae	18	C
Bothriochloa	. Poaceae (Gramineae)	42	C
Bouteloua	Poaceae (Gramineae)	42	C
Brachiaria	-Poaceae (Gramineae)	36	C
Brachyscome	Asteraceae (Compositae)	5	
Brassica	Brassicaceae (Cruciferae)	11	
Briza	Poaceae (Gramineae)	34	C
Bromus	Poaceae (Gramineae)	33	C
Browallia	Solanaceae	10	
Brunnera	Boraginaceae	18	C
Cajanus	Fabaceae (Leguminosae)	11	
Calceolaria	Scrophulariaceae	10	
Calendula	Asteraceae (Compositae)	1	C
Callistephus	Asteraceae (Compositae)	1	
Calocedrus	. Cupressaceae	49	C
Calopogonium	Fabaceae (Leguminosae)	11	
Camelina	Brassicaceae (Cruciferae)	11	
Campanula	Campanulaceae	10	
Cannabis	Cannabaceae	4	
Capsicum	Solanaceae	10	
Caragana	Fabaceae (Leguminosae)	11	
Carpinus	Betulaceae	57	C
Carthamus	Asteraceae (Compositae)	4	
Carum	Apiaceae (Umbelliferae)	15	
Cassia	Fabaceae (Leguminosae)	11	
Castanea	Fagaceae	57	

Continuation of addition 2

1	2	3	4
Castalis	Asteraceae (Compositae)	8	
Catalpa	Bignoniaceae	48	C
Cedrela	Meliaceae	48	C
Cedrus	Pinaceae	51	C
Celosia	Amaranthaceae	10	
Cenchrus	Poaceae (Gramineae)	43	C
Centaurea	Asteraceae (Compositae)	4	C
Centrosema	Fabaceae (Leguminosae)	11	
Cerastium	Caryophyllaceae	10	
Chamaecrista s	Fabaceae (Leguminosae)	11	
Chamaecyparis	Cupressaceae	49	C
Cheiranthus	Brassicaceae (Cruciferae)	11	
Chelidonium	Papaveraceae	13	C
Chloris	Poaceae (Gramineae)	42	C
Chrysanthemum	Asteraceae (Compositae)	1	C
Cicer	Fabaceae (Leguminosae)	11	
Cichorium	Asteraceae (Compositae)	4	C
Citrullus	Cucurbitaceae	10	
Clarkia	Onagraceae	10	
Claytonia	Portulacaceae	10	
Cleome	Capparidaceae	10	
Cnicus	Asteraceae (Compositae)	4	C
Cobaea	Polemoniaceae	14	C
Coix	Poaceae (Gramineae)	37	C
Coleostephus	Asteraceae (Compositae)	1	C
Coleus	Lamiaceae (Labiatae)	18	
Consolida	Ranunculaceae	10	C
Convolvulus	Convolvulaceae	10	
Corchorus	Tiliaceae	10	
Coreopsis	Asteraceae (Compositae)	8	C
Coriandrum	Apiaceae (Umbelliferae)	15	
Cornus	Cornaceae	55	
Coronilla	Fabaceae (Leguminosae)	21	
Corylus	Betulaceae	57	
Cosmos	Asteraceae (Compositae)	4	C
Cotoneaster	Rosaceae	56	
Crambe	Brassicaceae (Cruciferae)	23	
Crataegus	Rosaceae	56	
Crotalaria	Fabaceae (Leguminosae)	11	
Cryptomeria	Taxodiaceae	49	C
Cucumis	Cucurbitaceae	10	
Cucurbita	Cucurbitaceae	10	
Cuminum	Apiaceae (Umbelliferae)	15	C
Cupressus	Cupressaceae	49	C
Cyamopsis	Fabaceae (Leguminosae)	11	
Cyclamen	Primulaceae	10	
Cydonia	Rosaceae	10	
Cymbalaria	Scrophulariaceae	10	C
Cynara	Asteraceae (Compositae)	4	

Continuation of addition 2

1	2	3	4
Cynosurus	Poaceae (Gramineae)	28	C
Cytisus	Fabaceae (Leguminosae)	50	
Dactylis	Poaceae (Gramineae)	33	C
Dahlia	Asteraceae (Compositae)	9	C
Datura	Solanaceae	10	
Daucus	Apiaceae (Umbelliferae)	15	C
Delphinium	Ranunculaceae	10	C
Deschampsia	Poaceae (Gramineae)	28	C
Desmodium	Fabaceae (Leguminosae)	11	C
Dianthus	Caryophyllaceae	10	C
Dichanthium	Poaceae (Gramineae)	42	C
Dichondra	Convolvulaceae	10	
Digitalis	Scrophulariaceae	10	
Digitaria	Poaceae (Gramineae)	36	C
Dimorphotheca	Asteraceae (Compositae)	8	C
Doronicum	Asteraceae (Compositae)	4	C
Dorotheanthus	Aizoaceae	10	
Echinace	Asteraceae (Compositae)	1	C
Echinochloa	Poaceae (Gramineae)	36	C
Echinops	Asteraceae (Compositae)	26	C
Echium	Boraginaceae	18	C
Ehrharta	Poaceae (Gramineae)	29	C
Elaeagnus	Elaeagnaceae	57	
Eleusine	Poaceae (Gramineae)	61	
Elymus	Poaceae (Gramineae)	28	C
Elytrigia	Poaceae (Gramineae)	28	C
Eragrostis	Poaceae (Gramineae)	28	
Erigeron	Asteraceae (Compositae)	4	C
Eruca	Brassicaceae (Cruciferae)	11	
Erysimum	Brassicaceae (Cruciferae)	11	
Eschscholzia	'Papaveraceae	10	
Eucalyptus	Myrtaceae	60	C
Euonymus	Celastraceae	10	
Fagopyrum	Polygonaceae	2	C
Fagus	Fagaceae	57	C
Fatsia	Araliaceae	10	C
Festuca	Poaceae (Gramineae)	33	C
xFestulolium	Poaceae (Gramineae)	33	C
Foeniculum	Apiaceae (Umbelliferae)	15	C
Fragaria	Rosaceae	1	
Fraxinus	Oleaceae	52	C
Freesia	Iridaceae	10	
Gaillardia	Asteraceae (Compositae)	4	C
Galega	Fabaceae (Leguminosae)	11	
Galeopsis	Lamiaceae (Labiatae)	18	
Gazania	Asteraceae (Compositae)	4	C
Gentiana	Gentianaceae	10	C
Geranium	Geraniaceae	17	

Continuation of addition 2

1	2	3	4
Ginkgo	Ginkgoaceae	10	
Glandularia	Verbenaceae	18	
Gleditsia	Astraceae	1	C
Gleditsia	Fabaceae (Leguminosae)	11	
Glycine	Fabaceae (Leguminosae)	11	
Godetia	Onagraceae	10	
Gomphrena	Amaranthaceae	2	C
Goniolimon	Plumbaginaceae	27	C
Gossypium	Malvaceae	12	C
Grevillea	Proteaceae	14	C
Gypsophila	Caryophyllaceae	10	
Hedysarum	Fabaceae (Leguminosae)	11	
Helenium	Asteraceae (Compositae)	4	C
Helianthemum	Cistaceae	10	
Helianthus	Asteraceae (Compositae)	4	
Helichrysum	Asteraceae (Compositae)	4	C
Heliopsis	Asteraceae (Compositae)	1	
Heliotropium	Boraginaceae	18	C
Helipterum	Asteraceae (Compositae)	4	C
Hesperis	Brassicaceae (Cruciferae)	11	
Heteranthemis	Asteraceae (Compositae)	1	C
Heuchera	Saxifragaceae	10	C
Hibiscus	Malvaceae	10	
Hippeastrum	Amaryllidaceae	10	
Holcus	Poaceae (Gramineae)	35	C
Hordeum	Poaceae (Gramineae)	62	
Hypericum	Hypericaceae (Guttiferae)	10	
Hyssopus	Lamiaceae (Labiatae)	18	
Iberis	Brassicaceae (Cruciferae)	11	
Ilex	Aquifoliaceae	56	
Impatiens	Balsaminaceae	10	
Inula	Asteraceae (Compositae)	4	C
Ipomoea	Convolvulaceae	10	
Juniperus	Cupressaceae	11	
Kalanchoe	Crassulaceae	10	C
Kniphofia	Asphodelaceae	10	C
Kochia	Chenopodiaceae	2	C
Koeleria	Poaceae (Gramineae)	33	C
Koelreuteria	Sapindaceae	10	
Lablab	Fabaceae (Leguminosae)	11	
Laburnum	Fabaceae (Leguminosae)	11	
Lactuca	Asteraceae (Compositae)	4	C
Lagenaria	Cucurbitaceae	10	
Larix	Pinaceae	51	C
Lathyrus	Fabaceae (Leguminosae)	11	C
Lavandula	Lamiaceae (Labiatae)	18	
Lavatera	Malvaceae	16	
Legousia	Campanulaceae	10	
Lens	Fabaceae (Leguminosae)	11	

Continuation of addition 2

1	2	3	4
Leontopodium	Asteraceae (Compositae)	1	C
Leonurus	Lamiaceae (Labiatae)	18	
Lepidium	Brassicaceae (Cruciferae)	11	
Lespedeza	Fabaceae (Leguminosae)	22	
Leucaena	Fabaceae (Leguminosae)	11	
Leucanthemum	Asteraceae (Compositae)	1	C
Levisticum	Apiaceae (Umbelliferae)	15	C
Liatris	Asteraceae (Compositae)	4	C
Ligustrum	Oleaceae	10	C
Li Hum	Liliaceae	10	C
Limonium	Plumbaginaceae	27	C
Linaria	Scrophulariaceae	10	C
Linum	Linaceae	10	
Liquidambar	Hamamelidaceae	48	C
Liriodendron	Magnoliaceae	52	C
Lobelia	Campanulaceae	10	C
Lobularia	Brassicaceae (Cruciferae)	11	C
Loliwn	Poaceae (Gramineae)	33	C
Lonas	Asteraceae (Compositae)	4	C
Lotononis	Fabaceae (Leguminosae)	11	
Lotus	Fabaceae (Leguminosae)	11	
Luffa	Cucurbitaceae	10	
Lunaria	Brassicaceae (Cruciferae)	11	
Lupinus	Fabaceae (Leguminosae)	11	
Lychnis	Caryophyllaceae	10	
Lycopersicon	Solanaceae	10	C
Macroptilium	Fabaceae (Leguminosae)	11	
Macrotyloma	Fabaceae (Leguminosae)	11	
Mahonia	Berberidaceae	50	
Malcolmia	Brassicaceae (Cruciferae)	11	
Malope	Malvaceae	16	
Malus	Rosaceae	10	
Malva	Malvaceae	16	
Marrubium	Lamiaceae (Labiatae)	18	
Matricaria	Asteraceae (Compositae)	1	C
Matthiola	Brassicaceae (Cruciferae)	11	C
Medicago	Fabaceae (Leguminosae)	11	
Melilotus	Fabaceae (Leguminosae)	21	
Melinis	Poaceae (Gramineae)	36	C
Melissa	Lamiaceae (Labiatae)	18	
Mentha	Lamiaceae (Labiatae)	18	
Mimosa	Fabaceae (Leguminosae)	11	
Mimulus	Scrophulariaceae	10	
Mirab His	Nyctaginaceae	1	
Moluccella	Lamiaceae (Labiatae)	18	

Continuation of addition 2

1	2	3	4
Momordica	Cucurbitaceae	10	
Morus	Moraceae	57	
Mucuna	Fabaceae (Leguminosae)	11	
Myosotis	Boraginaceae	18	
Nasturtium	Brassicaceae (Cruciferae)	11	
Nemesia	Scrophulariaceae	10	C
Nemophila	Hydrophyllaceae	10	C
Neonotonia	Fabaceae (Leguminosae)	11	
Nepeta	Lamiaceae (Labiatae)	18	
Nicotiana	Solanaceae	10	
Nierembergia	Solanaceae	10	C
Nigella	Ranunculaceae	10	
Nothofagus	Fagaceae	57	C
Ocimum	Lamiaceae (Labiatae)	18	
Oenothera	Onagraceae	10	
Onobrychis	Fabaceae (Leguminosae)	21	C
Origanum	Lamiaceae (Labiatae)	18	
Ornithopus	Fabaceae (Leguminosae)	23	C
Oryza	Poaceae (Gramineae)	38	C
Osteospermum	Asteraceae (Compositae)	8	C
Panicum	Poaceae (Gramineae)	36	C
Papaver	Papaveraceae	10	
Pascopyrum	Poaceae (Gramineae)	28	C
Paspalum	Poaceae (Gramineae)	36	C
Pastinaca	Apiaceae (Umbelliferae)	15	C
Pelargonium	Geraniaceae	17	
Pennisetum	Poaceae (Gramineae)	43	C
Penstemon	Scrophulariaceae	10	C
Perilla	Lamiaceae (Labiatae)	18	
Petroselinum	Apiaceae (Umbelliferae)	15	C
Petunia	Solanaceae	10	
Phacelia	Hydrophyllaceae	10	C
Phalaris	Poaceae (Gramineae)	29	C
Phaseolus	Fabaceae (Leguminosae)	11	
Phleum	Poaceae (Gramineae)	28	C
Phlox	Polemoniaceae	10	
Pholistoma	Hydrophyllaceae	10	C
Physalis	Solanaceae	10	
Picea	Pinaceae	47	C
Pimpinella	Apiaceae (Umbelliferae)	15	C
Pinus I (лише для P.palustris, P.rigida)	Pinaceae	51	C
Pinus II (для всіх інших видів)	Pinaceae	47	
Piptatherum	Poaceae (Gramineae)	31	C
Pisum	Fabaceae (Leguminosae)	11	
Plantago	Plantaginaceae	10	

Continuation of addition 2

1	2	3	4
Platanus	Platanaceae	58	C
Роса (крім P.bulbosa)	Poaceae (Gramineae)	41	C
Poa bulbosa	Poaceae (Gramineae)	63	C
Populus	Salicaceae	12	C
Portulaca	Portulacaceae	10	
Primula	Primulaceae	10	
Prunus	Rosaceae	56	
Psathyrostachys	Poaceae (Gramineae)	28	C
Pseudoroegneria	Poaceae (Gramineae)	28	C
Pseudotsuga	Pinaceae	51	C
Psophocarpus	Fabaceae (Leguminosae)	11	
Psylliostachys	Plumbaginaceae	27	C
Pueraria	Fabaceae (Leguminosae)	11	
Pulsatilla	Ranunculaceae	4	C
Pyrethrum (див. Tanacetum)			
Pyrus	Rosaceae	10	
Quercus	Fagaceae	57	
Ranunculus	Ranunculaceae	4	C
Raphanus raphanistrum	Brassicaceae (Cruciferae)	23	
Raphanus (для всіх інших видів)	Brassicaceae (Cruciferae)	11	
Rapistrum	Brassicaceae (Cruciferae)	23	
Reseda	Resedaceae	10	
Rheum	Polygonaceae	2	C
Rhodanthe (див. Helipterum)			
Ricinus	Euphorbiaceae	13	
Robinia	Fabaceae (Leguminosae)	11	
Rosa	Rosaceae	57	
Rosmarinus	Lamiaceae (Labiatae)	18	
Rudbeckia	Asteraceae (Compositae)	1	C
Rumex	Polygonaceae	2	C
Ruta	Rutaceae	10	
Saintpaulia	Gesneriaceae	10	
Salix	Salicaceae	12	C
Salpiglossis	Solanaceae	10	
Salvia	Lamiaceae (Labiatae)	18	
Sanguisorba	Rosaceae	3	C
Sanvitalia	Asteraceae (Compositae)	5	C
Sappnaha	Caryophyllaceae	10	
Sarothamnus (див. Cytisus)			
Satureja	Lamiaceae (Labiatae)	18	
Scabiosa	Dipsacaceae	6	C
Schefflera	Araliaceae	10	

Continuation of addition 2

1	2	3	4
Schizachyrium	Poaceae	42	C
Schizanthus	Solanaceae	10	
Scorzonera	Asteraceae (Compositae)	4	C
Secale	Poaceae (Gramineae)	40	
Senecio	Asteraceae (Compositae)	4	C
Senna	Fabaceae (Leguminosae)	11	
Sequoia	Taxodiaceae	49	C
Sequoiadendron	Taxodiaceae	49	C
Sesamum	Pedaliaceae	10	
Setaria	Poaceae (Gramineae)	36	C
Silene	Caryophyllaceae-	10	
Silybum	Asteraceae (Compositae)	4	
Sinapis	Brassicaceae (Cruciferae)	11	
Sinningia	Gesneriaceae	10	
Solanum	Solanaceae	10	
Sophora	Fabaceae (Leguminosae)	20	
Sorbus	Rosaceae	10	
Sorghastrum	Poaceae (Gramineae)	42	C
Sorghum	Poaceae (Gramineae)	42	C
Spartium	Fabaceae (Leguminosae)	11	
Spergula	Caryophyllaceae	10	
Spinacia	Chenopodiaceae	2	C
Stachys	Lamiaceae (Labiatae)	18	
Statice (див. Limonium)			
Stylosanthes	Fabaceae (Leguminosae)	24	C
Syringa	Oleaceae	48	C
Taeniatherum	Poaceae (Gramineae)	30	C
Tagetes	Asteraceae (Compositae)	4	C
Tanacetum	Asteraceae (Compositae)	1	C
Taraxacum	Asteraceae (Compositae)	4	C
Taxodium	Taxodiaceae	11	C
Taxus	Taxaceae	50	
Tectona	Verbenaceae	54	
Tetragonia	Aizoaceae	19	
Thuja	Cupressaceae	49	C
Thunbergia	Acanthaceae	10	
Thymus	Lamiaceae (Labiatae)	18	
Tilia	Tiliaceae	57	C
Torenia	Scrophulariaceae	10	
Tragopogon	Asteraceae (Compositae)	4	C
Trifolium	Fabaceae (Leguminosae)	11	
Trigonella	Fabaceae (Leguminosae)	11	
Trisetum	Poaceae (Gramineae)	28	C
x Triticosecale	Poaceae (Gramineae)	40	

Continuation of addition 2

1	2	3	4
Triticum (окрім T. spelta та T. dicoccon)	Poaceae (Gramineae)	40	
Triticum (для T. spelta та T. dicoccon)	Poaceae (Gramineae)	33	C
Tropaeolum	Tropaeolaceae	16	
Tsuga	Pinaceae	51	C
Ulmus	Ulmaceae	52	C
Urochloa	Poaceae (Gramineae)	36	C
Vaccaria	Caryophyllaceae	10	
Valeriana	Valerianaceae	7	C
Valerianella	Valerianaceae	25	C
Verbascum	Scrophulariaceae	10	
Verbena	Verbenaceae	18	
Viburnum	Adoxaceae	55	
Vicia	Fabaceae (Leguminosae)	11	
Vigna	Fabaceae (Leguminosae)	11	
Vinca	Apocynaceae	10	
Viola	Violaceae	13	
Xeranthemum	Asteraceae (Compositae)	4	C
Zea	Poaceae (Gramineae)	40	
Zelkova	Ulmaceae	59	C
Zinnia	Asteraceae (Compositae)	9	C
Zoysia	Poaceae (Gramineae)	39	C

Addition 2

Methods for Determining Seed Germination. Agricultural and Vegetable Crop Seeds

Plant	Substrate	Temperature, (°C)	Accounting periods, days		Additional conditions and guidelines for overcoming seed dormancy	Additional instructions	Additional tips
			first	final			
1	2	3	4	5	6	7	8
<i>Abelmoschus esculentus</i>	TP; BP; S	20<=>30	4	21	-	-	-
<i>Achillea millefolium</i>	TP	20<=>30	5	14	-	-	-
<i>Aeschynomene americana</i>	TP	20<=>30; 20<=>35	4	14	-	-	-
<i>Agropyron cristatum</i>	TP	20<=>30; 15<=>25	5	14	Cooling; KN0 ₃	-	-
<i>Agropyron desertorum</i>	TP	20<=>30; 15<=>25	5	14	Cooling; KN0 ₃	-	-
<i>Agrostis canina</i>	TP	20<=>30; 15<=>25; 10<=>30	7	21	Cooling; KN0 ₃	-	-
<i>Agrostis capillaris</i>	TP	20<=>30; 15<=>25; 10<=>30	7	28	Cooling; KN0 ₃	-	-
<i>Agrostis gigantea</i>	TP	20<=>30; 15<=>25; 10<=>30	5	10	Cooling; KN0 ₃	-	-
<i>Agrostis stolonifera</i>	TP	20<=>30; 15<=>25; 10<=>30	7	28	Cooling; KN0 ₃	-	-
<i>Allium cepa</i>	TP; BP; S	20; 15	6	12	Cooling	-	-
<i>Allium fistulosum</i>	TP; BP; S	20; 15	6	12	Cooling	-	-
<i>Allium porrum</i>	TP; BP; S	20; 15	6	14	Cooling	-	-
<i>Allium schoenprasum</i>	TP; BP; S	20; 15	6	14	Cooling	-	-
<i>Allium tuberosum</i>	TP	20<=>30; 20	6	14	Cooling	-	-
<i>Alopecurus pratensis</i>	TP	20<=>30; 15<=>25; 10<=>30	7	14	Cooling ; KN0 ₃	-	-

Continuation of addition 2

1	2	3	4	5	6	7	8
<i>Alysicarpus vaginalis</i>	BP	35	4	21	Seed warming 21 days, analysis continued up to 35 days; seeds can be kept for 2 days at 20°C, then 3 days at 35°C	-	-
<i>Andropogon gayanus</i>	TP	20<=>35	7	14	Lighting; KN0 ₃	-	-
<i>Andropogon gerardii</i>	TP	20<=>30	7	28	Cooling; KN0 ₃	-	-
<i>Andropogon hallii</i>	TP	20<=>30	7	28	Cooling; KN0 ₃	-	-
<i>Anethum graveolens</i>	TP; BP	20<=>30; 10-<=>30	7	21	Cooling	-	-
<i>Anthoxanthum odoratum</i>	TP	20<=>30	6	14	-	-	-
<i>Anthriscus cerefolium</i>	TP; BP	20<=>30	7	21	Cooling	-	-
<i>Anthyllis vulneraria</i>	TP; BP	20	5	10	Cooling	-	-
<i>Apium graveolens</i>	TP	20<=>30	10	21	Cooling; KN0 ₃ , lighting	-	-
<i>Arachis hypogaea</i>	BP; S	20<=>30; 25	5	10	Removal of the shell; warming (40 ± 2 °C)	-	-
<i>Arctium lappa</i>	BP; TP	20<=>30; 20	14	35	Cooling	-	To overcome deep dormancy of seeds, it is recommended TTZ
<i>Arrhenatherum elatius</i>	TP	20<=>30	6	14	Cooling	-	-
<i>Asparagus officinalis</i>	TP; BP; S	20<=>30	10	28	-	-	-
<i>Astragalus cicer</i>	BP; TP	15<=>25; 20	10	21	-	-	-
<i>Astrebla lappacea</i>	TP	32	7	14	KN0 ₃	-	-

Continuation of addition 2

1	2	3	4	5	6	7	8
<i>Atriplex hortensis</i>	TP; BP	20<=>30	7	28	-	-	-
<i>Atropa belladonna</i>	TP; BP	20<=>30	10	28	Cooling	-	-
<i>Avena nuda</i>	BP;S	20	5	10	Warming up (30-35 °C); Cooling	-	-
<i>Avena sativa</i>	BP;S	20	5	10	Warming up (30-35 °C); Cooling	-	-
<i>Avena strigosa</i>	BP;S	20	5	10	Cooling; GA3	-	-
<i>Axonopus compressus</i>	TP	20<=>35	10	21	KN03; lighting	-	-
<i>Axonopus fissifolius</i>	TP	20<=>35	10	21	KN03; lighting	-	-
<i>Beckmannia eruciformis</i>	TP	20<=>30	7	21	-	-	-
<i>Beta vulgaris</i>	TP; BP; S	20<=>30; 15<=>25; 20	4	14	Washing (multi-seeded - 2 hours; single-seeded - 4 hours). Drying at a maximum temperature of 25 °C	-	-
<i>Borago officinalis</i>	TP; BP	20<=>30; 20	5	14	-	-	-
<i>Bothriochloa insculpta</i>	TP	20<=>35	3	21	Lighting; KN03	-	-
<i>Bothriochloa pertusa</i>	TP	20<=>35	3	21	Lighting; KN03;	-	-
<i>Bouteloua gracilis</i>	TP	20<=>30; 15<=>30	7	28	KN03	-	-
<i>Brachiaria brizantha</i>	TP	20<=>35	7	21	Warming up, KN03	-	-
<i>Brachiaria decumbens</i>	TP	20<=>35	7	21	H2S04; KN03; lighting	-	-
<i>Brachiaria humidicola</i>	TP	20<=>35	7	21	KN03	-	-
<i>Brachiaria mutica</i>	TP	20<=>35	7	21	H2S04; KN03	-	-
<i>Brachiaria ramosa</i>	BP	20<=>30	4	14	Warming up; KN03	-	-
<i>Brachiaria ruziziensis</i>	TP	20<=>35	7	21	H2S04; KN03	-	-
<i>Brassica juncea</i>	TP	20<=>30; 20	5	7	Cooling; KN03	-	-

Continuation of addition 2

1	2	3	4	5	6	7	8
<i>Brassica napus</i>	BP; TP	20<=>30; 20	5	7	Cooling; KN03	-	-
<i>Brassica napus</i> var. <i>napobrassica</i>	TP	20<=>30; 20	5	14	Cooling	-	-
<i>Brassica nigra</i>	BP; TP	20<=>30; 20	5	10	Cooling; KN03	-	-
<i>Brassica oleracea</i>	BP; TP	20<=>30; 20	5	10	Cooling; KN03	-	-
<i>Brassica perviridis</i>	BP; TP	20<=>30; 20	5	7	Cooling	-	-
<i>Brassica rapa</i>	BP; TP	20<=>30; 20	5	7	Cooling; KN03	-	-
<i>Bromus arvensis</i>	TP	20<=>30; 15<=>25	7	21	Cooling; KN03	-	-
<i>Bromus carinatus</i>	TP	20<=>30; 15<=>25; 10<=>30	7	14	Cooling; KN03	-	-
<i>Bromus catharticus</i>	TP	20-30	7	28	Cooling; KN03	-	-
<i>Bromus erectus</i>	TP	20<=>30; 15<=>25	7	14	Cooling; KN0 ₃	-	-
<i>Bromus hordeaceus</i>	TP	20<=>30	7	14	Cooling	-	-
<i>Bromus inermis</i>	TP	20<=>30; 15<=>25	7	14	Cooling; KN0 ₃	-	-
<i>Bromus marginatus</i>	TP	20-<=>30; 15<=>25	7	14	Cooling; KN0 ₃	-	-
<i>Bromus riparius</i>	TP	20-30; 15-25	7	14	Cooling; KN0 ₃	-	-
<i>Bromus sitchensis</i>	TP	20<=>30; 15-25	7	21	Cooling	-	-
<i>Cajanus cajan</i>	BP; S	20<=>30; 25	4	10	-	-	-
<i>Calopogonium mucunoides</i>	TP	25; 20	3	10	-	-	-
<i>Camelina sativa</i>	TP	20<=>30	4	10	-	-	-
<i>Cannabis sativa</i>	TP; BP	20<=>30; 20	3	7	-	-	-
<i>Capsicum</i> spp.	TP; BP; S	20<=>30	7	14	KN0 ₃	-	-
<i>Carthamus tinctorius</i>	TP; BP; S	20<=>30; 25	4	14	-	-	-
<i>Carum carvi</i>	TP	20<=>30	7	21	-	-	-
<i>Cenchrus ciliaris</i>	TP; S	20<=>35; 20<=>30;	7	28	Warming up; Cooling; KN0 ₃	-	-

Continuation of addition 2

1	2	3	4	5	6	7	8
<i>Cenchrus setigerus</i>	TP	20<=>35	3	14	Warming up (40 ± 2°C); KNO ₃	-	-
<i>Centrosema pascuorum</i>	TP	35	3	7	-	-	-
<i>Centrosema pubescens</i>	TP	20<=>35	4	10	-	-	-
<i>Chamaecrista rotundifolia</i>	TP	20<=>30	4	14	-	-	-
<i>Chloris gayana</i>	TP	20<=>35; 20<=>30	7	14	KNO ₃ ; lighting; Cooling	-	-
<i>Cicer arietinum</i>	BP;S	20<=>30; 20	5	8	-	-	-
<i>Cichorium endivia</i>	TP	20<=>30; 20	5	14	KNO ₃	-	-
<i>Cichorium intybus</i>	TP	20<=>30; 20	5	14	KNO ₃	-	-
<i>Citrullus lanatus</i>	BP;S	20<=>30; 25	5	14	-	-	Recommended PP
<i>Claytonia perfoliata</i>	BP	10	7	21	-	-	-
<i>Corchorus capsularis</i>	TP; BP	30	3	5	-	-	-
<i>Corchorus olitorius</i>	TP; BP	30	3	5	-	-	-
<i>Coriandrum sativum</i>	TP; BP	20<=>30; 20	7	21	-	-	-
<i>Crambe abyssinica</i>	TP; BP	20<=>30; 20	4	7	KNO ₃	-	-
<i>Crotalaria brevidens</i>	BP	20<=>30	4	10	-	-	-
<i>Crotalaria juncea</i>	BP;S	20<=>30	4	10	-	-	-
<i>Crotalaria lanceolata</i>	BP	20<=>30	4	10	-	-	-
<i>Crotalaria pallida</i>	BP	20<=>30	4	10	-	-	-
<i>Crotalaria spectabilis</i>	BP	20<=>30	4	10	-	-	-
<i>Cucumis melo</i>	BP; S	20<=>30; 25	4	8	-	-	Recommended PP
<i>Cucumis sativus</i>	TP; BP; S	20<=>30; 25	4	8	-	-	Recommended PP

Continuation of addition 2

1	2	3	4	5	6	7	8
<i>Cucumis</i> spp.	BP;S	20<=>30; 25	4	8	-	-	Recommended PP
<i>Cucurbita maxima</i>	BP;S	20<=>30; 25	4	8	-	-	Recommended PP
<i>Cucurbita moschata</i>	BP;S	20<=>30; 25	4	8	-	-	Recommended PP
<i>Cucurbita pepo</i>	BP;S	20<=>30; 25	4	8	-	-	Recommended PP
<i>Cucurbita</i> spp.	BP;S	20<=>30; 25	4	8	-	-	Recommended PP
<i>Cucurbita hybrids</i>	BP;S	20<=>30; 25	4	8	-	-	Recommended PP
<i>Cuminum cyminum</i>	TP	20<=>30	5	14	-	-	-
<i>Cyamopsis tetragonoloba</i>	BP	20<=>30	5	14	-	-	-
<i>Cynara cardunculus</i>	BP;S	15<=>20; 20	7	21	-	-	-
<i>Cynodon dactylon</i>	TP	20<=>35; 20<=>30	7	21	Cooling я; KN0 ₃ ; lighting	-	-
<i>Cynosurus cristatus</i>	TP	20<=>30	10	21	Cooling ; KN0 ₃	-	-
<i>Dactylis glomerata</i>	TP	20<=>30; 15<=>25	7	21	Cooling; KN0 ₃	-	-
<i>Daucus carota</i>	TP; BP	20<=>30; 20	7	14	-	-	-
<i>Deschampsia cespitosa</i>	TP	20<=>30; 20	7	16	Cooling; KN0 ₃	-	-
<i>Deschampsia flexuosa</i>	TP	20<=>30; 20	7	16	Cooling; KN0 ₃	-	-
<i>Desmodium intortum</i>	TP	20<=>30	4	10	H ₂ S0 ₄	-	-
<i>Desmodium uncinatum</i>	TP	20<=>30	4	10	H ₂ S0 ₄	-	-
<i>Dichanthium aristatum</i>	TP	20<=>35	7	21	KN0 ₃	-	-
<i>Dichondra repens</i>	TP	20<=>30	7	21	-	-	-
<i>Digitaria eriantha</i>	TP	20<=>30	4	10	-	-	-

Continuation of addition 2

1	2	3	4	5	6	7	8
<i>Echinochloa crus-galli</i>	TP	20<=>30; 25	4	10	Warming up (40 ± 2°C)	-	-
<i>Ehrharta calycina</i>	TP	20	7	21	Cooling	-	-
<i>Eleusine coracana</i>	TP	20<=>30	4	8	KN0 ₃	-	-
<i>Elymus trachycaulus</i>	TP	20<=>30; 15<=>25	5	14	Cooling; KN0 ₃	-	-
<i>Elytrigia elongata</i>	TP	20<=>30; 15<=>25	5	21	Cooling; KN0 ₃	-	-
<i>Elytrigia intermedia</i>	TP	20<=>30; 15<=>25	5	28	Cooling; KN0 ₃	-	-
<i>Elytrigia repens</i>	TP	20<=>30; 15<=>25	7	21	Cooling; KN0 ₃	-	-
<i>Eragrostis curvula</i>	TP	20<=>35; 15<=>30	6	10	Cooling; KN0 ₃	-	-
<i>Eragrostis tef</i>	TP	20<=>30	4	10	Cooling; KN0 ₃	-	-
<i>Eruca sativa</i>	TP; BP	20	4	7	-	-	-
<i>Fagopyrum esculentum</i>	TP; BP	20<=>30; 20	4	7	-	-	-
<i>Festuca arundinacea</i>	TP	20<=>30; 15<=>25	7	14	Cooling; KN0 ₃	-	-
<i>Festuca filiformis</i>	TP	20<=>30; 15<=>25	7	21	Cooling; KN0 ₃	-	-
<i>Festuca heterophylla</i>	TP	20<=>30; 15<=>25	7	21	Cooling; KN0 ₃	-	-
<i>Festuca ovina</i>	TP	20<=>30; 15<=>25	7	21	Cooling; KN0 ₃	-	-
<i>Festuca pratensis</i>	TP	20<=>30; 15<=>25	7	14	Cooling; KN0 ₃	-	-
<i>Festuca rubra</i>	TP	20<=>30; 15<=>25	7	21	Cooling; KNO ₃	-	-
<i>*Festulolium</i> spp.	TP	20<=>30; 15<=>25;20	5	14	Cooling; KN0 ₃	-	-
<i>Foeniculum vulgare</i>	TP; BP; TS	20<=>30	7	14	-	-	-
<i>Fragaria</i> spp.	TP	20<=>30; 20	7	28	-	-	-
<i>Galega orientalis</i>	TP; BP	20	5	14	-	-	-
<i>Glycine max</i>	BP; TPS; S	20<=>30; 25	5	8	-	-	-
<i>Gossypium</i> spp.	BP;S	20<=>30; 25	4	12	-	-	-
<i>Hedysarum coronarium</i>	TP; BP	20<=>30; 20	7	14	-	-	-

Continuation of addition 2

1	2	3	4	5	6	7	8
<i>Helianthus annuus</i>	BP; TPS; S; 0	20<=>30; 25; 20	4	10	Warming up; Cooling	-	-
<i>Hibiscus cannabinus</i>	BP; S	20<=>30	4	8	-	-	-
<i>Holcus lanatus</i>	TP	20<=>30	6	14	Cooling; KNO ₃	-	-
<i>Hordeum vulgare</i>	BP;S	20	4	7	Warming up (30-35 °C); Cooling; GA ₃ ; KNO ₃	-	-
<i>Ipomoea aquatica</i>	BP;S	30	4	10	-	-	-
<i>Koeleria macrantha</i>	TP	20<=>30	5	14	Cooling 8-10 °C 5 днів; lighting	-	-
<i>Kummerowia stipulacea</i>	BP	20-35	5	14	-		
<i>Kummerowia striata</i>	BP	20-35	7	14	-	-	-
<i>Lablab purpureus</i>	BP;S	20-30; 25	4	10	-	-	-
<i>Lactuca sativa</i>	TP; BP	20	4	7	Cooling	-	-
<i>Lagenaria siceraria</i>	BP; S	20<=>30	4	14	-	-	Recommended PP
<i>Lathyrus cicera</i>	S	20	5	10	-	-	-
<i>Lathyrus hirsutus</i>	BP; S	20	7	14	-	-	-
<i>Lathyrus sativus</i>	BP;S	20	5	14	-	-	-
<i>Lens culinaris</i>	BP;S	20	5	10	Cooling	-	-
<i>Lepidium sativum</i>	TP	20<=>30; 20	4	10	Cooling	-	-
<i>Lespedeza juncea</i>	BP	20-35	7	21	-	-	-
<i>Leucaena leucocephala</i>	TP; BP	25	4	10	Cut seeds	-	-
<i>Linum usitatissimum</i>	TP; BP	20<=>30; 20	3	7	Cooling	-	-
<i>Lolium x boucheanum</i>	TP	20<=>30; 15<=>25; 20	5	14	Cooling; KNO ₃	-	-
<i>Lolium multiflorum</i>	TP	20<=>30; 15<=>25; 20	5	14	Cooling; KNO ₃	-	-

Continuation of addition 2

1	2	3	4	5	6	7	8
<i>Lolium perenne</i>	TP	20<=>30; 15<=>25; 20	5	14	Cooling; KN0 ₃	-	-
<i>Lolium rigidum</i>	TP	20<=>30; 15<=>25	5	14	Lighting; KN0 ₃ ; Cooling at 5-10 °C for 7 days; if necessary repeat Cooling for 15-25 days and continue analysis at 15-25 °C for 4 days	-	-
<i>Lotononis bainesii</i>	TP	20<=>30	7	21	-	-	-
<i>Lotus corniculatus</i>	TP; BP	20<=>30; 20	4	12	Cooling	-	-
<i>Lotus tenuis</i>	TP; BP	20<=>30; 20	4	12	Cooling	-	-
<i>Lotus uliginosus</i>	TP; BP	20<=>30; 20	4	12	Cooling	-	-
<i>Luffa acutangula</i>	BP;S	30	4	14	-	-	-
<i>Luffa aegyptiaca</i>	BP;S	20<=>30; 30	4	14	-	-	-
<i>Lupinus albus</i>	BP;S	20	5	10	Cooling	-	-
<i>Lupinus angustifolius</i>	BP;S	20	5	10	Cooling	-	-
<i>Lupinus luteus</i>	BP;S	20	10	21	Cooling	-	-
<i>Lycopersicon esculentum</i>	TP; BP; S	20<=>30	5	14	KN0 ₃	-	-
<i>Lycopersicon spp.</i>	TP; BP; S	20<=>30	5	14	KN0 ₃	-	-
<i>Lycopersicon hybrids</i>	TP; BP; S	20<=>30	5	14	KNO ₃	-	-
<i>Macroptilium atropurpureum</i>	TP	25	4	10	H ₂ SO ₄	-	-
<i>Macroptilium lathyroides</i>	TP	25	4	10	H ₂ SO ₄	-	-
<i>Macrotyloma axillare</i>	BP	25	4	10	H ₂ SO ₄ ; a6o Cut seeds	-	-
<i>Macrotyloma uniflorum</i>	TP;S	20<=>30; 25	4	10	Cut seeds	-	-

Continuation of addition 2

1	2	3	4	5	6	7	8
<i>Medicago arabica</i>	TP; BP	20	4	14	-	-	-
<i>Medicago italica</i>	TP; BP	20; 15	4	14	-	-	-
<i>Medicago littoralis</i>	TP	20	4	14	-	-	-
<i>Medicago lupulina</i>	TP; BP	20	4	10	Cooling	-	-
<i>Medicago orbicularis</i>	TP; BP	20	4	10	Cooling	-	-
<i>Medicago polymorpha</i>	TP; BP	20	4	14	-	-	-
<i>Medicago rugosa</i>	TP; BP	20	4	14	-	-	-
<i>Medicago sativa</i>	TP; BP	20	4	10	Cooling	-	-
<i>Medicago scutellata</i>	TP; BP	20	4	14	-	-	-
<i>Medicago truncatula</i>	TP; BP	20	4	10	-	-	-
<i>Melilotus albus</i>	TP; BP	20	4	7	Cooling	-	-
<i>Melilotus indicus</i>	TP; BP	20	3	14	-	-	-
<i>Melilotus officinalis</i>	TP; BP	20	4	7	Cooling	-	-
<i>Melinis minutiflora</i>	TP	20<=>30	7	21	Cooling; KNO ₃	-	-
<i>Momordica charantia</i>	BP;S	20<=>30; 30	4	14	-	-	-
<i>Mucuna pruriens</i>	TP;S	20<=>30; 30	3	14	Cut seeds	-	-
<i>Nasturtium officinale</i>	TP; BP	20<=>30	4	14	-	-	-
<i>Neonotonia wightii</i>	TP	20<=>30; 10<=>35	4	10	-	-	-
<i>Nicotiana tabacum</i>	TP	20<=>30	7	16	KNO ₃	-	-
<i>Ocimum basilicum</i>	TP	20<=>30	4	14	KNO ₃	-	-
<i>Oenothera biennis</i>	TP	20<=>30; 20	7	21	KNO ₃	-	-
<i>Onobrychis viciifolia</i>	TP;BP; S	20<=>30; 20	4	14	Cooling	-	-
<i>Origanum majorana</i>	TP	20<=>30; 20	7	21	-	-	-

Continuation of addition 2

1	2	3	4	5	6	7	8
<i>Origanum vulgare</i>	TP	20<=>30; 20	7	21	-	-	-
<i>Ornithopus compressus</i>	TP	15	7	21	-	-	-
<i>Ornithopus sativus</i>	TP; BP	20	7	14	-	-	-
<i>Oryza sativa</i>	TP; BP; S	20<=>30; 25	5	14	Warming up (50 ± 2°C); замочування в H ₂ O чи HNO ₃ (24 год)	-	-
<i>Panicum antidotale</i>	TP	20<=>30	7	28	-	-	-
<i>Panicum coloratum</i>	TP	20<=>35	7	28	-	-	-
<i>Panicum maximum</i>	TP	15<=>35; 20<=>30	10	28	Cooling; KNO ₃	-	-
<i>Panicum miliaceum</i>	TP; BP	20<=>30; 25	3	7	-	-	-
<i>Panicum virgatum</i>	TP	15<=>30	7	28	Cooling; KNO ₃	-	-
<i>Papaver somniferum</i>	TP	20	5	10	Cooling	-	-
<i>Pascopyrum smithii</i>	TP	20<=>30; 15<=>25	7	28	Cooling; KNO ₃	-	-
<i>Paspalum dilatatum</i>	TP	20-35	7	28	KNO ₃ ; Cooling	-	-
<i>Paspalum notatum</i>	TP	20<=>35; 20<=>30	7	28	H ₂ SO ₄ , KNO ₃	-	-
<i>Paspalum plicatulum</i>	TP	20<=>35	7	28	KNO ₃ ; lighting	-	-
<i>Paspalum scrobiculatum</i>	TP	20<=>30	7	20	KNO ₃	-	-
<i>Paspalum urvillei</i>	TP	20<=>35	7	21	KNO ₃	-	-
<i>Paspalum wettsteinii</i>	TP	20<=>35	7	28	KNO ₃	-	-
<i>Pastinaca sativa</i>	TP; BP	20<=>30	6	28	-	-	-
<i>Pennisetum clandestinum</i>	TP	20<=>35; 20<=>30	7	14	Cooling; KNO ₃	-	-
<i>Pennisetum glaucum</i>	TP; BP	20<=>30; 20<=>35	3	7	-	-	-
<i>Petroselinum crispum</i>	TP; BP	20<=>30; 20	10	28	-	-	-
<i>Phacelia tanacetifolia</i>	TP; BP	20<=>30; 20; 15	5	14	Cooling	not to illuminate	-

Continuation of addition 2

1	2	3	4	5	6	7	8
<i>Phalaris aquatica</i>	TP	20<=>30; 20	7	21	Cooling; KNO ₃	-	-
<i>Phalaris arundinacea</i>	TP	20<=>30	7	21	Cooling; KNO ₃	-	-
<i>Phalaris canariensis</i>	TP; BP	20<=>30; 15<=>25	7	21	Cooling я; KNO ₃	-	-
<i>Phaseolus coccineus</i>	BP; S	20<=>30; 20	5	9	-	-	-
<i>Phaseolus lunatus</i>	BP; S	20<=>30; 25	5	9	-	-	-
<i>Phaseolus vulgaris</i>	BP; TPS; S	20<=>30; 25; 20	5	9	-	-	-
<i>Phleum nodosum</i>	TP	20<=>30; 15<=>25	7	10	Cooling; KNO ₃	-	-
<i>Phleum pratense</i>	TP	20<=>30; 15<=>25	7	10	Cooling; KNO ₃	-	-
<i>Physalis pubescens</i>	TP	20<=>30	7	28	KNO,	-	-
<i>Pimpinella anisum</i>	TP; BP	20<=>30	7	21	-	-	-
<i>Piptatherum miliaceum</i>	S	15	7	42	Cooling	-	-
<i>Pisum sativum</i>	BP; TPS; S	20	5	8	-	-	-
<i>Plantago lanceolata</i>	TP; BP	20<=>30; 20	4-7	21	-	-	-
<i>Poa annua</i>	TP	20<=>30; 15<=>25	7	21	Cooling; KNO ₃	-	-
<i>Poa bulbosa</i>	TP	15<=>25	10	35	KNO ₃	-	-
<i>Poa compressa</i>	TP	15<=>25; 10<=>30	10	28	Cooling; KNO ₃	-	-
<i>Poa nemoralis</i>	TP	20<=>30; 15<=>25; 10<=>30	10	28	Cooling; KNO ₃	-	-
<i>Poa palustris</i>	TP	20<=>30; 15<=>25; 10<=>30	10	28	Cooling; KNO ₃	-	-
<i>Poa pratensis</i>	TP	20<=>30; 15<=>25; 10<=>30	10	28	Cooling; KNO ₃	-	-
<i>Poa secunda</i>	TP	20<=>30; 15<=>25; 10<=>30	7	28	Cooling; KNO ₃	-	-
<i>Poa trivialis</i>	TP	20<=>30; 15<=>25	7	21	Cooling; KNO ₃	-	-
<i>Portulaca oleracea</i>	TP; BP	20<=>30	5	14	Cooling	-	-
<i>Psathyrostachys juncea</i>	TP	20<=>30	5	14	Cooling	-	-

Continuation of addition 2

1	2	3	4	5	6	7	8
<i>Pseudoroegneria a spicata</i>	TP	20<=>30; 15<=>25	7	21	Cooling; KNO ₃	-	-
<i>Psophocarpus tetragonolobus</i>	BP;S	20<=>30; 30	4	14	-	-	-
<i>Pueraria lobata</i>	BP	20<=>30	5	14	-	-	-
<i>Pueraria phaseoloides</i>	TP	25	4	10	H ₂ SO ₄	-	-
<i>Raphanus sativus</i>	TP; BP; S	20<=>30; 20	4	10	Cooling	-	-
<i>Rheum rhaponticum</i>	TP	20<=>30	7	21	-	-	-
<i>Ricinus communis</i>	BP; S	20<=>30	7	14	-	-	-
<i>Rosmarinus officinalis</i>	TP	20<=>30; 20	7	28	-	-	-
<i>Rumex acetosa</i>	TP	20<=>30	3	14	Cooling	-	-
<i>Sanguisorba minor</i>	TP; BP	20<=>30; 20	7	28	-	-	-
<i>Satureja hortensis</i>	TP	20<=>30	5	21	-	-	-
<i>Schizachyrium scoparium</i>	TP	20<=>30	7	28	Cooling; KNO ₃	-	-
<i>Scorzonera hispanica</i>	TP; BP; S	20<=>30; 20	4	8	Cooling	-	-
<i>Secale cereale</i>	TP; BP; S	20	4	7	Cooling; GA ₃	-	-
<i>Securigera varia</i>	TP; BP	20	7	14	-	-	-
<i>Sesamum indicum</i>	TP	20<=>30	3	6	-	-	-
<i>Setaria italica</i>	TP; BP	20<=>30	4	10	-	-	-
<i>Setaria sphacelata</i>	TP	20<=>35	7	21	KNO ₃	-	-
<i>Sinapis alba</i>	BP ; TP	20<=>30; 20	3	7	Cooling	-	-
<i>Solanum melongena</i>	TP; BP; S	20<=>30	7	14	-	-	-
<i>Solanum tuberosum</i>	TP	20<=>30	3	14	Розчиняти в 1,5 % GA ₃ протягом 24 годин	-	-
<i>Sorghastrum nutans</i>	TP	20<=>30	7	28	Cooling; KNO ₃	-	-
<i>Sorghum x alrum</i>	TP; BP	20<=>35; 20<=>30	5	21	Cooling	-	-

Continuation of addition 2

1	2	3	4	5	6	7	8
<i>Sorghum bicolor</i>	TP; BP	20<=>30; 25	4	10	Cooling	-	-
<i>Sorghum bicolor</i> x <i>S. sudanense</i>	TP; BP	20<=>30	4	10	Cooling	-	-
<i>Sorghum halepense</i>	TP; BP	20<=>35; 20<=>30	7	35	-	-	-
<i>Sorghum sudanense</i>	TP; BP	20-30	4	10	Cooling	-	-
<i>Spergula arvensis</i>	TP	20	4	10	-	-	-
<i>Spinacia oleracea</i>	TP; BP	15; 10	7	21	Cooling	-	-
<i>Stylosanthes guianensis</i>	TP	20<=>35; 20<=>30	4	10	H ₂ SO ₄	-	-
<i>Stylosanthes hamata</i>	TP	20<=>35; 10<=>35	4	10	Cut seeds	-	-
<i>Stylosanthes humilis</i>	TP	20<=>30; 10<=>35	2	5	Cut seeds	-	-
<i>Stylosanthes scabra</i>	TP	20<=>35	4	10	Cut seeds	-	-
<i>Taraxacum officinale</i>	TP	20<=>30; 20	7	21	-	-	-
<i>Tetragonia tetragonoides</i>	BP; S	20<=>30; 20	7	35	Видалити м'якиш; промивання в воді протягом 24 годин	-	-
<i>Thymus vulgaris</i>	TP	20<=>30; 20	7	21	-	-	-
<i>Tragopogon porrifolius</i>	TP; BP	20	5	10	Cooling	-	-
<i>Trifolium alexandrinum</i>	TP; BP	20	3	7	-	-	-
<i>Trifolium campestre</i>	TP; BP	20	4	14	-	-	-
<i>Trifolium dubium</i>	TP; BP	20	5	14	Cooling	-	-
<i>Trifolium fragiferum</i>	TP; BP	20	3	7	-	-	-
<i>Trifolium glomeratum</i>	TP; BP	20	4	10	-	-	-
<i>Trifolium hirtum</i>	TP; BP	20	4	10	-	-	-

Continuation of addition 2

1	2	3	4	5	6	7	8
<i>Trifolium hybridum</i>	TP; BP	20	4	10	Cooling	-	-
<i>Trifolium incarnatum</i>	TP; BP	20	4	7	Cooling	-	-
<i>Trifolium lappaceum</i>	TP; BP	20	3	7	Cooling	-	-
<i>Trifolium michelianum</i>	TP	15; 20	4	10	Cooling	-	-
<i>Trifolium pratense</i>	TP; BP	20	4	10	Cooling	-	-
<i>Trifolium repens</i>	TP; BP	20	4	10	Cooling	-	-
<i>Trifolium resupinatum</i>	TP; BP	20	4	7	-	-	-
<i>Trifolium semipilosum</i>	BP;S	20; 15	3	7	-	-	-
<i>Trifolium squarrosum</i>	TP; BP	20; 15	4	14	Cooling	-	-
<i>Trifolium subterraneum</i>	TP; BP	20; 15	4	14	-	Не освітлювати	-
<i>Trifolium vesiculosum</i>	TP; BP	20; 15	4	10	-	-	-
<i>Trigonella foenum-graecum</i>	TP; BP	20<=>30; 20	5	14	-	-	-
<i>Trisetum flavescens</i>	TP	20<=>30	7	21	Cooling; KN0 ₃	-	-
x <i>Triticosecale</i>	TP;BP; S	20	4	8	Warming up (30-35 °C); Cooling; GA ₃	-	-
<i>Triticum aestivum</i>	TP;BP; S	20	4	8	Warming up (30-35 °C); Cooling; GA ₃	-	-
<i>Triticum dicoccon</i>	TP;BP; S	20	4	8	Cooling (30-35 °C); Cooling; GA ₃		

Continuation of Table 5A part 1

1	2	3	4	5	6	7	8
<i>Triticum durum</i>	TP;BP; S	20	4	8	Warming up (30-35 °C); Cooling; GA ₃		
<i>Triticum spelta</i>	BP; S	20	4	8	Warming up (30-35 °C); Cooling; GA ₃		
<i>Urochloa mosambicensis</i>	TP	20<=>35	7	21	GA ₃ ; KNO ₃		
<i>Valerianella locusta</i>	TP; BP	20; 15	7	28	Cooling, GA ₃		
<i>Vicia benghalensis</i>	BP	20	5	10	-		
<i>Vicia ervilia</i>	BP; S	20	5	8	-		
<i>Vicia faba</i>	BP;S; O	20	4	14	Cooling		
<i>Vicia narbonensis</i>	BP; S	20	5	10	-		
<i>Vicia pannonica</i>	BP;S	20	5	10	Cooling		
<i>Vicia sativa</i>	BP; S	20	5	14	Cooling		
<i>Vicia villosa</i>	BP; S	20	5	14	Cooling		
<i>Vigna angularis</i>	BP; S	20<=>30	4	10	-		
<i>Vigna marina</i>	BP	20<=>30	4	8	-		
<i>Vigna mungo</i>	BP;S	20<=>30; 25; 20	4	7	-		
<i>Vigna radiata</i>	BP;S	20<=>30; 25	5	7	-		
<i>Vigna subterranea</i>	BP; S	20<=>30; 30; 25	5	10	-		
<i>Vigna unquiculata</i>	BP; S	20<=>30; 25	5	8	-		
<i>Zea mays</i>	BP; TPS; S	20<=>30; 25; 20	4	7	-		
<i>Zoysia japonica</i>	TP	20<=>35	10	28	KNO ₃		

Addition 3

Seed Germination Testing Methods. Seed of Trees and Bushes

For certain plant species specified in column 6, "dual tests" (with and without pre chilling) are mandatory.

Less important methods are indicated in parentheses in the table.

Plant	Substrate	Temperature, (°C)	Accounting periods, days		Additional conditions and guidelines for overcoming seed dormancy	Additional instructions	Additional tips
			first	final			
1	2	3	4	5	6	7	8
<i>Abies alba</i> , <i>Abies balsamea</i> , <i>Abies cilicica</i> , <i>Abies firma</i> , <i>Abies fraseri</i> , <i>Abies homolepis</i> , <i>Abies lasiocarpa</i> , <i>Abies magnifica</i> , <i>Abies numidica</i> , <i>Abies sachalinensis</i>	TP	20<=>30	7	28	Cooling 21 days	-	-
<i>Abies amabilis</i> , <i>Abies cephalonica</i> , <i>Abies concolor</i> , <i>Abies grandis</i> , <i>Abies nordmanniana</i> , <i>Abies pinsapo</i> , <i>Abies procera</i> , <i>Abies veitchi</i>	TP	20<=>30	7	28	-	Double analysis: without refrigeration and with refrigeration (21 days)	
<i>Acacia spp.</i> 21	TP	20<=>30; (20)	7	21	1. Prick, cut or saw the seed coat from the cotyledon end; soak for 3 hours 2. (Soak for 1 hour in conc. H ₂ SO ₄ ; rinse in running water)	-	-
<i>Acer campestre</i>	-	-	-	-	-	TTZ	-

Continuation of Addition 3

1	2	3	4	5	6	7	8
<i>Acer negundo</i> , <i>Acer platanoides</i> , <i>Acer pseudoplatanus</i> , <i>Acer saccharum</i>	S; TP	20	7	21	Refrigerate for 2 months. Freshly harvested seeds are mostly dormant.	-	-
<i>Acer palmatum</i>	S; TP	20	7	21	Refrigerate for 4 months. This is to remove the pericarp.	-	recommended TTZ (EET)
<i>Acer rubrum</i> , <i>Acer saccharinum</i>	S; (TP)	20	7	21	-	-	-
<i>Aesculus hippocastanum</i>	TS; (S)	20<=>30; (20)	7	21	Soak in water for 48 hours; cut off the seed scar. Do not remove the seed coat from the remaining part of the seed. Fresh seed may require pre-cooling	-	-
<i>Ailanthus altissima</i>	TP	20<=>30	7	21	Removing the pericarp after soaking for 24 hours can speed up germination.	-	-
<i>Alnus cordata</i> , <i>Alnus glutinosa</i> , <i>Alnus incana</i> , <i>Alnus rubra</i>	TP	20<=>30	7	21	-	-	-
<i>Amorpha fruticosa</i>	TP	20<=>30	10	28	Lighting	-	-
<i>Betula papyrifera</i>	TP	20<=>30	7	21	-	-	-

Continuation of Addition 3

1	2	3	4	5	6	7	8
<i>Betula pendula</i>	TP	20<=>30	7	21	-	Double analysis: without refrigeration and with refrigeration (21 days)	Weighted Replication Method (Chapter 13)
<i>Betula pubescens</i>	TP	20<=>30	7	21	-	-	Weighted Repetition Analysis (Chapter 13)
<i>Calocedrus decurrens</i>	TP	20<=>30	7	28	Cooling 28 days	-	TTZ (EET)
<i>Caragana arborescens</i>	TP	20<=>30	7	21	To prick the seed; or to cut or file away part of the seed coat at the cotyledon cone;	-	-
<i>Carpinus betulus</i>	S	20	14	42	Keep in a moist substrate for 1 month at 20°C and the next 4 months at 1 to 5 °C)	-	TTZ
<i>Castanea sativa</i>	TS; (S)	20<=>30	7	21	Soak in water for 48 hours; cut off the seed scar and remove the seed coat	-	-
<i>Catalpa spp.</i>	TP	20<=>30	7	21	-	-	-
<i>Cedrela spp.</i>	TP	20<=>30	7	28	-	-	-
<i>Cedrus atlantica</i> , <i>Cedrus deodora</i> , <i>Cedrus libani</i>	TP	20; (20<=>30)	7	21	Cooling 21 days	-	-
<i>Chamaecyparis lawsoniana</i>	TP	20; (20<=>30)	7	28	-	-	-

Continuation of Addition 3

1	2	3	4	5	6	7	8
<i>Chamaecyparis nootkatensis</i>	TP	20; (20<=>30)	7	28	Cooling 21 days	-	-
<i>Chamaecyparis obtusa</i>	TP	20<=>30	7	21	-	-	-
<i>Chamaecyparis pisifera</i>	TP	20<=>30	7	21	-	-	-
<i>Chamaecyparis thyoides</i>	TP	20	7	28	Cooling 90 days	-	Recommended TTZ
<i>Cornus sanguinea</i>	-	-	-	-	-	TTZ	-
<i>Corylus avellana</i>	S	20; 20<=>30	14	35	Remove pericarp and chill for 2 months	-	Recommended TTZ
<i>Cotoneaster spp.</i>	-	-	-	-	-	TTZ	-
<i>Crataegus monogyna</i>	S	20<=>30	7	28	Keep in a moist substrate for 3 months at 25 °C followed by cooling (9 months)	-	TTZ
<i>Cryptomeria japonica</i>	TP	20<=>30	7	28	-	-	-
<i>Cupressus arizonica</i>	TP	20<=>30	7	28	-	Double analysis: no refrigeration and refrigeration for 21 days	-
<i>Cupressus macrocarpa</i>	TP	20<=>30	14	35	-	-	-
<i>Cupressus sempervirens</i>	TP	20	7	28	-	-	-
<i>Cydonia oblonga</i>	-	-	-	-	-	TTZ	-
<i>Cytisus scoparius</i>	TP	20<=>30	7	28	Prick, cut, or file the seed coat at the cotyledon end; soak for 3 hours	-	-
<i>Elaeagnus angustifolia</i>	-	-	-	-	-	TTZ	-

Continuation of Addition 3

1	2	3	4	5	6	7	8
<i>Eucalyptus spp.</i>	-	-	-	-	-	Required by weighted replicates method (see Section 13, Table 13 A)	-
<i>Eonymus europaeus</i>	TP	20<=>30	7	28	Cooling 45 days	-	TTZ
<i>Fagus sylvatica</i>	TP	5	-	-	The duration of the analysis depends on the state of dormancy of the seeds and, in a special case, may be about 24 weeks.	-	To overcome the calmness Recommended TTZ
<i>Fraxinus spp.</i>	TP	20<=>30	14	56	Storage 2 months at 20°C and then 7 months at 1-5°C	-	TTZ - EET
<i>Ginkgo biloba</i>	TP;BP	20<=>30; 20	10	30	Remove the seed coat	-	-
<i>Gleditsia triacanthos</i>	TP	20	7	21	1. Prick, cut or file the seed coat at the cotyledon end; soak in water for 6 hours 2. Soak in conc. H ₂ SO ₄ until pits appear; rinse in running water	-	-
<i>Ilex aquifolium</i>	-	-	-	-	-	TTZ	-
<i>Juniperus communis</i>	TP; S	20	14	28	Cooling 90 days	-	TTZ
<i>Juniperus scopulorum</i>	TP; S	15	14	42	Storage 60 days at 20 °C after 40 days at 1-5 °C	-	TTZ

Continuation of Addition 3

1	2	3	4	5	6	7	8
<i>Juniperus virginiana</i>	TP; S	15	14	28	Storage 60 days at 20 °C after 40 days at 1-5 °C	-	TTZ
<i>Koelreuteria paniculata</i>	-	-	-	-	-	TTZ	-
<i>Laburnum alpinum</i> , <i>Laburnum anagyroides</i>	TP	20<=>30	7	21	1. Prick, cut or file the seed coat at the cotyledon end; soak in water for 6 hours 2. Soak in conc. H ₂ SO ₄ until pits appear; rinse in running water	-	-
<i>Larix decidua</i> , <i>Larix * eurolepis</i> , <i>Larix gmelinii</i> , <i>Larix laricina</i> , <i>Larix sibirica</i>	TP	20<=>30	7	21	-	-	-
<i>Larix kaempferi</i> , <i>Larix occidentalis</i>	TP	20<=>30	7	21	-	Double analysis: unrefrigerated and refrigerated 21 days	-
<i>Ligustrum vulgare</i>	-	-	-	-	-	TTZ	-
<i>Liquidambar styraciflua</i>	TP	20<=>30	7	21	Sensitive to drying during analysis	-	-
<i>Liriodendron tulipifera</i>	TP	20<=>30	7	28	Cooling 60 days	-	TTZ
<i>Mahonia aquifolium</i>	-	-	-	-	-	TTZ	-
<i>Malus</i> spp. (except <i>M. sylvestris</i> , <i>M. sargentii</i>)	-	-	-	-	-	TTZ - EET	-
<i>Malus sargentii</i> , <i>Malus sylvestris</i>	-	-	-	-	-	TTZ	-
<i>Malva sylvestris</i>	TP	20<=>30; 20	7	21	-	-	-

Continuation of Addition 3

1	2	3	4	5	6	7	8
<i>Morus spp.</i>	TP	20<=>30	14	28	-	-	-
<i>Nothofagus obliqua</i>	TP	20<=>30	7	28	-	Double analysis: without refrigeration and with refrigeration on 28 days	-
<i>Nothofagus procera</i>	TP	20<=>30	7	28	-	-	-
<i>Picea abies</i> , <i>Picea engelmannii</i> , <i>Picea koyamai</i> , <i>Picea mariana</i> , <i>Picea omorika</i> , <i>Picea orientalis</i> , <i>Picea polita</i> , <i>Picea pungens</i> , <i>Picea rubens</i>	TP	20<=>30	7	21	-	-	-
<i>Picea glauca</i> , <i>Picea glehnii</i> , <i>Picea jezoensis</i> , <i>Picea sitchensis</i>	TP	20<=>30	7	21	-	Double analysis: without refrigeration and with refrigeration on 21 days	-
<i>Pinus albicaulis</i>	TP	20<=>30	7	28	Cooling 28 days	-	-
<i>Pinus aristata</i>	TP	20<=>30	7	14	-	-	-
<i>Pinus banksiana</i>	TP	20<=>30	7	14	-	-	-
<i>Pinus bruita</i>	TP	20	7	28	-	-	-
<i>Pinus canariensis</i>	TP	20	7	28	-	-	-
<i>Pinus caribaea</i>	TP	20<=>30	7	21	-	-	-
<i>Pinus cembra</i>	S	20<=>30	7	28	Refrigeration 6-9 months	-	TTZ - EET
<i>Pinus cembroides</i>	S	20	7	28	Cooling 21 days	-	-
<i>Pinus clausa</i>	TP; (TS)	20	7	21	-	-	Sensitive to excess moisture

Continuation of Addition 3

1	2	3	4	5	6	7	8
<i>Pinus contorta</i>	TP	20<=>30	7	21	-	Double analysis: unrefrigerated and refrigerated 21 days	-
<i>Pinus coulteri</i>	S	20<=>30	7	28	Refrigeration 60-90 days	-	TTZ - EET
<i>Pinus densiflora</i>	TP	20<=>30	7	21	Refrigeration 14 days	-	-
<i>Pinus echinata</i>	TP	20<=>30	7	28	-	-	-
<i>Pinus edulis</i>	TP	20<=>30	7	28	Lighting for 16 hours or more	-	-
<i>Pinus elliottii</i>	TP	22; 20<=>30	7	28	-	Double analysis: without refrigeration and with refrigeration 14 days	-
<i>Pinus flexilis</i>	TP	20<=>30	7	21	Cooling 21 days	-	-
<i>Pinus glabra</i>	TP	20<=>30	7	21	Cooling 21 days	-	-
<i>Pinus halepensis</i>	TP	20	7	28	-	-	-
<i>Pinus heldreichii</i>	TP	20<=>30	7	28	Cooling 42 days	-	TTZ - EET
<i>Pinus jeffreyi</i>	TP; (S)	20<=>30	7	28	Cooling 28 days	-	TTZ - EET
<i>Pinus kesiya</i>	TP	20<=>30	7	21	-	-	-
<i>Pinus koraiensis</i>	S	20<=>30	7	28	Storage 2 months at 25 °C then 3 months at 1-5°C	-	TTZ - EET
<i>Pinus lambertiana</i>	TP; (S)	20<=>30	7	28	Refrigeration 60-90 days	-	TTZ - EET
<i>Pinus merkusii</i>	TP	20<=>30	7	21	-	-	-
<i>Pinus monticola</i>	TP	20<=>30	7	28	Refrigeration 60-90 days	-	TTZ - EET
<i>Pinus mugo</i>	TP	20<=>30	7	21	-	-	-
<i>Pinus muricata</i>	TP	20<=>30	7	21	-	-	-
<i>Pinus nigra</i>	TP	20<=>30	7	21	-	-	-

Continuation of Addition 3

1	2	3	4	5	6	7	8
<i>Pinus oocarpa</i>	TP	20<=>30	7	21	-	-	-
<i>Pinus palustris</i>	S; (TP)	20	7	21	-	-	-
<i>Pinus parviflora</i>	TP; (S)	20<=>30	7	28	Refrigeration 6-9 months		TTZ - EET
<i>Pinus patula</i>	TP	20; (20<=>30)	7	21	-	-	-
<i>Pinus peuce</i>	TP; (S)	(20<=>30)	7	28	Refrigeration 6-6 months	-	TTZ чи EET
<i>Pinus pinaster</i>	TP	20	7	35	-	Double analysis: unrefrigerated and refrigerated 28 days	TTZ
<i>Pinus pinea</i>	TP	20	7	28	Soak in water for 24 hours	-	-
<i>Pinus ponderosa</i>	TP	20<=>30	7	21	-	Double analysis: no refrigeration and refrigeration for 28 days	-
<i>Pinus pumila</i>	S	20<=>30	7	21	Refrigeration 4 months	-	TTZ
<i>Pinus radiata</i>	TP	20	7	28	-	-	-
<i>Pinus resinosa</i>	TP	20<=>30; (25)	7	14	-	-	-
<i>Pinus rigida</i>	TP	20<=>30	7	14	-	-	-
<i>Pinus strobus</i>	TP	20; 20<=>30	7	28	-	Double analysis: unrefrigerated and refrigerated 28 days	TTZ
<i>Pinus sylvestris</i>	TP	20<=>30; (20)	7	21	For seeds of Eastern and Mediterranean origin, cooling is 21 days	-	-

Continuation of Addition 3

1	2	3	4	5	6	7	8
<i>Pinus tabuliformis</i>	TP	20<=>30	7	14	-	-	-
<i>Pinus taeda</i>	TP	22; 20<=>30	7	28	-	Double analysis: unrefrigerated and refrigerated 28 days	-
<i>Pinus taiwanensis</i>	TP	20<=>30	7	21	-	-	-
<i>Pinus thunbergii</i>	TP	20<=>30	7	21	-	-	-
<i>Pinus virginiana</i>	TP	20<=>30	7	21	-	-	-
<i>Pinus wallichiana</i> (<i>P. excelsa</i>)	TP	20<=>30	7	28	-	-	-
<i>Platanus spp.</i>	TP	20<=>30	7	21	-	-	-
<i>Platycladus orientalis</i>	tp	20	7	21	-	-	-
<i>Populus spp.</i>	TP	20<=>30	3	10	-	-	-
<i>Prunus avium</i> , <i>Prunus padus</i> , <i>Prunus serotina</i>	S	20<=>30; (20)	7	28	Refrigeration 3-4 months	-	TTZ - EET
<i>Pseudotsuga menziesii</i>	TP	20<=>30	7	21	-	Double analysis: unrefrigerated and refrigerated 21 days	-
<i>Pyrus spp.</i>	S	20<=>30	7	28	Refrigeration 3-4 months	-	TTZ - EET
<i>Quercus spp.</i>	TS; (S)	20	7	28	Soak the seeds in water for 48 hours, cut off the seed scar and remove the seed coat.	-	-

Continuation of Addition 3

1	2	3	4	5	6	7	8
<i>Robinia pseudoacacia</i>	TP	20<=>30	7	14	1. Prick, cut or file the seed coat at the cotyledon end; soak in water for 3 hours 2. Soak in conc. H ₂ SO ₄ until pits appear; rinse in running water	-	-
<i>Rosa</i> spp. (except <i>R. multiflora</i>)	S	20	35	70	Refrigeration for 12 months	-	TTZ
<i>Rosa multiflora</i>	T	10<=>30	7	28	Cooling 28 days	-	TTZ
<i>Salix</i> spp.	TP	20<=>30	7	14	-	-	-
<i>Sequoia sempervirens</i>	TP	20<=>30	7	21	-	-	-
<i>Sequoiadendron giganteum</i>	TP	20<=>30	7	28	-	-	-
<i>Sorbus</i> spp.	S	20<=>30	7	28	Refrigeration 4 months	-	TTZ
<i>Spartium junceum</i>	TP	20	7	14	Prick, cut, or file the seed coat from the cotyledon end; then soak for 3 hours	-	-
<i>Styphnolobium japonica</i>	-	-	-	-	-	TTZ	-
<i>Syringa reflexa</i>	TP	20	7	21	-	Double analysis: unrefrigerated and refrigerated 27 days	-
<i>Syringa villosa</i>	TP	20<=>30	7	21	-	-	-
<i>Syringa vulgaris</i>	TP	20	7	21	-	-	-
<i>Taxodium distichum</i>	S	20<=>30; (20)	7	28	Cooling 30 days	-	TTZ

Continuation of Addition 3

1	2	3	4	5	6	7	8
<i>Taxus</i> spp.	S	20<=>30	7	28	Refrigeration 9 months	-	TTZ
<i>Tectona grandis</i>	S	30	14	28	Soak in water and dry for 3 days. Repeat 6 times.	-	-
<i>Thuja occidentalis</i>	TP	20<=>30	7	21	-	-	-
<i>Thuja plicata</i>	TP	20<=>30	7	21	-	-	-
<i>Tilia cordata</i> , <i>Tilia platyphyllos</i>	S	20<=>30	7	28	Refrigeration 6-9 months	-	TTZ - EET
<i>Tsuga canadensis</i>	TP	15	7	28	Cooling 28 days	-	-
<i>Tsuga heterophylla</i>	TP	20	7	35	-	Double analysis: unrefrigerated and refrigerated 21 days	-
<i>Ulmus americana</i> , <i>Ulmus parviflora</i> , <i>Ulmus pumila</i>	TP	20<=>30; (20)	7	14	Remove pericarp	-	-
<i>Viburnum opulus</i>	-	-	-	-	-	Use TTZ	-
<i>Zelkova serrata</i>	TP	10<=>30	7	28	-	Double analysis: do not refrigerate and refrigerate for 14 days	-

Addition 4

Seed Germination Testing Methods. Seed of Flower, Spice, Herb and Medicinal Species

Plant	Substrate	Temperature (°C)	Accounting periods, days		Additional conditions and guidelines for overcoming seed dormancy
			First	final	
1	2	3	4	5	6
<i>Abutilon x hybridum</i>	TP; BP	20<=>30; 20	5-7	21	-
<i>Achillea clavennae</i>	TP; BP	20<=>30; 20	5	14	Lighting
<i>Achillea filipendulina</i>	TP; BP	20<=>30; 20	5	14	Lighting
<i>Achillea ptarmica</i>	TP; BP	20<=>30; 20	5	14	Lighting
<i>Achillea umbellata</i>	TP; BP	20<=>30; 20	5	14	Lighting
<i>Adonis vernalis</i>	TP; BP	15; 10	7-14	35	Cooling; KN0 ₃
<i>Ageratum houstonianum</i>	TP	20<=>30; 20	3-5	14	-
<i>Agrimonia eupatoria</i>	TP	20<=>30	7-14	60	Soak in water for 24 hours; зрізати або надпиляти частину насінневої оболонки
<i>Alcea rosea</i>	TP; BP	20<=>30; 20	4-7	21	Наколоти насіння, або зрізати або надпиляти частину насінневої оболонки у сім'ядольного кінця
<i>Althaea hybrids</i>	TP; BP	20<=>30; 20	4-7	21	Наколоти насіння, або зрізати або надпиляти частину насінневої оболонки у сім'ядольного кінця
<i>Althaea officinalis</i>	TP; BP	20<=>30; 20	4-7	21	-
<i>Alyssum argenteum</i>	TP	20<=>30; 20; 15	4-7	21	Cooling;; KN0 ₃
<i>Alyssum montanum</i>	TP	20<=>30; 20; 15	4-7	21	Cooling;; KN0 ₃
<i>Amaranthus caudatus</i>	TP	20<=>30; 20	4-5	14	Cooling;; KN0 ₃
<i>Amaranthus cruentus</i>	TP	20<=>30; 20	4-5	14	Cooling;; KN0 ₃
<i>Amaranthus hybridus</i>	TP	20<=>30; 20	4-5	14	Cooling;; KN0 ₃
<i>Amaranthus tricolor</i>	TP	20<=>30; 20	4-5	14	Cooling;; KN0 ₃
<i>Amberboa moschata</i>	TP; BP	20<=>30; 20; 15	4-7	21	Cooling
<i>Ammobium alatum</i>	TP; BP	20<=>30; 20	5-7	14	-
<i>Anagallis arvensis</i>	TP	20<=>30; 20; 15	7-10	21	Cooling; KN0 ₃
<i>Anchusa azurea</i>	TP; BP	20-30; 20	5-7	21	-
<i>Anchusa capensis</i>	TP;BP	20<=>30; 20; 15	5-7	21	-
<i>Anemone coronaria</i>	TP	20<=>30; 20; 15	7-14	28	Cooling

Continuation of Addition 4

1	2	3	4	5	6
<i>Anemone pulsatilla</i>	TP	20<=>30; 20; 15	7-14	28	Cooling
<i>Anemone sylvestris</i>	TP	20<=>30; 20; 15	7-14	28	Cooling
<i>Angelica archangelica</i>	TP; BP	20<=>30	7-10	28	Lighting; Cooling
<i>Antirrhinum majus</i>	TP	20<=>30; 20	5-7	21	Cooling; KN0 ₃
<i>Aquilegia alpina</i>	TP; BP	20<=>30; 15	7-14	28	Lighting; Cooling
<i>Aquilegia canadensis</i>	TP; BP	20<=>30; 15	7-14	28	Lighting; Cooling
<i>Aquilegia chrysantha</i>	TP; BP	20<=>30; 15	7-14	28	Lighting; Cooling
<i>Aquilegia x cultorum</i>	TP; BP	20<=>30; 15	7-14	28	Lighting; Cooling
<i>Aquilegia vulgaris</i>	TP; BP	20<=>30; 15	7-14	28	Lighting; Cooling
<i>Arabis alpina</i>	TP	20<=>30; 15	5-7	21	Cooling; KN0 ₃
<i>Arabis x arendsii</i>	TP	20<=>30; 15	5-7	21	Cooling; KN0 ₃
<i>Arabis blepharophylla</i>	TP	20<=>30; 15	5-7	21	Cooling; KN0 ₃
<i>Arabis caucasica</i>	TP	20<=>30; 15	5-7	21	Cooling; KN0 ₃
<i>Arabis procurrens</i>	TP	20<=>30; 15	5-7	21	Cooling; KN0 ₃
<i>Arabis scopoliana</i>	TP	20<=>30; 15	5-7	21	Cooling; KN0 ₃
<i>Arctotis stoechadifolia</i>	TP; BP	20<=>30; 20; 15	7	21	Lighting
<i>Armeria maritima</i>	TP; BP	20<=>30; 15	4-7	21	KN0 ₃
<i>Artemisia absinthium</i>	TP	20<=>30	4-7	21	-
<i>Artemisia dracunculus</i>	TP	20<=>30	4-7	21	-
<i>Artemisia maritima</i>	TP	20<=>30	4-7	21	-
<i>Artemisia vulgaris</i>	TP	20<=>30	4-7	21	-
<i>Asclepias tuberosa</i>	TP	20<=>30	7	28	-
<i>Asparagus densiflorus</i>	TP; BP; S	20<=>30; 20	7-14	35	Soak in water for 24 hours
<i>Asparagus setaceus</i>	TP;BP;S	20<=>30; 20	7-14	35	Soak in water for 24 hours
<i>Aster alpinus</i>	TP	20<=>30; 20	3-5	14	Cooling
<i>Aster amellus</i>	TP	20<=>30; 20	3-5	14	Cooling
<i>Aster dumosus</i>	TP	20<=>30; 20	3-5	14	Cooling
<i>Aubrieta deltoidea</i>	TP	20; 15; 10	7	21	Cooling
<i>Aurinia saxatilis</i>	TP	20<=>30; 20; 15	4-7	21	Cooling; KN0 ₃
<i>Begonia Semperflorens-Cultorum group</i>	TP	20<=>30; 20	7-14	21	Cooling
<i>Begonia x tuberhybrida</i>	TP	20<=>30; 20	7-14	21	Cooling
<i>Bellis perennis</i>	TP	20<=>30; 20	4-7	14	Cooling
<i>Brachyscome iberidifolia</i>	TP	20<=>30; 15	4-7	14	-

Continuation of Addition 4

1	2	3	4	5	6
<i>Briza maxima</i>	TP	20<=>30; 20	4-7	21	Cooling
<i>Browallia viscosa</i>	TP; BP	20<=>30; 20	7	21	-
<i>Brunnera macrophylla</i>	TP; BP	20<=>30; 20	7	21	-
<i>Calceolaria x herbeohybrida</i>	TP	20<=>30; 15	7	21	Cooling; KN0 ₃
<i>Calceolaria polyrhiza</i>	TP	20<=>30; 15	7	21	Cooling; KN0 ₃
<i>Calendula officinalis</i>	TP; BP	20<=>30; 20	4-7	14	Lighting; Cooling; KN0 ₃
<i>Callistephus chinensis</i>	TP	20<=>30; 20	4-7	14	Lighting
<i>Campanula carpatia</i>	TP; BP	20<=>30; 20	4-7	21	Lighting; Cooling
<i>Campanula fragilis</i>	TP; BP	20<=>30; 20	4-7	21	Lighting; Cooling
<i>Campanula garganica</i>	TP; BP	20<=>30; 20	4-7	21	Lighting; Cooling
<i>Campanula glomerata</i>	TP; BP	20<=>30; 20	4-7	21	Lighting; Cooling
<i>Campanula lactiflora</i>	TP; BP	20<=>30; 20	4-7	21	Lighting; Cooling
<i>Campanula medium</i>	TP; BP	20<=>30; 20	4-7	21	Lighting; Cooling
<i>Campanula persicifolia</i>	TP; BP	20<=>30; 20	4-7	21	Lighting; Cooling
<i>Campanula portenschlagiana</i>	TP; BP	20<=>30; 20	4-7	21	Lighting; Cooling
<i>Campanula pyramidalis</i>	TP; BP	20<=>30; 20	4-7	21	Lighting; Cooling
<i>Campanula rapunculus</i>	TP; BP	20<=>30; 20	4-7	21	Lighting; Cooling
<i>Celosia argentea</i>	TP	20<=>30; 20	3-5	14	Cooling
<i>Centaurea americana</i>	TP; BP	20<=>30; 20; 15	4-7	21	Lighting; Cooling; Soak in water for 24 hours
<i>Centaurea cyanus</i>	TP; BP	20<=>30; 20; 15	4-7	21	Lighting; Cooling
<i>Centaurea dealbata</i>	TP; BP	20<=>30; 20; 15	4-7	21	Lighting; Cooling
<i>Centaurea gymnocarpa</i>	TP; BP	20<=>30; 20; 15	4-7	21	Lighting; Cooling
<i>Centaurea imperialis</i>	TP; BP	20<=>30; 20; 15	4-7	21	Lighting; Cooling
<i>Centaurea macrocephala</i>	TP; BP	20<=>30; 20; 15	4-7	21	Lighting; Cooling
<i>Centaurea montana</i>	TP; BP	20<=>30; 20; 15	4-7	21	Lighting; Cooling

Continuation of Addition 4

1	2	3	4	5	6
<i>Centaurea ragusina</i>	TP; BP	20<=>30; 20; 15	4-7	21	Lighting; Cooling
<i>Cerastium tomentosum</i>	TP; BP	20<=>30; 20	4-7	21	KN0 ₃
<i>Chelidonium majus</i>	20<=>30	20<=>30	7-14	28	Cooling
<i>Chrysanthemum indicum</i>	TP; BP	20<=>30; 20	4-7	21	Lighting; Cooling
<i>Clarkia amoena</i>	TP; BP	20<=>30; 15	4-7	14	Lighting; Cooling
<i>Clarkia pulchella</i>	TP	20<=>30; 15	3-5	14	Lighting; Cooling
<i>Clarkia unguiculata</i>	TP	20<=>30; 15	3-5	14	Lighting; Cooling
<i>Cleome hassleriana</i>	TP	20<=>30; 20	7	28	KN0 ₃
<i>Cnicus benedictus</i>	TP; BP; S	20<=>30	7	21	Cooling
<i>Cobaea scandens</i>	TP; BP	20<=>30; 20	4-7	21	-
<i>Coix lacrymajobi</i>	BP	20<=>30	7-10	21	-
<i>Coleostephus multicaulis</i>	TP; BP	20<=>30; 20	4-7	21	Lighting; Cooling
<i>Coleus blumei</i>	TP; BP	20<=>30; 20	5-7	21	Lighting
<i>Consolida ajacis</i>	TP; BP	20; 15; 10	7-10	21	Cooling
<i>Consolida regalis</i>	TP; BP	20; 15; 10	7-10	21	Cooling
<i>Convolvulus tricolor</i>	TP; BP	20<=>30; 20	4-7	14	To prick the seed, or to cut or saw off part of the seed coat
<i>Coreopsis basalis</i>	TP; BP	20<=>30; 20	4-7	14	Lighting; Cooling; KN0 ₃
<i>Coreopsis lanceolata</i>	TP; BP	20<=>30; 20	4-7	14	Lighting; Cooling; KN0 ₃
<i>Coreopsis maritima</i>	TP; BP	20<=>30; 20	4-7	14	Lighting; Cooling; KN0 ₃
<i>Coreopsis tinctoria</i>	TP	20<=>30; 20	4-7	14	Cooling; KN0 ₃
<i>Cosmos bipinnatus</i>	TP; BP	20<=>30; 20	3-5	14	Lighting; Cooling; KN0 ₃
<i>Cosmos sulphureus</i>	TP; BP	20<=>30; 20	3-5	14	Lighting; Cooling; KN0 ₃
<i>Cyclamen persicum</i>	TP; BP; S	20; 15	14-21	35	KN0 ₃ ; Soak in water for 24 hours
<i>Cymbalaria muralis</i>	TP	15; 10	4-7	21	Cooling
<i>Cynoglossum amabile</i>	TP; BP	20<=>30; 20	4-7	14	Lighting; Cooling; KN0 ₃
<i>Dahlia pinnata</i>	TP; BP	20<=>30; 20; 15	4-7	21	Cooling
<i>Datura metel</i>	TP; BP; S	20<=>30; 20	5-7	21	Cooling; to file hard seeds

Continuation of Addition 4

1	2	3	4	5	6
<i>Datura stramonium</i>	TP; BP; S	20<=>30; 20	5-7	21	Cooling; to file hard seeds
<i>Delphinium x belladonna</i>	TP; BP	20<=>15; 10	7-10	21	Lighting; Cooling
<i>Delphinium cardinale</i>	TP; BP	20; 15; 10	7-10	21	Cooling
<i>Delphinium x cultorum</i>	TP; BP	20; 15; 10	7-10	21	Lighting; Cooling
<i>Delphinium formosum</i>	TP; BP	20<=>15; 10	7-10	21	Lighting; Cooling
<i>Delphinium grandiflorum</i>	TP; BP	20; 15; 10	7-10	21	Lighting; Cooling
<i>Dianthus barbatus</i>	TP; BP	20<=>30; 20	4-7	14	Cooling
<i>Dianthus caryophyllus</i>	TP; BP	20<=>30; 20	4-7	14	Cooling
<i>Dianthus chinensis</i>	TP; BP	20<=>30; 20	4-7	14	Cooling
<i>Dianthus deltoides</i>	TP; BP	20<=>30; 20	4-7	14	Cooling
<i>Dianthus plumarius</i>	TP; BP	20<=>30; 20	4-7	14	Cooling
<i>Digitalis lanata</i>	TP	20<=>30; 20	4-7	14	Cooling
<i>Digitalis purpurea</i>	TP	20<=>30; 20	4-7	14	Cooling
<i>Dimorphotheca pluvialis</i>	TP; BP	20<=>30; 15	4-7	14	Lighting; Cooling; KN0 ₃
<i>Dimorphotheca tragus</i>	TP; BP	20<=>30; 20; 15	4-7	14	Lighting; Cooling; KN0 ₃
<i>Doronicum orientate</i>	TP	20<=>30; 20	4-7	21	Cooling; KN0 ₃
<i>Dorotheanthus bellidiformis</i>	TP; BP	20; 15	5-7	35	Cooling; KN0 ₃
<i>Echinacea purpurea</i>	TP; BP	20<=>30; 20	4-7	21	Lighting; Cooling
<i>Echinops ritro</i>	TP; BP	20<=>30	7-14	21	-
<i>Echium candicans</i>	TP; BP	20<=>30; 20	4-7	14	-
<i>Echium plantagineum</i>	TP; BP	20<=>30; 20	4-7	14	-
<i>Erigeron speciosus</i>	TP	20<=>30; 20	7	28	-
<i>Erysimum cheiri</i>	TP	20<=>30; 20; 15	4-5	14	Lighting; Cooling; KN0 ₃
<i>Erysimum × marshallii</i>	TP	20<=>30; 20; 15	4-7	14	Cooling; KN0 ₃
<i>Eschscholzia californica</i>	TP; BP	15; 10	4-7	14	KN0 ₃
<i>Fatsia japonica</i>	TP	20<=>30; 20	7-14	28	-
<i>Freesia refracta</i>	TP; BP	20; 15	7-10	35	To prick the seed, or to cut or saw off part of the seed coat; Cooling
<i>Gaillardia aristata</i>	TP; BP	20<=>30; 20	4-7	21	Cooling; Cooling

Continuation of Addition 4

1	2	3	4	5	6
<i>Gaillardia pulchella</i>	TP; BP	20<=>30; 20	4-7	21	Cooling; Cooling
<i>Galega officinalis</i>	TP; BP	20<=>30; 20	3-5	14	Soak in water for 24 hours
<i>Galeopsis segetum</i>	TP; BP	20<=>30; 20	7	21	Cooling; to file hard seeds
<i>Gazania rigens</i>	TP; BP	20<=>30; 15	4-7	21	Cooling
<i>Gentiana acaulis</i>	TP	20<=>30; 20	7-14	28	Cooling
<i>Geranium hybrids</i>	TP; BP	20<=>30	7	28	To prick the seed, or to cut or saw off part of the seed coat
<i>Gerbera jamesonii</i>	TP	20<=>30; 20	4-7	14	-
<i>Geum coccineum</i>	TP; BP	20<=>30; 20	7-10	21	Lighting
<i>Geum quellyon</i>	TP; BP	20<=>30; 20	7-10	21	Lighting
<i>Gilia tricolor</i>	TP; BP	20<=>30; 15	4-7	14	-
<i>Glandularia canadensis</i>	TP	20<=>30; 15	7-10	28	Cooling; KN03
<i>Glebionis carinata</i>	TP; BP	20<=>30; 15	4-7	21	Lighting; Cooling
<i>Glebionis coronaria</i>	TP; BP	20<=>30; 15	4-7	21	Lighting; Cooling
<i>Glebionis segetum</i>	TP; BP	20<=>30; 15	4-7	21	Cooling
<i>Gomphrena globosa</i>	TP; BP	20<=>30; 20	4-7	14	KN03
<i>Goniolimon tataricum</i>	TP; BP	15; 10	5-7	21	Soak in water for 24 hours
<i>Grevillea robusta</i>	TP	20<=>30	7-10	28	Cooling; KN03
<i>Gypsophila elegans</i>	TP; BP	20; 15	4-7	14	Lighting
<i>Gypsophila paniculata</i>	TP; BP	20; 15	4-7	14	Lighting
<i>Gypsophila repens</i>	TP; BP	20; 15	4-7	14	Lighting
<i>Helenium autumnale</i>	TP; BP	20<=>30; 20	5	14	-
<i>Helianthemum nummularium</i>	TP; BP	20<=>30; 20	5-7	28	KNO ₃
<i>Helianthus debilis</i>	TP; BP; S	20<=>30; 20	3-5	14	Cooling
<i>Helichrysum bracteatum</i>	TP; BP	20<=>30; 15	4-7	14	Lighting; Cooling; KN0 ₃
<i>Heliopsis helianthoides</i>	TP; BP	20<=>30	4-7	21	KN0 ₃ ; Soak in water for 24 hours

Continuation of Addition 4

1	2	3	4	5	6
<i>Heliotropium arborescens</i>	TP	20<=>30; 20	7	21	-
<i>Helipterum humboldtianum</i>	TP; BP	20<=>30; 15	7-14	21	Cooling
<i>Helipterum manglesii</i>	TP; BP	20<=>30; 15	7-14	21	Cooling
<i>Helipterum roseum</i>	TP; BP	20<=>30; 15	7-14	21	Cooling
<i>Hesperis matronalis</i>	TP	20<=>30; 20	4-7	14	Cooling; KN0 ₃
<i>Heteranthesis viscidiflora</i>	TP; BP	20<=>30; 20	4-7	21	Cooling
<i>Heuchera sanguinea</i>	TP	20<=>30; 20	7	21	Cooling; KN0 ₃
<i>Hibiscus trionum</i>	TP; BP	20<=>30	4-7	21	-
<i>Hippeastrum hybrids</i>	TP; BP	20<=>30	7-10	28	-
<i>Hypericum perforatum</i>	TP	20<=>30; 20	4-7	21	-
<i>Hyssopus officinalis</i>	TP; BP	20<=>30; 20	4-7	14	Lighting
<i>Iberis amara</i>	TP; BP	20<=>30; 20; 15	4-7	14	Cooling; KN0 ₃
<i>Iberis gibraltarica</i>	TP; BP	20<=>30; 15	4-7	14	Cooling; KN0 ₃
<i>Iberis sempervirens</i>	TP; BP	20<=>30; 15	4-7	14	Cooling; KN0 ₃
<i>Iberis umbellata</i>	TP; BP	20<=>30; 15	4-7	14	Cooling; KN0 ₃
<i>Impatiens balsamina</i>	TP; BP	20<=>30; 20	4-7	21	Lighting; Cooling; KN0 ₃
<i>Impatiens walleriana</i>	TP; BP	20<=>30; 20	4-7	21	Lighting; Cooling; KN0 ₃
<i>Inula helenium</i>	TP	20<=>30; 20	7-10	28	-
<i>Ipomoea alba</i>	TP; BP; S	20<=>30; 20	4-7	21	To prick the seed, or to cut or saw off part of the seed coat
<i>Ipomoea purpurea</i>	TP; BP; S	20<=>30; 20	4-7	21	To prick the seed, or to cut or saw off part of the seed coat
<i>Ipomoea quamoclit</i>	TP; BP; S	20<=>30; 20	4-7	21	To prick the seed, or to cut or saw off part of the seed coat
<i>Ipomoea tricolor</i>	TP; BP; S	20<=>30; 20	4-7	21	To prick the seed, or to cut or saw off part of the seed coat
<i>Kalanchoe blossfeldiana</i>	TP	20<=>30; 20	7-14	21	-
<i>Kalanchoe crenata</i>	TP	20<=>30; 20	14	21	-
<i>Kalanchoe globulifera</i>	TP	20<=>30; 20	7-14	21	-

Continuation of Addition 4

1	2	3	4	5	6
<i>Kniphofia uvaria</i>	TP	20<=>30	4-7	21	-
<i>Kochia scoparla</i>	TP; BP	20<=>30; 20	3-5	14	Cooling; GA ₃
<i>Lathyrus latifolius</i>	TP; BP; S	20	7-10	21	Cooling; To prick the seed, or to cut or saw off part of the seed coat
<i>Lathyrus odoratus</i>	TP; BP; S	20	5-7	14	Cooling
<i>Lavandula angustifolia</i>	TP; BP; S	20<=>30; 20	7-10	21	Cooling; GA ₃
<i>Lavatera trimestris</i>	TP; BP	20<=>30; 20	4-7	21	Cooling
<i>Legousia speculum-veneris</i>	TP; BP	20<=>30; 20	4-7	21	Lighting; Cooling
<i>Leontopodium alpinum</i>	TP	20<=>30; 20	5	14	Cooling
<i>Leonurus cardiaca</i>	TP	20<=>30	5-7	42	Cooling
<i>Leucanthemum maximum</i>	TP; BP	20<=>30; 20	4-7	21	Lighting; Cooling
<i>Leucanthemum vulgare</i>	TP; BP	20<=>30; 20	4-7	21	Lighting; Cooling
<i>Levisticum officinale</i>	TP; BP	20<=>30; 20	10	21	-
<i>Liatris pyenostachya</i>	TP	20<=>30	5-7	28	-
<i>Liatris spicata</i>	TP	20<=>30	5-7	28	-
<i>Lilium regale</i>	TP; S	20<=>30; 20	7	28	-
<i>Limonium bellidifolium</i>	TP; BP	15; 10	5-7	21	Soak in water for 24 hours
<i>Limonium bonduellei</i>	TP; BP; S	20; 15	5-7	21	Soak in water for 24 hours
<i>Limonium gerberi</i>	TP; BP	15; 10	5-7	21	Soak in water for 24 hours
<i>Limonium sinuatum</i>	TP; BP; S	15; 10	5-7	21	Soak in water for 24 hours
<i>Linaria bipartita</i>	TP	15; 10	4-7	21	Cooling
<i>Linaria maroccana</i>	TP	15; 10	4-7	21	Cooling
<i>Linaria vulgaris</i>	TP	15; 10	4-7	21	Cooling
<i>Linum flavum</i>	TP; BP	20<=>30; 15	4-7	21	KN03
<i>Linum grandiflorum</i>	TP; BP	20; 15; 10	4-7	21	KNO ₃
<i>Linum narbonense</i>	TP; BP	20<=>30; 20; 15	4-7	21	KN03
<i>Linum perenne</i>	TP; BP	20; 15; 10	4-7	21	KNO ₃
<i>Lobelia cardinalis</i>	TP	20<=>30; 20	7-14	21	Cooling; KN03
<i>Lobelia erinus</i>	TP	20<=>30; 20	7-14	21	Cooling; KN03
<i>Lobularia maritima</i>	TP	20<=>30; 20; 15	4-7	21	Cooling; KN0 ₃
<i>Lonas annua</i>	TP	20<=>30	4-5	14	
<i>Lunaria annua</i>	TP; BP	20; 15	7	21	Cooling; KN0 ₃

Continuation of Addition 4

1	2	3	4	5	6
<i>Lupinus hartwegii</i>	TP; BP; S	20<=>30; 20	4-7	21	To prick the seed, or to cut or saw off part of the seed coat; Cooling
<i>Lupinus hybrids</i>	TP; BP; S	20<=>30; 20	4-7	21	-
<i>Lupinus nanus</i>	TP; BP; S	20<=>30; 20	4-7	21	-
<i>Lupinus polyphyllus</i>	TP; BP; S	20<=>30; 20	4-7	21	-
<i>Malcolmia maritima</i>	TP	20<=>30; 20; 15	4-5	14	Lighting; Cooling; KN0 ₃
<i>Malope trifida</i>	TP; BP	20<=>30; 20	4-7	14	Cooling
<i>Marrubium vulgare</i>	TP	20<=>30	5-7	21	Cooling
<i>Matricaria recutita</i>	TP	20<=>30; 20	4-7	14	Cooling
<i>Matthiola incana</i>	TP	20<=>30; 20	4-7	14	Cooling; KN0 ₃
<i>Matthiola longipetala</i>	TP	20<=>30; 20; 15	4-7	14	Cooling; KN0 ₃
<i>Melissa officinalis</i>	TP	20<=>30; 20	4-7	21	Cooling
<i>Mentha × piperita</i>	TP	20<=>30	7-14	21	Cooling; KN0 ₃
<i>Mimosa pudica</i>	TP; BP	20<=>30; 20	4-7	28	Soak in water for 24 hours
<i>Mimulus cardinalis</i>	TP	20<=>30; 20	4-7	21	Cooling
<i>Mimulus cupreus</i>	TP	20<=>30; 20	4-7	21	Cooling
<i>Mimulus × hybridus</i>	TP	20<=>30; 20	4-7	21	Cooling
<i>Mimulus luteus</i>	TP	20<=>30; 20	4-7	21	Cooling
<i>Mirabilis jalapa</i>	TP; BP; S	20<=>30; 20	4-7	14	Lighting; Cooling
<i>Moluccella laevis</i>	TP; BP	20<=>30; 20	5-7	21	Lighting; Cooling
<i>Myosotis hybrids</i>	TP; BP	20<=>30; 20; 15	5-7	21	Lighting; Cooling
<i>Myosotis scorpioides</i>	TP; BP	20<=>30; 20; 15	5-7	21	Lighting; Cooling
<i>Myosotis sylvatica</i>	TP; BP	20<=>30; 20; 15	5-7	21	Lighting; Cooling
<i>Nemesia strumosa</i>	TP; BP	20; 15	5-7	21	Lighting; Cooling
<i>Nemesia versicolor</i>	TP; BP	20; 15	5-7	21	Lighting; Cooling
<i>Nemophila maculata</i>	TP; BP	15; 10	5-7	21	Cooling
<i>Nemophila menziesii</i>	TP; BP	15; 10	5-7	21	Cooling
<i>Nepeta cataria</i>	TP; BP	20<=>30; 20	7-14	28	Cooling
<i>Nicotiana alata</i>	TP	20<=>30; 20	5-7	14	KN0 ₃
<i>Nicotiana × sanderae</i>	TP	20<=>30; 20	5-7	14	KN0 ₃

Continuation of Addition 4

1	2	3	4	5	6
<i>Nicotiana suaveolens</i>	TP	20<=>30; 20	5-7	14	KNO ₃
<i>Nierembergia hippomanica</i>	TP	20<=>30; 20	5-7	21	-
<i>Nigella damascena</i>	TP; BP	20<=>30; 20; 15	7-10	21	KN ₃ ; at 15 °C in the dark for 14 days, then at 20-30 °C; Cooling
<i>Nigella hispanica</i>	TP; BP	20<=>30; 20; 15	7-10	21	KN ₃ ; at 15 °C in the dark for 14 days, then at 20-30 °; Cooling
<i>Nigella sativa</i>	TP; BP	20<=>30; 20	7-10	21	Cooling; KN ₃
<i>Oenothera macrocarpa</i>	TP; BP	20<=>30; 20	4-7	21	KN ₃
<i>Osteospermum ecklonis</i>	TP; BP	20<=>30; 20	4-7	14	Lighting; Cooling; KN ₃
<i>Papaver alpinum</i>	TP	15; 10	4-7	14	KN ₃
<i>Papaver glaucum</i>	TP	15; 10	4-7	14	Lighting; KN ₃
<i>Papaver nudicaule</i>	TP	15; 10	4-7	14	Lighting; KN ₃
<i>Papaver orientale</i>	TP	20<=>30; 20	4-7	14	Cooling; KN ₃
<i>Papaver rhoeas</i>	TP	20<=>30; 20; 15	4-7	14	Lighting; Cooling; KN ₃
<i>Pelargonium Zonale Group</i>	TP; BP	20<=>30; 20	7	28	To prick the seed, or to cut or saw off part of the seed coat
<i>Penstemon barbatus</i>	TP	20<=>30; 15	7	21	Cooling
<i>Penstemon hartwegii</i>	TP	20<=>30; 15	7	21	Cooling
<i>Penstemon hybrids</i>	TP	20<=>30; 15	7	21	Cooling
<i>Perilla frutescens</i>	TP; BP	20<=>30; 20	5-7	21	Cooling
<i>Petunia × hybrida</i>	TP	20<=>30; 20	5-7	14	Cooling; KN ₃
<i>Phacelia campanularia</i>	TP; BP	15; 10	3-5	21	Cooling; KN ₃
<i>Phlox drummondii</i>	TP; BP	20<=>30; 20; 15	5-7	21	Cooling; KN ₃
<i>Phlox paniculata</i>	TP; BP	20; 15	5-7	21	Cooling; KN ₃
<i>Phlox subulata</i>	TP; BP	20; 15	5-7	21	Cooling; KN ₃
<i>Pholistoma auritum</i>	TP; BP	15; 10	5-7	21	Cooling
<i>Physalis alkekengi</i>	TP	20<=>30	4-7	28	Lighting; Cooling; KN ₃
<i>Pimpinella major</i>	TP; BP	20<=>30	7-10	21	Cooling
<i>Pimpinella saxifraga</i>	TP; BP	20<=>30	5-7	21	-
<i>Portulaca grandiflora</i>	TP; BP	20<=>30; 20	4-7	14	Lighting; Cooling; KN ₃
<i>Primula auricula</i>	TP	20<=>30; 20; 15	7-14	28	Cooling; KNO ₃

Continuation of Addition 4

1	2	3	4	5	6
<i>Primula denticulata</i>	TP	20<=>30; 20; 15	7-14	28	Cooling; KNO ₃
<i>Primula elatior</i>	TP	20<=>30; 20; 15	7-14	28	Cooling; KNO ₃
<i>Primula japonica</i>	TP	20<=>30; 20; 15	7-14	28	Cooling; KNO ₃
<i>Primula</i> × <i>kewensis</i>	TP	20<=>30; 20; 15	7-14	28	Cooling; KNO ₃
<i>Primula malacoides</i>	TP	20<=>30; 20; 15	7-14	28	Cooling; KNO ₃
<i>Primula obconica</i>	TP	20<=>30; 20; 15	7-14	28	Cooling; KNO ₃
<i>Primula praenitens</i>	TP	20<=>30; 20; 15	7-14	28	Cooling; KNO ₃
<i>Primula veris</i>	TP	20<=>30; 20; 15	7-14	28	Cooling; KNO ₃
<i>Primula vulgaris</i>	TP	20<=>30; 20; 15	7-14	28	Cooling; KNO ₃
<i>Psylliostachys suworowii</i>	TP; BP	15; 10	5-7	21	Soak in water for 24 hours
<i>Ranunculus asiaticus</i>	TP; S	20; 15	7-14	28	-
<i>Reseda odorata</i>	TP; BP	20<=>30; 15	4-7	14	Lighting
<i>Rheum palmatum</i>	TP; BP	20<=>30; 20	7	21	-
<i>Rudbeckia fulgida</i>	TP; BP	20<=>30; 20	4-7	21	Lighting; Cooling
<i>Rudbeckia hirta</i>	TP; BP	20<=>30; 20	4-7	21	Lighting; Cooling
<i>Ruta graveolens</i>	TP; BP	20<=>30; 20	7	28	Cooling
<i>Saintpaulia ionantha</i>	TP	20<=>30; 20	7-14	28	-
<i>Salpiglossis sinuata</i>	TP; BP	20<=>30; 20	4-7	21	Lighting; Cooling; KN ₃
<i>Salvia coccinea</i>	TP	20<=>30; 20	4-7	21	Cooling
<i>Salvia farinacea</i>	TP	20<=>30; 20	4-7	21	Cooling
<i>Salvia officinalis</i>	TP	20<=>30; 20	4-7	21	Cooling
<i>Salvia patens</i>	TP	20<=>30; 20	4-7	21	Cooling
<i>Salvia pratensis</i>	TP	20<=>30; 20	4-7	21	Cooling
<i>Salvia sclarea</i>	TP; BP	20<=>30; 20	4-7	21	Cooling
<i>Salvia splendens</i>	TP	20<=>30; 20	4-7	21	Cooling
<i>Salvia viridis</i>	TP	20<=>30; 20	4-7	21	Cooling
<i>Sanvitalia procumbens</i>	TP; BP	20<=>30; 20	3-5	14	Cooling
<i>Saponaria calabrica</i>	TP; BP	15; 10	4-7	21	Lighting; Cooling
<i>Saponaria ocymoides</i>	TP; BP	15; 10	4-7	21	Lighting; Cooling
<i>Saponaria officinalis</i>	TP; BP	15; 10	4-7	21	Lighting; Cooling

Continuation of Addition 4

1	2	3	4	5	6
<i>Scabiosa atropurpurea</i>	TP; BP	20<=>30; 20	4-7	21	Cooling
<i>Scabiosa caucasica</i>	TP; BP	20<=>30; 20; 15	4-7	21	Cooling
<i>Schefflera elegantissima</i>	TP; BP	20<=>30	7-14	28	-
<i>Schizanthus pinnatus</i>	TP; BP	15; 10	4-7	14	Cooling
<i>Senecio cineraria</i>	TP	20<=>30; 20	4-7	21	Cooling
<i>Senecio cruentus</i>	TP	20<=>30; 20	4-7	21	Cooling
<i>Senecio elegans</i>	TP	20<=>30; 20	4-7	21	Cooling
<i>Silene chalcedonica</i>	TP	20<=>30; 20	5-10	21	Lighting
<i>Silene coronaria</i>	TP	20<=>30	5-10	21	-
<i>Silene pendula</i>	TP; BP	20<=>30; 20	7-14	28	KNO ₃
<i>Silybum marianum</i>	TP; BP	20<=>30; 20	5-7	21	Cooling
<i>Sinningia speciosa</i>	TP	20<=>30; 20	7-14	28	Cooling
<i>Solanum diflorum</i>	TP; BP	20<=>30; 20	5-7	28	Lighting; KNO ₃
<i>Solanum giganteum</i>	TP; BP	20<=>30; 20	5-7	28	Lighting; KNO ₃
<i>Solanum laciniatum</i>	TP	20<=>30; 20	5-7	28	KNO ₃
<i>Solanum marginatum</i>	TP; BP	20<=>30; 20	5-7	28	Lighting; KNO ₃
<i>Stachys macrantha</i>	TP	20	7	14	-
<i>Tagetes erecta</i>	TP; BP	20<=>30; 20	3-5	14	Lighting
<i>Tagetes patula</i>	TP; BP	20<=>30; 20	3-5	14	Lighting
<i>Tagetes tenuifolia</i>	TP; BP	20<=>30; 20	3-5	14	Lighting
<i>Tanacetum achilleifolium</i>	TP; BP	20<=>30; 15	4-7	21	Lighting; Cooling
<i>Tanacetum cinerariifolium</i>	TP; BP	20<=>30; 20	4-7	21	Cooling
<i>Tanacetum coccineum</i>	TP; BP	20<=>30; 15	4-7	21	Lighting; Cooling; KNO ₃
<i>Tanacetum parthenium</i>	TP; BP	20<=>30; 20	4-7	21	Lighting; Cooling
<i>Thunbergia alata</i>	TP; BP	20<=>30; 20	4-7	21	-
<i>Thymus serpyllum</i>	TP; BP	20<=>30; 20; 15	7	21	Lighting
<i>Torenia fournieri</i>	TP	20<=>30	5-7	14	KNO ₃
<i>Tripleurospermum maritimum</i>	TP	20<=>30; 20	4-7	14	Cooling

Continuation of Addition 4

1	2	3	4	5	6
<i>Tripleurospermum perforatum</i>	TP	20<=>30; 20	4-7	14	Cooling
<i>Tropaeolum majus</i>	TP;BP;S	20<=>30; 20; 15	4-7	21	Cooling
<i>Tropaeolum peltophorum</i>	TP;BP;S	20; 15	4-7	21	Cooling
<i>Tropaeolum peregrinum</i>	TP;BP;S	20; 15	4-7	21	Cooling
<i>Vaccaria hispanica</i>	TP; BP	15<=>10	4-7	21	Lighting; Cooling
<i>Valeriana officinalis</i>	TP	20<=>30; 20	5-7	21	Cooling
<i>Verbascum densiflorum</i>	TP	20<=>30	4-7	21	Cooling
<i>Verbascum phlomoides</i>	TP	20<=>30	4-7	21	Cooling
<i>Verbascum thapsus</i>	TP	20<=>30	4-7	21	Cooling
<i>Verbena bonariensis</i>	TP	20<=>30; 15	7-10	28	Cooling; KN0 ₃
<i>Verbena Hybrida Group</i>	TP	20-30; 20; 15	7-10	28	Cooling; KNO ₃
<i>Verbena rigida</i>	TP	20<=>30; 15	7-10	28	Cooling; KN0 ₃
<i>Vinca minor</i>	TP	20<=>30; 20	4-7	14	-
<i>Viola cornuta</i>	TP	20<=>30; 20	4-7	21	Cooling; KN0 ₃
<i>Viola odorata</i>	TP	20; 10	4-7	21	Cooling; KN0 ₃
<i>Viola tricolor</i>	TP	20<=>30; 20	4-7	21	Cooling; KN0 ₃
<i>Xeranthemum annuum</i>	TP; BP	20<=>30; 20	4-7	14	-
<i>Zinnia elegans</i>	TP; BP	20<=>30; 20	3-5	10	Lighting; Cooling
<i>innia haageana</i>	TP; BP	20<=>30; 20	3-5	10	Lighting; Cooling