CROP PRODUCTION TECHNOLOGY

Textbook

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The textbook focuses on morphological and biological features of field and fodder crops. It describes intensive technologies for growing the main agricultural crops, as well as technologies for growing root and tuber crops, melons, oil and essential oil, spinning, narcotic,intermediate crops, and hops. The issues of seed preparation for sowing, crop care, harvesting, and the basics of seed science are considered. 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, tillage and fertilization in regulating the agro-ecological conditions of field crop vegetation. Ecologically clean energy-saving technologies for growing the main grain and industrial crops are considered. For training Bachelor’s degree seekers in specialty 051 “Economics” (specialization “Economics of entrepreneurship”) at agrarian higher educational institutions of II-IV levels of accreditation.

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Scientific interests: development of new and improvement of existing elements of resource-saving farming technologies. cultures

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Everything beautiful on the Earth
Begins with a spikelet,
Which will shine on the stem,
Like the worker's soul.
The steel clattering in the furnace,
The black layers cut,
The highway on the horizon,
Or spaceships
Raised by someone's hand -
Everything big on the Earth
Begins with a spikelet...
(Oleksandr BOHACHUK)

INTRODUCTION

Agriculture is the oldest branch of material production and a special branch of the economy. It deals with producing cultivated plants (crop production) as well as breeding and rearing domestic animals (animal husbandry). Thus, agriculture provides the population with food and, at the same time, it supplies raw materials to industry. About half of the world's economically active population is employed in agricultural production. In developing countries, this indicator is 2/3 or more, while in developed countries it is less than 10%, in the USA and some countries of Western Europe it is only 2-3%.

Agriculture is developing in one way or another in almost all countries. The biggest producers of agricultural products are the largest countries in terms of size and number of consumers, such as: the USA, Canada, Brazil, China, and India. Developing countries are dominated by domestic consumption, while economically developed countries are the largest exporters of agricultural products. At the same time, economically developed countries are the biggest importers of agricultural products, as they have an extremely large consumer market.

The ratio of the two main branches of agriculture – crop production and animal husbandry – depends on a number of factors. First of all, the specificity of the economy is determined by natural conditions, which can impose significant restrictions on certain types of agricultural production, while simultaneously promoting the development of others. A large role is also played by the level of industrialization of the country, which can provide a highly mechanized economy. In some places, the development of certain branches of agriculture is determined by the country's ethnic and religious characteristics. Thus, for example, Islam forbids eating pork, and Hinduism – killing cows. Likewise, some African peoples kill cattle extremely rarely.

In general, crop production predominates in most developing countries. Exceptions are the countries located in tropical deserts, where the area of arable land is extremely small, as well as those situated in the Pampas of South America (Argentina, Uruguay), where high-product livestock breeding is developed. Instead, in economically developed countries preference is given to animal husbandry.

In the agricultural sector of economically developed countries, high-product agro-industrial production prevails. This means that farmers produce an amount of agricultural products that far exceeds their needs. In developing countries, small-scale agriculture prevails. Farmers are able to sell only a small part of their production. Production is mostly focused on meeting farms' own needs in food products.

When describing the current state of world agriculture, the term "green revolution" is often used. Why "green"? Because green is the color of agriculture. Why "revolution"? Because large-scale transformations are taking place in agriculture based on modern agricultural technology. Nowadays, a new stage of the "green revolution", which is called the "biotechnological revolution", is underway. At this stage, biotechnology, computer tools, new methods of plant protection and soil cultivation, etc. are widely used. As a result of the "green revolution", many developing countries have managed to fully meet their needs in food products at the expense of their own production. Some believe that the "demographic explosion" characteristic of this group of countries is not least due to the "green revolution". Based on its achievements, some countries of this group have even managed to turn into exporters of agricultural products.

The basis of crop production is grain farming. Cereal crops occupy almost 1/2 of the cultivated area, they are the main source of vegetable proteins in food. About 2 billion tons of grain are collected annually. The three main "crops of mankind" – wheat, rice and corn – account for almost

4/5 of world production. The main areas of wheat cultivation are the temperate and subtropical latitudes of Eurasia, North and South America, and Australia. The world's major wheat producers are China, India, the USA, France, Canada, and Australia.

The main areas of corn cultivation are located in North and South America. The largest producers are the USA, Argentina, China, Brazil, France, and Mexico. The main crop of equatorial, tropical and subtropical zones is rice. As of 2014, the most widely grown crops were wheat (240 million hectares), corn (180 million hectares), and rice (152 million hectares), and their gross production amounted to 676 million tons, 855 million tons, and 485 million tons, respectively.

Industrial crops (sugar cane, cotton, rubber trees), as well as grapes, tea, coffee, and cocoa are grown in the equatorial, tropical, and subtropical zones. Flax, sunflower, soybeans, and sugar beets are cultivated in the temperate zone.

Mankind has learned to produce sugar mainly from two crops – sugar cane and sugar beet. Sugar cane likes tropical, subtropical and monsoon climates. It is grown by developing countries. Sugar beet grows in a temperate climate. Sugar beets are grown mainly in developed countries. Most of the sugar produced from sugar beets is consumed in the producing countries. International sugar trade is primarily trade in raw cane sugar. It needs to be refined (purified).

The production of natural rubber is concentrated in Southeast and South Asia. There are also significant plantations of rubber trees in Africa (Liberia) and Latin America.

The world's largest producer of tobacco is China, followed by the USA, India, and Brazil. There are also tobacco plantations in Italy, Greece, Indonesia, Bulgaria, Turkey, Japan, and Cuba.

Potatoes are important agricultural crops. People use them not only for food. Potatoes are excellent fodder for livestock and valuable raw material for technical needs. The homeland of potatoes is the region that covers the current territories of Peru, Ecuador and Bolivia. From there, potatoes spread all over the globe. Potatoes appeared in the Russian Empire at the beginning of the 18th century in the Okhtyrka region (currently it is the Sumy region of Ukraine). Russia, Poland and China are considered significant world producers of potatoes.

Sunflower and soybeans are the most widely cultivated oil crops. The former is grown in Ukraine, Russia, countries of Southern Europe, the USA, Argentina, and China. The latter is mainly produced in the USA, China, and Korea The largest producers of tea are India, Sri Lanka, and China. Coffee is predominantly grown in Brazil, Colombia, Mexico, India and East African countries. The homeland of tea is considered to be India, while those of coffee and cocoa are Ethiopia and Mexico respectively.

Among non-food crops, cotton should be mentioned first. The main region of its cultivation is Asia, in particular India, China, Pakistan, Thailand, and Turkey. Cotton is also grown in other regions. World exporters of cotton are Uzbekistan, China, Pakistan, India, Australia, Paraguay, and some African countries. Many countries with developed market economies import cotton.

The largest producers of grapes are France and Italy. Every year, each of these countries gathers about 6 million tons of this fruit. Notable producers are also Spain, Russia, the USA, Argentina, Germany, Portugal, South Africa, and Romania. 80% of grapes harvested in the world are used to make wine, while 7% – to make raisins. In the United States, the share of grapes used for wine production is smaller, but a variety of jam and raisins are made from it here.

Cultivation of citrus and tropical fruits. Subtropical and tropical regions of Asia and the Malay Archipelago are considered the homeland of lemon, orange, tangerine, and grapefruit. The main fields of these plants are in the Mediterranean countries, in India, Australia, and China. The United States is also a large producer of citrus fruits. Every year, 35 million tons of bananas are harvested in the world. Most of them are exported by Central American and Caribbean countries. The homeland of banana trees is Southeast Asia. Coconuts are grown in the Hawaiian Islands, Malaysia, Thailand and other tropical countries. Mango is native to India. There are about 2,000 varieties of this plant. Its fruits are yellow, green or red.

Horticulture is developed in many countries. The most common fruit tree in the world is an apple tree. Pears, plums and other fruits are also grown. Olives are cultivated mainly in Mediterranean countries.

Floriculture is aimed both at meeting countries' own needs and at supplying flowers for export. For example, many flowers are exported, by the Netherlands.

Plant growing dates back to ancient times, when man previously engaged in gathering fruit of wild plants was forced to take over the primitive cultivation of land and growing of necessary plants The most ancient centers where agricultural crops were grown were located in China, the Middle East countries, North Africa, South America, Central Asia, and Transcaucasia.

The history of crop production is conventionally divided into 5 periods:

The first one characterized by primitive plant cultivation (50 thousand BC – 10 thousand BC) is the period of the Mesolithic and Neolithic Stone Ages. It features the first primitive division of labor, man's beginning to lead a sedentary lifestyle, domesticate wild animals and cultivate cereals, legumes, root crops, melons and other plants.

The second period involves plant growing by the slave-owning ancient society of the countries of Asia, Egypt, Mesopotamia, Slavic settlements on the territory of Rome, Byzantium, Ukraine, and medieval feudal Europe. During that period the role of fallow land was determined, leguminous and cider crops were widely used, and crop rotation was introduced. The works of the ancient Roman author Cato ("On

Agriculture") and those of the Dominican monks Albert the Great ("Plants") and Peter Crescentius have survived to our days; Pliny the Elder listyв 146 Roman and 327 foreign language works on plant cultivation.

The third period (18-19 centuries) is associated with the development of manufacturing capitalism, the rapid advancement of agricultural science, the increase in the sown areas of grain and leguminous crops.

The fourth one is known as the "green revolution" of the 20th century. In the 60s, the "green revolution" (yield growth thanks to modern technologies) confirmed the effectiveness and importance of applying the principle of crossing geographically distant forms. N. Borlaug's creation of a group of short-stemmed varieties due to the use of the Japanese variety Norin 10 made it possible to raise the yield in Mexico from 0.7 to 3-4 t/ha.

The fifth, intensive period, which started in the second half of the 20th century, is based on modern combinations of achievements in biology, genetics, agrochemistry and other sciences, intensification of plant growing technologies, biologicalization of crop protection, resource-saving technologies, etc.

Growing the necessary plants, man, in order to increase their productivity in the process of centuries-old economic activity, changed their forms, turning them into cultural ones through artificial selection and other selective breeding methods. As a result of enhanced development of the most valuable parts and organs of plants, their productivity increased. For example, modern sugar beets with a large root (up to 1 kg) and a high (18-20%) sugar content were created from the wild form of beets with an underdeveloped root and low sugar content. At the same time, the leaves and inflorescences of beets have hardly changed. Sunflower, which was grown as an ornamental plant with small heads and small seeds, thanks to man's efforts turned into a cultivated plant with well-developed heads, a large number of seeds on them and high oiliness. Thanks to selection and genetics using methods of remote hybridization and mutagenesis, varieties and hybrids of intensive type and even new crops have been grown and introduced into production.

Unlike their wild counterparts, cultivated plants can successfully grow and develop, showing their valuable qualities, only under the condition of the necessary soil cultivation, fertilizer application, sowing at the optimal time at a high agrotechnical level, timely integrated plant care, and other technological measures aimed at creating the best conditions for crop formation.

In crop production, products are created by green plants in the process of photosynthesis. With the help of plants, the kinetic energy of the sun is transformed into the potential energy of organic substances - proteins, carbohydrates, fats. Only green plants are able to synthesize various organic substances from mineral substances with the help of solar energy. It is crop production that provides the largest part of the growing needs of the population not only in food energy (about 88%), but also in proteins (about 80%), vitamins, minerals and other physiologically important substances. Plant products make up more than 93% of the human diet. According to the data of the State Statistics Service of Ukraine, the crop production index (Fig. 1) in 2014 compared to 2013 was 103.1%, including at agricultural enterprises - 103.9%, and in households - 101.9%.

Fig. 1 – Dynamics of the volume of agricultural production (in % to the previous year)

In crop production, 40-50% of the by-products (straw, corn stalks, pulp, molasses, etc.) are used in animal husbandry through fodder production. A harmonious combination of crop production, livestock rearing and fodder production is a necessary condition for the successful functioning of the country's agrarian sector.

According to the data of the State Service of Ukraine for Geodesy, Cartography and Cadastre (Fig. 2), in 2015 the area of agricultural land in Ukraine decreased by 5,100 hectares and as of January 1, 2016 amounted to 42,726.4 thousand hectares against 42,731.5 thousand hectares on the same date in 2015. The share of the area of agricultural land in the total area (territory) of Ukraine has not changed and is 70.8%. The greatest decrease in areas was in the following categories: pastures (decrease by 6.9 thousand hectares to 5434.1 thousand hectares), fallow lands (decrease by 5.7 thousand hectares to 233.7 thousand hectares) and hayfields (decrease by 0 .9 thousand ha to 2406.4 thousand ha). Forests and other wooded areas continue to show growth dynamics - in 2015, they increased by 2.8 thousand hectares - to 10,633.1 thousand hectares. They account for 17,6% of the country's total area.

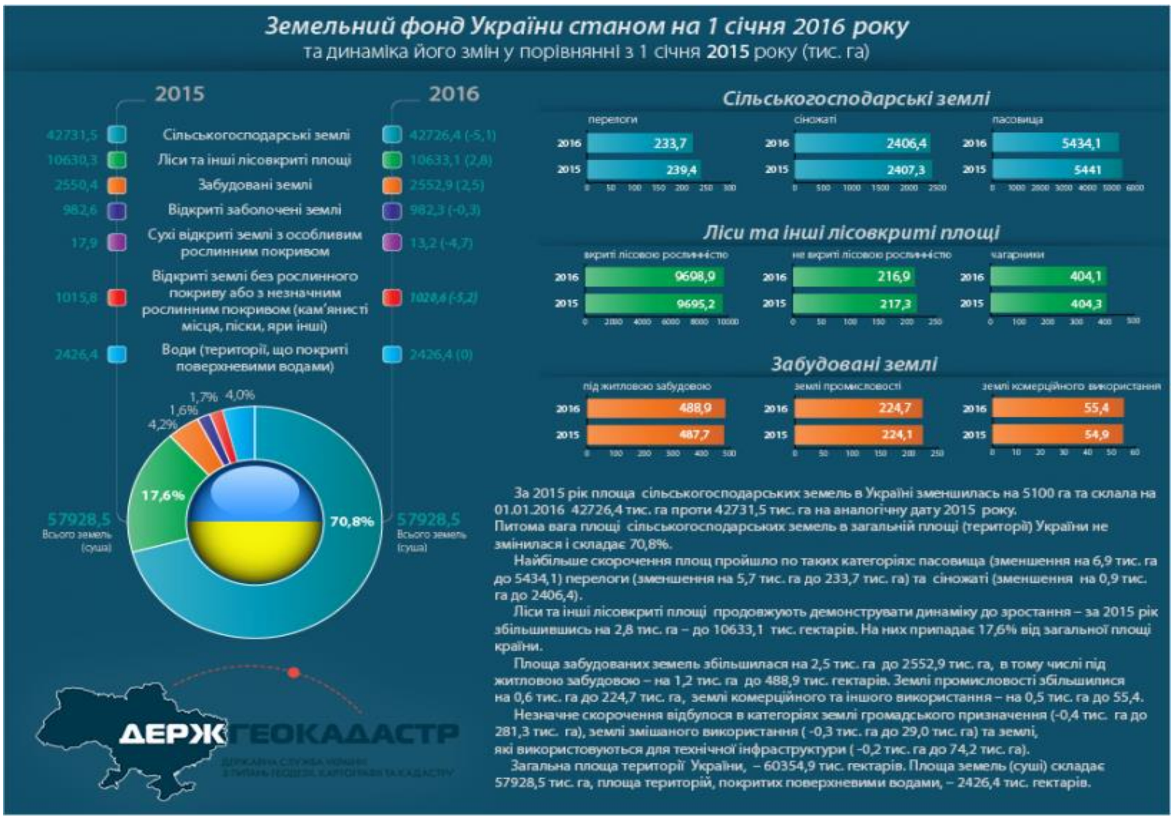


Fig. 2 – Total land fund of Ukraine (as of January 1, 2016)

The area of built-up land increased by 2.5 thousand hectares to 2552.9 thousand hectares, including under residential construction - by 1.2 thousand hectares to 488.9 thousand hectares. Industrial lands increased by 0.6 thousand hectares to 224.7 thousand hectares, commercial and other land by 0.5 thousand hectares to 55.4 thousand hectares. A slight decrease occurred in the categories of public land (-0.4 thousand ha to 281.3 thousand ha), land of mixed use (-0.3 thousand ha to 29.0 thousand ha) and land used for technical infrastructure (-0.2 thousand ha to 74.2 thousand hectares). The total area of the territory of Ukraine is 60,354.9 thousand hectares. The land area (dry land) is 57,928.5 thousand hectares, the area of territories covered by surface water is 2,426.4 thousand hectares.

Ukraine has more than 42 million hectares (71% of the country's territory) of agricultural land, including 32,525.5 million hectares (2014) of arable land. The plowed area of its territory is almost 55%, and in some regions it is more than 80%. In the developed countries of the world, this indicator is much lower, for example, in the USA - 30%, France - 35%, Germany - 32%, England only 19%.

More than half of all agricultural land and 60% of arable land in Ukraine are black soils (chornozems), which over the past 25-30 years have been on the verge of degradation and desertification, losing their fertility, natural biological properties, and buffer capacity. Violation of the ecological balance of natural landscapes has led to the strengthening of erosion processes, which have reached, according to experts, one of the highest levels in the world.

During the 1950s and 1960s, 2 million hectares of unproductive natural lands and sloping lands were unreasonably plowed, and the area of row crops was significantly expanded. The plowed land reached 81%, i.e. 57% of the entire territory. Only 8% of the lands of the territory of Ukraine are currently in a natural state (swamps, lakes, mountain ranges, covered and not covered by forest). The ecologically permissible ratio among the areas of arable land, natural land, forest and water resources has changed. This had a negative impact on the stability of the agricultural landscape, resulting in intensified erosion processes. Thus, over the past 25 years, the area of eroded arable land has increased by 33% and reached 123.1 million ha, and the area under the threat of deflation (wind erosion) - 19.8 million ha (55.2%), the humus content has decreased from 3.5 to 3.2%. Every year, the area of eroded land increases by 70-80 thousand hectares. In the early 2090s, a project was developed to remove 10 million hectares of arable land from circulation and transfer it to meadows and pastures (8 million hectares), and forests (2 million hectares). However, these activities are currently problematic due to land privatization and lack of funds. Land and other resources suffer significant environmental damage as a result of pollution by industrial emissions, waste, transboundary transport, as well as imperfect use of chemicals in the agricultural sector.

Grain production is a strategic sector of the natural and economic food complex of Ukraine. The annual need for food grain is 8.5 million tons, and the average annual volume of its production in recent years has been more than 50-60 million tons (Fig. 3). In 2014, the highest harvest of grain crops was obtained compared to previous years - 63,859 thousand tons. There were threshed 24.1 million tons of wheat, 28.5 million tons of corn, 9.1 million tons of barley, 478 thousand tons of rye, 612.5 thousand tons of oats, 18.0 thousand tons of millet, 167.4 thousand tons of buckwheat, 490.7 thousand tons of peas, 3.9 million tons of soybeans.

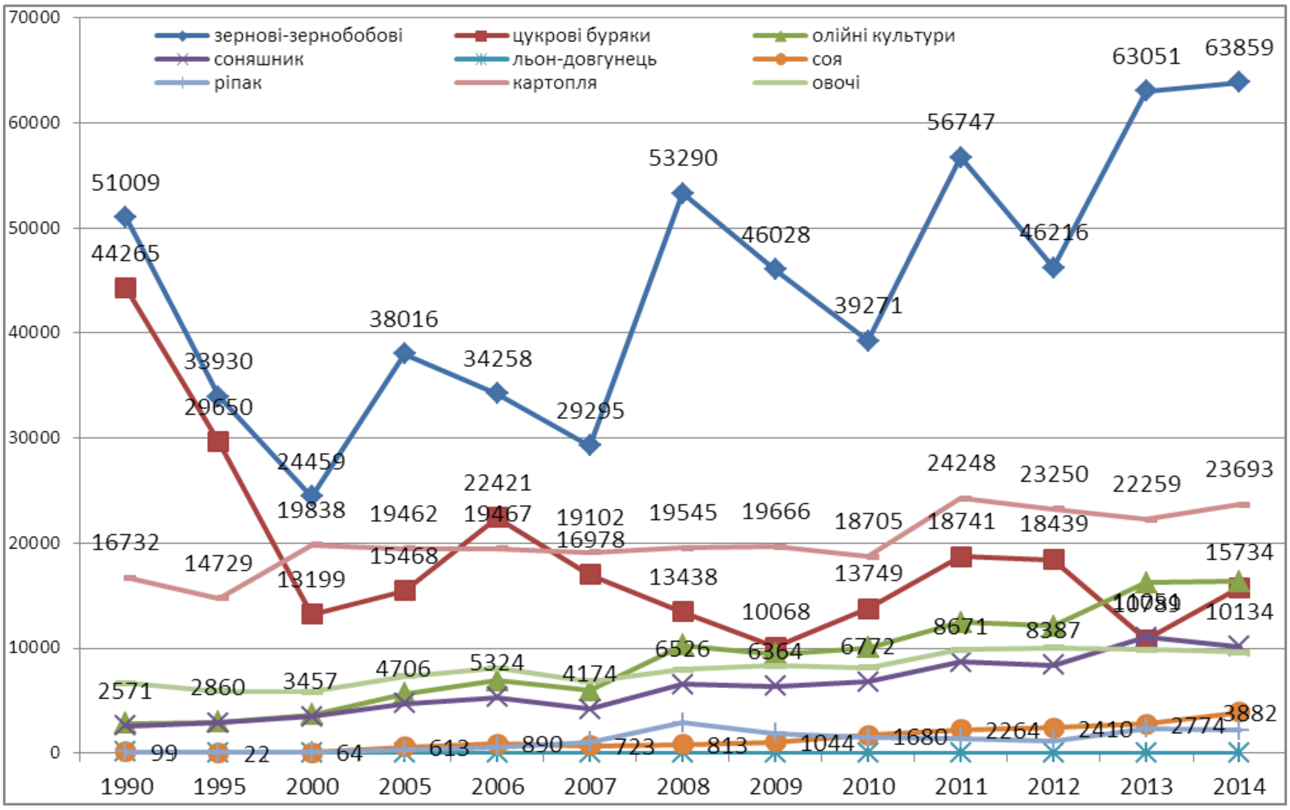


Fig. 3 – Production of agricultural crops, thousand tons

According to the data of the State Statistics Service of Ukraine, the lowest gross harvest of grain was obtained in 2003 – 20.2 million tons, which was caused by unfavorable conditions of overwintering of winter grain ear crops, 70% of which died (the share of spring crops in the harvest was 60%). Accordingly, grain crops were harvested from an area of 12.5 million hectares with an average yield of 18.2 t/ha.

According to the Ukrainian Club of Agrarian Business association, in terms of grain exports in the 2013/2014 marketing year, Ukraine joined the top three world exporters, following the USA (72.3 million tons) and the EU (38.5 million tons). The dynamics of the export of the main types of cereals in 2009/2010-2013/2014 marketing years has a clear tendency to increase those crops that benefit from increased demand on the world market: corn - by 3.75 times, wheat - by 1.1% (Table 1, Fig. 4). Over the past decade, grain exports from the country have grown by 77%.

Table 1 – Grain export in 2009/2010-2013/2014 (marketing years), mln t

Product	Marketing year				
	2009/2010	2010/2011	2011/2012	2012/2013	2013/2014
Grain, total	20,957	12,158	21,565	22,844	32,122
Wheat	9,157	4,166	5,254	6,871	9,256
Barley	6,232	2,791	2,463	2,132	2,444
Corn	5,348	5,087	13,684	13,600	20,061

In the structure of grain exports, corn accounted for the largest share of 62% with a volume of 20.1 million tons, wheat– for 29% with a volume of 9.4 million tons. Thus, corn and wheat together provided 91% of grain exports of Ukraine. Barley, with a volume of 2.4 million tons, accounted for almost 8%, other grains accounted for a little more than 1%.

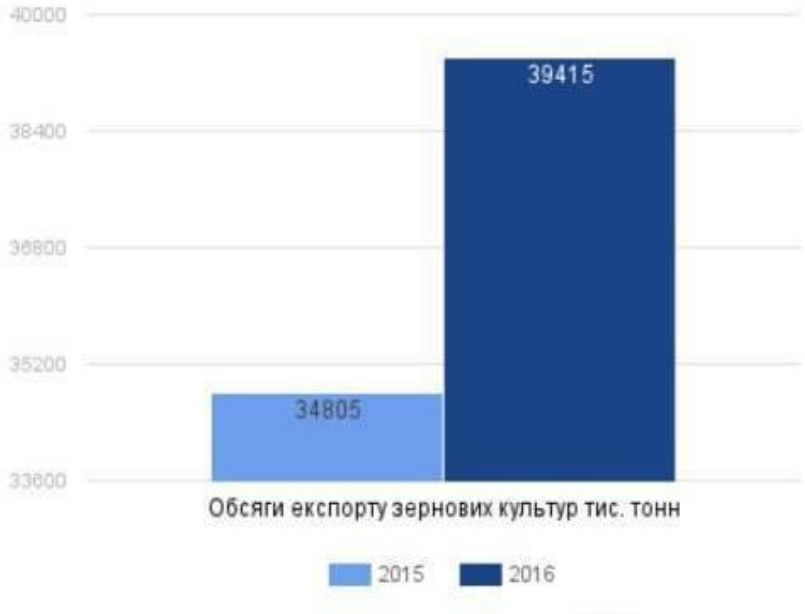


Fig. 4 – Grain export from Ukraine

In the structure of agricultural land in Ukraine, the group of grain crops occupies more than 16 million hectares or 57% (2016) of the sown area, while the group of fodder crops has decreased from 12 million hectares (37%) in 1990 to 2 million ha (8%) in 2016 (Fig. 5). The share of industrial crops in the structure of arable land virtually doubled: from 3,751 thousand hectares (12%) in 2009 to 7,869 thousand hectares (28%) in 2016.

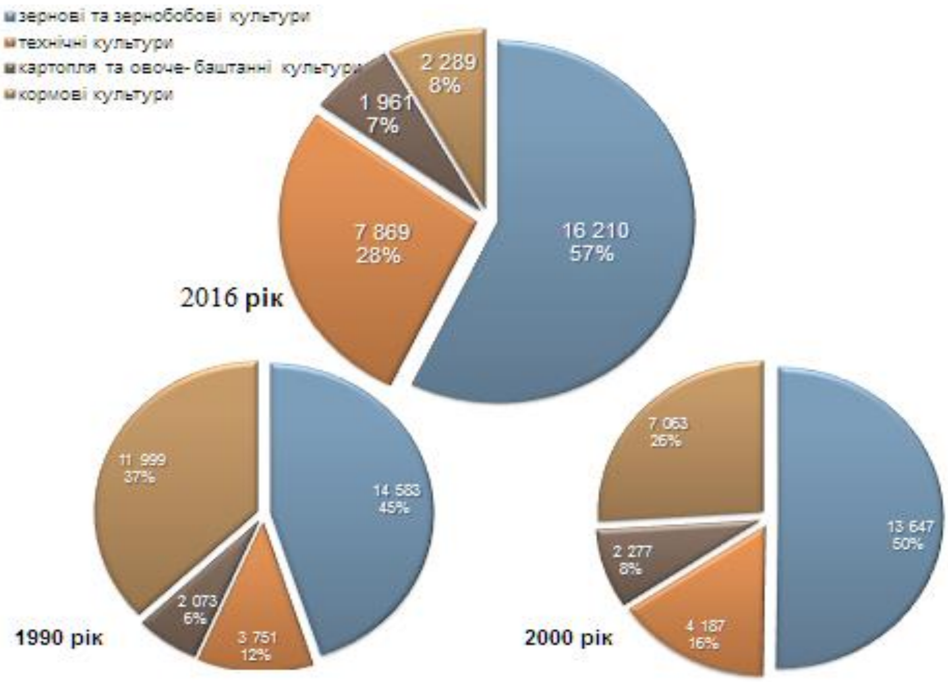


Fig. 5 – Dynamics of the structure of agricultural land

The structure of the grain producing area, wheat, barley and corn dominate (Fig. 6). The share of these crops in the structure of grain and leguminous crops exceeds 90%. Wheat has always been the main food crop. At the expense of this crop, most of the domestic food needs in grain, partly the needs of the livestock industry are provided, and the export grain fund is formed. During the last decade, fluctuations in the area of wheat sowing were observed within 27%. The smallest wheat sowing area - 5.6 million hectares - was in 2006, the largest - 7.5 million hectares - in 1990. In 2014, the sown area of winter wheat amounted to more than 6.0 million hectares. The agrarians of Zaporizhzhia and Odesa regions have more than half a million hectares for growing winter wheat. The farmers of Dnipropetrovsk and Kherson regions lack 15,000-20,000 hectares to reach this level. Barley remains an equally important crop of the grain producing area. In 2016, barley was sown on an area of more than 3.0 million hectares. The largest areas for growing winter barley are Odesa and Mykolaiv regions; spring barley - Kharkiv and Dnipropetrovsk regions.

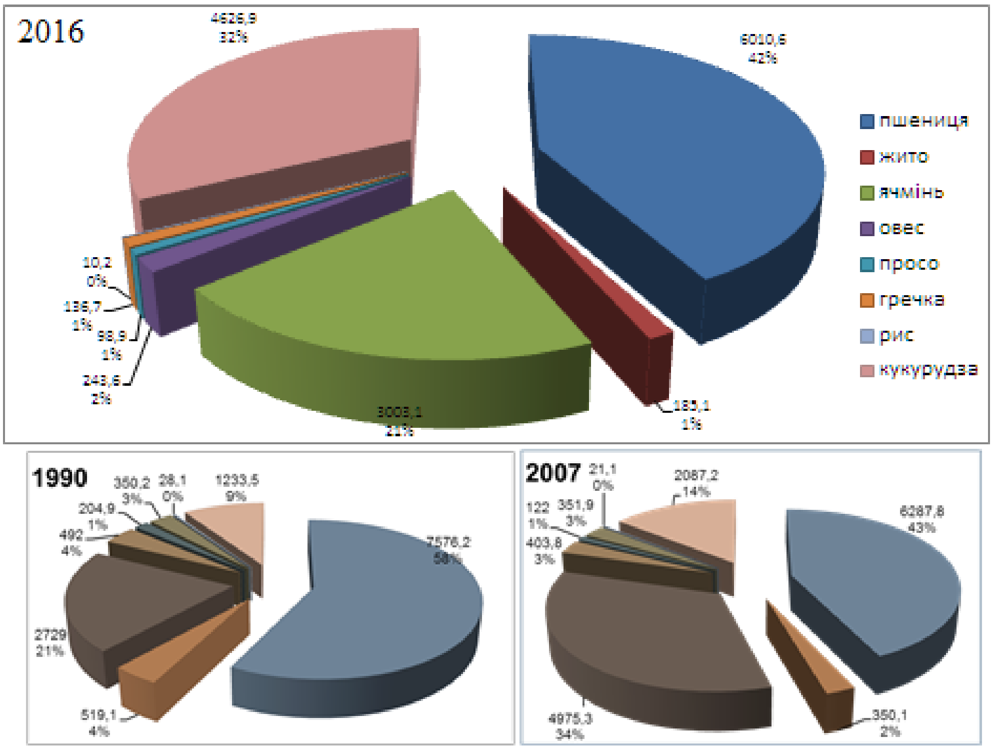
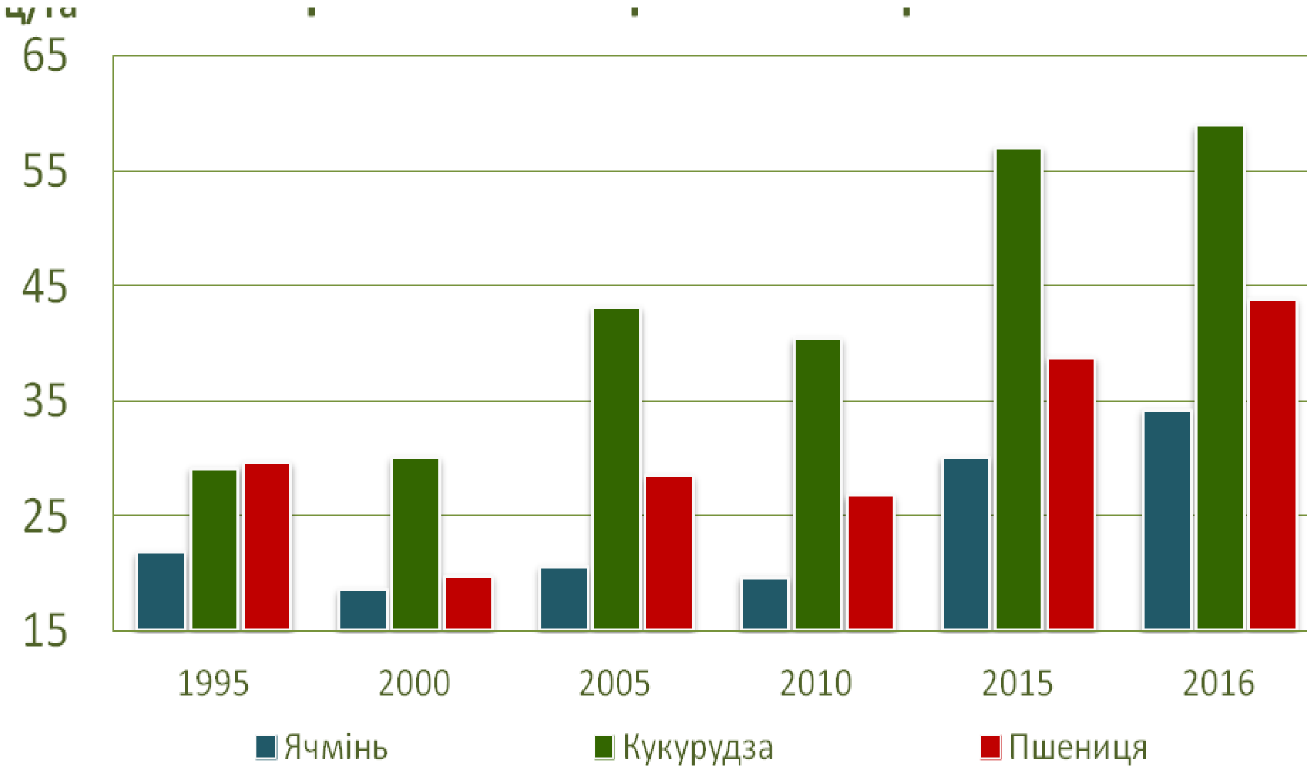


Fig. 6 – The structure of the sown area of grain crops in Ukraine, thousand hectars

Corn for grain is one of the leaders in the scale of agricultural crop growing. The area of its cultivation is second only to that of wheat.

Agrarians envisage the expansion of the corn sown areas to almost 5.2 million hectares. Over the past ten years, its cultivation has had a steady upward trend. If in 1990 only 1.2 million hectares were used for this culture, in 2007 - 2.0 million hectares, then in 2014 it was already 4.6 million hectares. Corn for grain is grown in all regions of Ukraine, but it occupies the largest areas in the Poltava and Kirovohrad regions. Within the spring grain producing area in accordance with the needs of the market, it is planned to expand the sowing of the late crops considerd to be technologically and economically attractive, in particular to 115 thousand hectares of millet and 165 thousand hectares of sorghum. The dynamics of the growth of the main cereals in Ukraine is significant. Over twenty years, the yield of wheat, corn and barley has increased by an average of 69%. Corn has become the leader in yield growth (Fig. 7).

Fig. 7 – Yield of grain crops in Ukraine



The first place among industrial crops belongs to sunflower, which in 2016 occupied 5.2 million hectares, which was more than half (60.3%) of the entire area of oil crops. In Ukraine, fairly high and stable yields of this crop are obtained (1.7-2.2 t/ha). The gross sunflower seeds harvest in the last two years exceeded 10 million tons (Fig. 8). The yield of the main oil crops (sunflower, soybean and rapeseed) increased from 1995 to 2016 by an average of 128%. This was the incentive for investments in the processing industry of Ukraine and for entering new world markets.

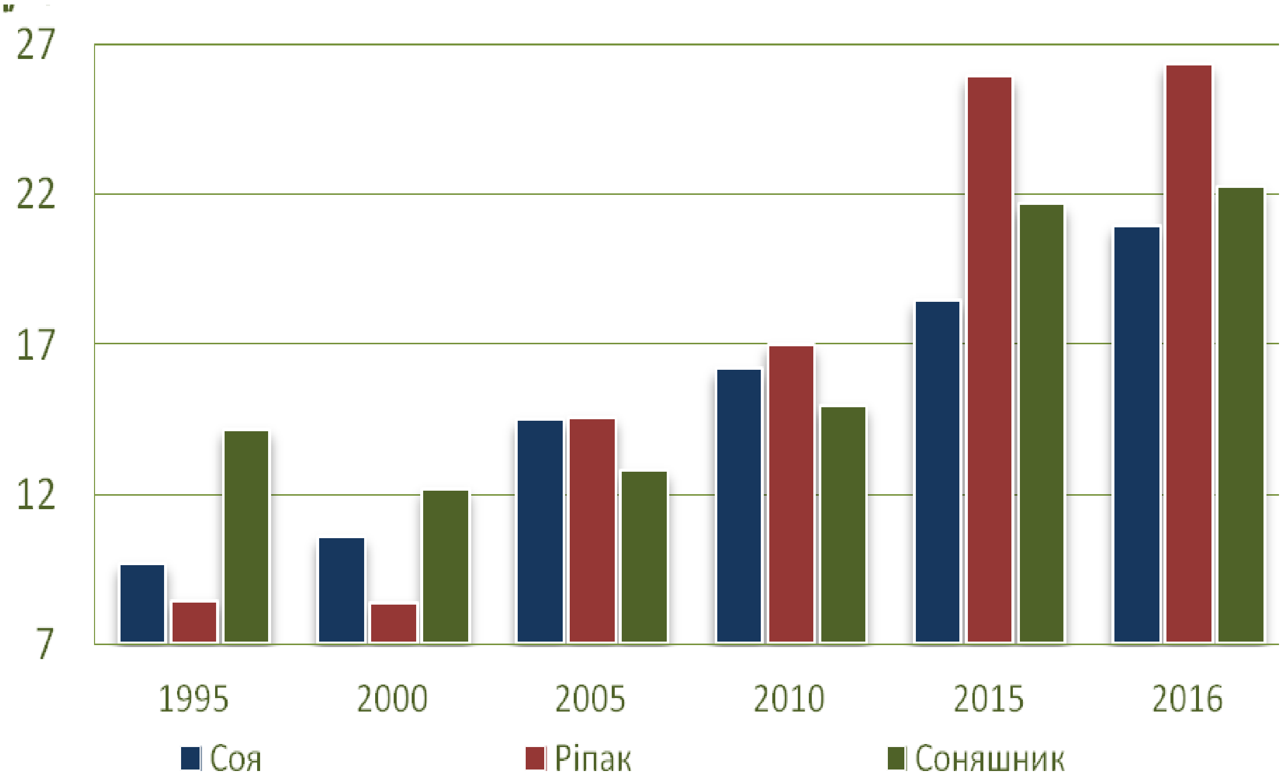


Fig. 8 – Yield of oil crops in Ukraine

More and more domestic producers of oilseeds prefer soybeans. A few years ago, soybean cultivation in Ukraine was mainly done by large agricultural companies, but now the situation has changed. The total number of economic entities growing soybeans is constantly growing. The attractiveness of this crop is explained by the possibility of using own seed material, moderate production costs, low price risks, which ensures a high level of profitability. In 2016, the sown area of soybeans in Ukraine amounted to 1.8 million hectares or 23.1% in the structure of oil crops, which exceeded last year's figure by 18% (Fig. 9). Compared to 2005, the scale of soybean cultivation increased by 3.7 times. Most soybeans are grown in Khmelnytskyi and Poltava regions, the least in Donetsk, Luhansk and Zaporizhzhia regions.

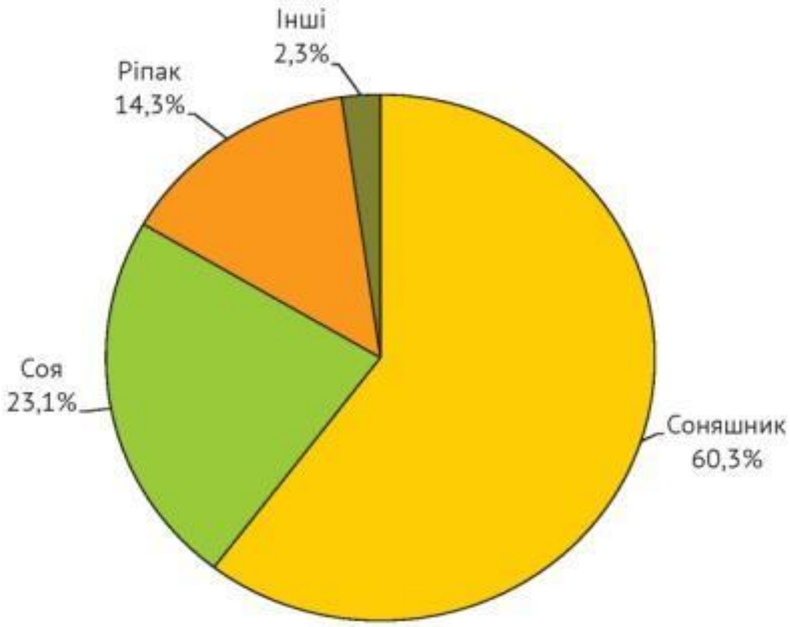


Fig. 9 – The structure of the sown area of oil crops, 2016.

The spring rapeseed area decreased to 46 thousand hectares. The largest spring rapeseed area was in 2007 and amounted to 142 thousand hectares. After that, a tendency to its reduction was observed. In turn, the winter rapeseed area has been growing over the past five years. In 2010–2011 it did not exceed 800,000 ha, while for the last two years they were kept within 950–970,000 ha.

In contrast to the growth of the oil crops sown area, the area allotted for fodder crops has a negative tendency to decrease (Fig. 10), which is primarily due to a significant decrease in the number of livestock, and consequently the need for them. The main fodder crops are annual and perennial grasses, which occupy almost 50% of the total area of fodder crops, about 25% - corn for silage and green fodder, and the rest is fodder root crops and fodder melon crops. The fodder base is formed at the expense of those fodder crops that require the least costs for seeds, fuel, equipment and wages, which, under crisis conditions, allows for reducing the level of unprofitability, but significantly worsens the condition of the fodder base. The unsatisfactory state of the fodder base, the overspending of fodder for raising livestock, their low profitability led to a significant decrease in animal productivity and a low level of competitiveness of the entire branch.

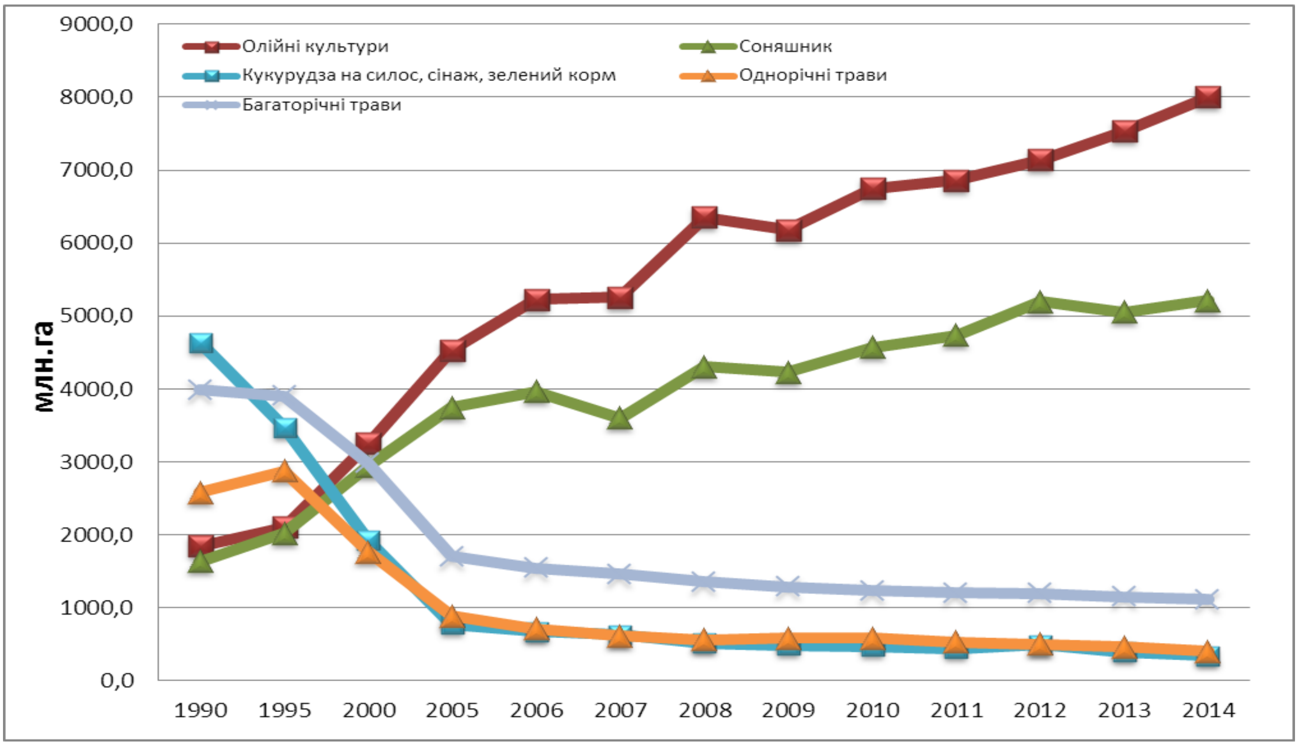


Fig. 10 – Reduction of the sown area of the main fodder crops in favor of the oil group

In 2016, the situation with sugar beet production changed for the better. The area of sweet root cultivation increased to 283 thousand hectares, which was at the level of the 2013 indicator. With a yield of 47.7 t/ha (Fig. 11), the gross production of sweet roots in 2016 amounted to 15.7 million tons. When processing such a crop at sugar factories, sugar production amounts to 19.0 million tons. The largest beet-growing regions of Ukraine include Vinnytsia , Ternopil and Poltava regions.

The main production of *potatoes* is concentrated in households. Therefore, most of the products remain to ensure own food needs and feed animals. This affects the stability of the areas allocated for the cultivation of this crop. In 2014, 1.34 million hectares were reserved for potato cultivation. The largest potato production areas are the Vinnytsia (105,000 ha), Kyiv (95,000 ha), and Lviv (94,000 ha) regions.

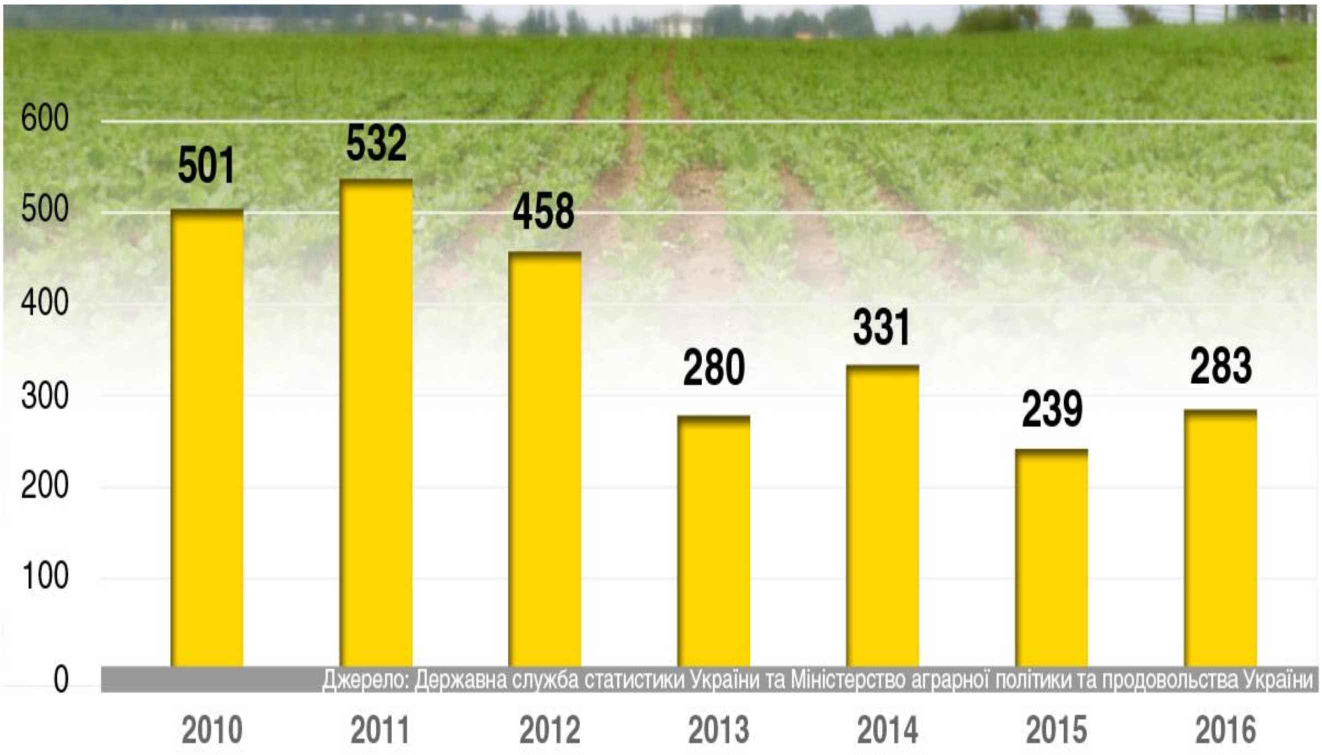


Fig. 11 – Dynamics of sugar beet sown area in Ukraine

Harvest and yield are the most important performance indicators of the field of crop production and agricultural production as a whole. The level of productivity reflects the influence of economic and natural conditions, as well as the quality of managerial and economic activity of agricultural enterprises and farms. In statistics, the harvest (gross harvest) is understood as the total volume of products gathered from the entire sown area of individual agricultural crops or their groups. Yield is the average volume of products gathered from a unit of sown area, usually expressed in t/ha or kg/ha. The productivity of the main field crops in Ukraine over the last decade has a clear tendency to increase due to selective breeding achievements, increasing soil fertility, the introduction of advanced production technology, the rational use of mineral and organic fertilizers, extensive land reclamation, the implementation of anti-erosion measures, the improvement of seed production, the introduction of the most productive varieties and hybrids into production, implementation of a system of measures to protect plants from diseases, pests and weeds, elimination of crop losses, improvement of the structure of sown areas, development of correct crop rotations. If in 2000 the average yield of winter wheat in Ukraine was 2.0 t/ha, by 2016 it had increased to 4.37 t/ha. During the specified period, the yield of corn increased from 3.01 to 6.16 t/ha, of soybeans – from 1.06 to 2.16 t/ha, of sugar beets – from 17.67 t/ha to 47.65 t/ha (Table 2).

The main tasks of the crop production field at the current stage are the following: production of high-quality environmentally friendly products with minimal energy and labor costs with maximum output per unit of time per unit of area, which requires wide implementation of varietal, intensive, energy- and resource-saving environmentally appropriate technologies; timely and effective variety replacement of field crops and their rational allocation in crop rotation aimed at improving growing conditions; the combination of intensive crop production with a complex of agrotechnical, agrochemical and remedial measures for the preservation and reproduction of soil fertility; crop production on the basis of modern perfect and highly productive agricultural machinery and its highly efficient operation; fight against crop losses during its cultivation, harvesting and transportation; highly effective use of fertilizers, application of plant protection products, irrigation water, anti-erosion measures, etc.; high professional qualification of agro-industrial complex employees and a clear system of organizational, managerial and economic measures.

Crop production in Ukraine is increasingly acquiring biological characteristics of, that is, it is based on the wide use of alternative - biological and related agrotechnical - methods of growing agricultural crops with a minimum use of chemicals in the plant protection system and with a maximum application of biological sources of plant nutrition.

Table 2 – Dynamics of production of main crops in Ukraine in farms of all types in 1990–2016 (according to the State Statistics Service of Ukraine)

Agricultural crops	Harvested area, million ha Yield, t/ha						
	1990	2000	2010	2013	2014	2015	2016[1]
Grains and legumes, total	14,522	12,587	14,576	15,321	14,792	15,327	14,627
	3,51	1,94	2,69	3,70	3,12	3,99	4,37
Winter wheat	7,549	4,888	5,982	6,390	5,400	6,414	5,849
	4,02	2,0	2,71	3,39	2,80	3,41	4,02
Winter rye	0,517	0,637	0,279	0,278	0,297	0,277	0,183
	2,43	1,52	1,66	2,07	2,27	2,28	2,58
Winter barley	0,526	0,322	1,437	1,180	0,676	1,062	1,084
	3,72	1,89	2,24	2,74	2,42	2,34	3,01
Spring barley	2,187	3,368	2,880	2,504	2,618	2,172	1,919
	3,30	1,86	1,83	2,34	2,14	2,16	2,97
Spring wheat	0,009	0,273	0,302	0,268	0,229	0,152	0,162
	3,02	1,54	2,1	2,54	2,75	3,19	3,95
Oat	0,486	0,481	0,311	0,280	0,301	0,241	0,244
	2,68	1,83	1,48	1,81	2,09	1,94	2,51
Millet	0,197	0,367	0,085	0,156	0,153	0,078	0,099
	1,72	1,16	1,37	1,78	1,03	1,31	1,80
Buckwheat	0,362	0,529	0,199	0,286	0,273	0,168	0,137
	1,16	0,91	0,67	0,99	0,87	1,06	1,22
Rice	0,028	0,025	0,029	0,030	0,026	0,024	0,010
	4,25	3,56	5,05	5,73	6,21	6,01	5,01
Corn	1,223	1,279	2,648	3,544	4,372	4,827	4,627
	3,87	3,01	4,51	6,44	4,79	6,41	6,16
Soybeans	0,093	0,065	1,076	1,110	1,412	1,351	1,793
	1,13	1,06	1,62	2,04	1,71	2,05	2,16
Sugar beets	1,605	0,747	0,492	0,516	0,449	0,271	0,330
	27,56	17,67	27,95	36,33	41,08	39,89	47,65
Flax	0,169	0,019	0,001	0,001	0,002	0,002	0,001
	0,64	0,42	0,40	0,59	0,86	0,73	0,63
Sunflowers	1,626	2,841	4,526	4,717	5,082	5,090	5,212
	1,58	1,22	1,50	1,84	1,65	2,17	1,94
Rapeseed	0,089	0,157	0,863	0,833	0,547	0,991	0,865
	1,45	0,84	1,70	1,73	2,20	2,36	2,54
Potatoes	1,432	1,631	1,412	1,443	1,444	1,394	1,343
	11,68	12,16	13,25	16,80	16,10	15,97	17,64

[1] The data are given without taking into account the temporarily occupied territory of the Autonomous Republic of Crimea and the city of Sevastopol.

An important feature of the branch of crop production is its seasonality, or the ability to produce products (grain, roots, fiber, etc.) only in a short frost-free period. In this regard, all scientifically substantiated agrotechnical methods must be performed on time and at a high technological level, without violating the crop growing technology and without harming the environment. It is very difficult to eliminate the shortcomings that often occur in the process of cultivating agricultural crops. Therefore, in crop production, it is necessary to take into account all the conditions on which the harvest depends.

Crop production has a *zonal* character. The set of crops and varieties and methods of their cultivation vary depending on the zone. When allocating field crops in the zones of Ukraine, agro-climatic conditions and biological features of crops and varieties are taken into account, because different zones are characterized by different levels of moisture, soil fertility, temperature regime, incoming solar radiation, etc.

From a scientific point of view, crop production is the science of cultivated plants and their cultivation. This science studies various types, sub-types and varieties of field crops and the most rational methods of their cultivation. From a production point of view, plant breeding is the science of technically perfect and economically profitable cultivation of high yields of agricultural crops of the best quality. Scientific plant breeding is based on the principles of modern biological science, which studies the peculiarities of plant growth and development and their requirements for environmental conditions. On the basis of the study of plant biological features, measures and methods of optimizing environmental factors are developed for the maximum fulfillment of agricultural crops' productivity potential.

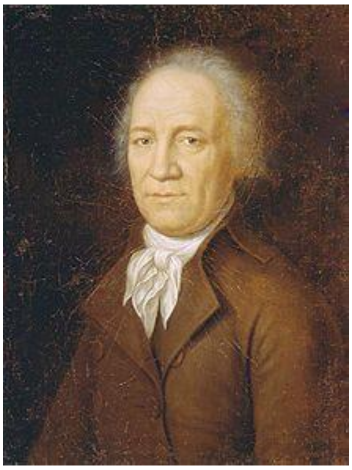
The yield of agricultural crops depends on the physical and chemical characteristics of the soil, its fertility, and methods of cultivation; application of appropriate forms and doses of fertilizers, bacterial preparations, plant protection products; use of agricultural machines and mechanisms, etc. The weather conditions of each individual year have a significant effect on the yield of crops. Crop losses can be caused by summer drought, frosty winter with little snow, excessively wet summer with floods, etc. Therefore, crop production is based on such basic branches of science 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 the basis for such sciences as economics and management of farming.

Domestic and foreign scholars made a significant contribution to the development of science. Carl Linnaeus (1707–1778) was a Swedish naturalist who created a system of flora and fauna classification. He

published his main work entitled "Systema" Naturae" (The System of Nature), which glorified his name. This work underwent 12 editions during Linnaeus' lifetime, and each time the author refined, clarified and supplemented it. In his "System of Nature" Carl Linnaeus was the first to introduce a scientific classification of plants and animals known at the time. The scientist described 4200 species of animals and divided them into six classes: mammals, birds, amphibians, fish, worms and insects. He divided plants into 24 classes. Carl Linnaeus was the first to apply and introduce binary nomenclature, according to which each species was denoted by two Latin names – generic and species ones. He devoted a lot of time to the study of plants from different countries and continents, collected in a number of famous European collections and herbariums. He himself personally studied and described approximately 1500 species of plants.

Mykhailo Vasyliovych Lomonosov (1711–1765) was one of the founders of scientific agriculture. He was the first among scientists to explain the origin of black soil. M. Lomonosov also initiated generalizing the experience of growing agricultural crops.

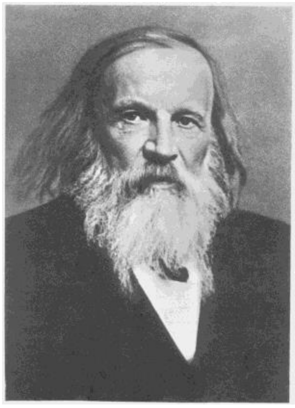
Andriy Tymofiyovych Bolotov (1738-1833) is known for his research on improving methods of soil cultivation and the use of organic and green fertilizers. The scientist developed a classification of weeds and methods of combating them. He also discovered and correctly assessed the phenomenon of dichogamy (non-simultaneous ripening of stamens and pistils of bisexual flowers) as the most important prerequisite for cross-pollination.



Ivan Oleksandrovych Stebut (1833-1923) developed and introduced the classification of field plants according to the peculiarities of their cultivation.

Vasyl Vasyliovych Dokuchaev (1846-1903) elaborated a plan for the complete reconstruction of agriculture in the southern regions, which included a set of measures to combat droughts and dry winds.

Dmytro Ivanovych Mendeleev (1834-1907) is known for initiating the organization of collective experiments on soil cultivation and fertilization of agricultural crop fields in different soil and climatic zones. He was one of the authors of the periodic table of chemical elements, and also dealt with the issue of irrigation of arid lands.



A significant contribution to the formation of scientifically substantiated crop production was made by Dmytro Mykolayovych Pryanyshnykov (1865-1948), the founder of agrochemistry and an outstanding researcher in such areas as the physiology of plant nutrition and the nitrogen cycle in nature. The scientist developed the theory of nitrate nutrition of plants, the scientific basis of liming acid soils,

applying gypsum to saline soils, and using mineral fertilizers in agriculture. D. Pryanishnikov investigated the issue of using phosphorites as fertilizers and proved the possibility of processing them into superphosphate, as well as compiled the physiological characteristics of domestic potash fertilizers.

Klyment Arkadiyovych Timiryazev (1843-1920) is a classic of modern scientific plant biology. His main merit was the experimental theoretical development of the problem of plant photosynthesis. He substantiated the possibility of significantly increasing the productivity of agricultural plants.

Mykola Ivanovich Vavilov (1887-1943) is best known for his research on identifying the centers of cultivated plants' origin. He devoted his life to the study and improvement of wheat, grain and other grain crops that feed the world's population. M. Vavilov was the founder of the scientific research institute of plant production, the author of the rule of homologous series in genetic variation, the doctrine of plant immunity to diseases and pests, etc. Under his leadership, a world collection of cultivated plants (more than 350,000 specimens) was created. He paid a lot of attention to the development of genetics – the science of genetic and variation rules of organisms. The scholar published about 300 academic works on selective breeding, agriculture, geography, and agriculture managent.

Faina Mykhailivna Kuperman, a representative of modern biological science, discovered twelve organogenesis stages in the life cycle of plants. They proceed in a certain sequence, which makes it possible to have an idea of the peculiarities of plant development in advance, before the full phase of development and to take the necessary measures for strengthening or weakening them.

Great achievements in plant breeding were made by the following scholars: P. P. Lukyanenko, V. M. Remeslo, F. G. Kyrychenko who were the authors of intensive wheat varieties; V. S. Pustovoit, who created sunflower varieties unsurpassed in terms of oil content; A. L. Mazlumov and O. K. Kolomiets who were the authors of high-sugar varieties and hybrids of sugar beets; M. I. Khadzhinov, who developed the methods of transferring fertile corn to a sterile basis, and others.

A significant contribution to the development of crop production was made by such well-known Ukrainian scientists as M. A. Bilonozhko, H. S. Kyyak, M. G. Horodniy, T. T. Demidenko, F.P. Yukhymchuk, Y.I. Vlasyuk, I.P. Proskura, O.I Zinchenko, O.S. Ustymenko and others.

Field crops studied in the crop production course differ in botanical, biological and economic characteristics, in the type of products and in the peculiarities of cultivation. For the convenience of studying field crops, they are divided into four groups according to the production principle: grain, technical, fodder, melons and gourds:

I. Cereals, which are grown for grain.

1. Typical cereals (wheat, rye, barley, triticale, oats).
2. Millets (millet, corn, sorghum, rice, foxtail millet).
3. Grain legumes (peas, soybeans, beans, chickpeas, lentils, fodder beans, lupin).
4. Cereals of other families (buckwheat).

II. Technical crops used as raw materials for industry.

1. Oilseeds (sunflower, safflower, rapeseed, mustard, rye, perilla, lalemantia, sesame, peanut, etc.).
2. Essential oils (coriander, cumin, fennel, anise, peppermint, clary sage, lavender).
3. Sugar-bearing (sugar beets, chicory).
4. Fiber crops: plants with fiber on the seeds (cotton); plants with fiber in the stems called bast fiber plants (flax, hemp, kenaf, etc.).
5. Starchy crops - tuberous vegetables (potatoes, Jerusalem artichoke).

III. Fodder crops used to feed farm animals.

1. Root crops (fodder beets, carrots, rutabagas, turnips).
2. Annual leguminous grasses (veca, ornithopus (bird's-foot), pisum, annual types of clover).
3. Annual poaceae grasses (Sudan grass, foxtail millet, annual oatgrass).
4. Perennial legumes grasses (alfalfa, onobrychis, clover, etc.).
5. Perennial poaceae grasses (meadow fescue, timothy, bromus inermis, dactylis glomerata (cock’s-foot) etc.).

IV. Melons and gourds, which are crops for food and fodder purposes.

1. Fodder (watermelon, melon, pumpkin, zucchini).
2. Food (watermelon, melon, pumpkin, zucchini)

In addition to the classification according to the method of production, there is a classification of crops based on the method of using the main product of the crop. According to this feature, field crops are divided into 6 groups: 1) cereals; 2) root crops, tubers, melons and gourds, kale; 3) fodder crops; 4) oil and essential oil crops; 5) fiber crops; 6) tobacco and Aztec tobacco (Nicotiana rustica).

Agroclimatic zoning is based on the study of morphoanatomical, physiological, immunological, agronomic and other features of field crops that determine the adaptability of a certain group of plant forms within a species to specific soil and climatic conditions.

The Polissia zone (Fig. 10) is located in the northern part of Ukraine and is characterized by a moderate climate with gloomy summers and relatively mild winters. The soils are infertile with humus content not exceeding 2%. Polissya occupies a fifth part of agricultural land. Polissya zone features those crops which are characterized by increased requirements for providing moisture, are undemanding to heat, grow well and develop on soils that are light in terms of particle-size distribution. Fodder crops, potatoes, and flax occupy the largest sown areas. Cereal crops account for from 25 to 50% in the sown area structure. High yields are provided by grains less dependant on soil fertility - rye, triticale, oats. Lupine is an important crop for this zone. There are also hop crops.

Fig. 10 – Map of soil and climate zones of Ukraine

The Forest-steppe zone is characterized by a moderate continental climate. The soil is fertile with a humus content of 3 to 5%. Forest-steppe occupies 1/3 of agricultural land. It is focused on the production of grain and sugar. In the structure of sown areas, cereals occupy 50-65%, the main crop of the Forest Steppe is winter wheat. Large areas are occupied by spring barley, corn, sugar beets, and soybeans. Buckwheat, rapeseed, peas, beans, fodder beets grow well here. Sunflowers are grown in the eastern part.

The Steppe zone is characterized by a continental climate. Most of the soils are fertile, with a humus content of 3 to 6%. A third of agricultural land is located in the steppe zone. Heat-loving, drought-resistant crops are sown here. The largest part of the cultivated area is occupied by grain crops. A mandatory farming condition is to allot 10-

20% of the arable land for fallow, after which winter crops are sown. About 80% of sunflower fields are licated in this zone. This is the main area for growing corn for grain, soybeans, and millet. Sorghum provides high yields on saline soils.

Different methods of research are used in crop production. The main one is a field experiment. The method of field experiment provides an opportunity to solve practical issues of agricultural technology related to soil cultivation, application of fertilizers, timing, methods of sowing, sowing rates, crop care, assessment of predecessors, crop rotation, etc., determination of the effectiveness of the complex and individual measures of the agricultural crop production technology , and as well as the selection of the best varieties. Research is carried out in the experimental fields of research institutions and educational institutions. Agricultural crops are sown on experimental plots of different sizes (from 10-25 to 100 m2) in 3-4 repetitions. Depending on the number of factors studied, one-, two-, and multi-factor field experiments are distinguished.

Laboratory-field, laboratory and vegetation research methods are used for the preliminary study of issues related to the biological features of crops and individual agrotechnical measures. The laboratory-field experiment differs from the field one in the smaller size of the plots (from 1 to 50 m2) and the greater repetition of options (from 4 to 8). The laboratory method implies examining plants in special agrochemical, biochemical, cytological, bacteriological and other laboratories.

Vegetation experimant is also widely used in crop production. Plants are grown and studied in vessels made of glass, metal or plastic, which are placed in special rooms (vegetation houses, greenhouses, etc.). The vegetation experiment is an analytical laborator-based method. It helps to study biological, physiological and agrochemical issues, in particular, those related to the development of plants and their nutrition. The value of the vegetation method lies in the fact that the action of individual factors can be studied in isolation from each other.

The final stage of the study of the effectiveness of various factors is a production experiment. This is a synthetic method that allows researchers to give the most complete assessment of the factors being studied directly in production conditions, to determine their probability and the possibility of introduction into production. Production experiments are carried out on large areas (1-2 hectares or more) in 2 cycles.

Taking into account the importance of the crop production branch in the national economy, the government of Ukraine should focus its efforts on the successful implementation of land reform, the completion of scientifically based reformation of collective agricultural enterprises, technical and technological re-equipment of the crop production branch, increase of soil fertility due to improved supply of farms with mineral fertilizers, effective use of irrigated and drained lands, increasing the effectiveness of selective breeding institutions and the activity of seed farms. The government's taking these and other measures will contribute to the growth of the gross crop production and the improvement of the Ukrainian people's standard of living.

1. FUNDAMENTALS OF AGRONOMY

1.1 Soil science

In all eras, the farmer treated the land with special hope and anxiety, considering it a bearer of fertility. His life and well-being depended on it. And it is not by chance that many peoples still call the earth a nursing mother.

Land is an undeniably general concept. The life of plants and the formation of their crops is provided by the surface layer of the earth’s land, which is called soil in science.

In our country, the sources of soil science date back to the beginning of the 18th century, when the great scientist M.V. Lomonosov first expressed a correct view of the origin of soils and their formation. That is why academician V. I. Vernadsky considered M. V. Lomonosov the first soil scientist of Russia.

However, soil science became an independent science in Russia only in the second half of the 19th century, which was facilitated by the works of such Russian scientists as D. I. Mendeleev, K. A. Timiryazev, I. A. Stebut, A. V. Stoletov and others. But the founder of scientific soil science is V.V Dokuchaev (1846-1903), whose scientific views were recognized in all countries of the world. It was Dokuchaev who proved that the soil was not a dead body, that all soils on the globe appeared as a result of long-term changes in nature, that the soil quality depended on the parent rock that had formed it, on the climate, plants and animals living on the surface and inside the soil, from the relief of the area and the continent age.

He made the first classification of soils, developed methods of mapping, their research, proved the favourable role of forests for steppe and desert-steppe areas.

The works of an number of prominent soil scientists were also of great importance for the development of academic soil science. Among them were P. A. Kostychev known as a profound geobotanist and agronomist and N. M. Sibirtsev hwo was V. V. Dokuchaev’s follower and student. K. K. Hedroits, V. R. Williams, D. M. Pryanishnikov, B. B. Polynov, L. I. Prasolov, I. V. Tyurin and other scholars made a significant contribution to the development of soil science.

The data of soil science are the basis of all measures aimed at improvimg soil fertility, fighting against water and wind erosion, developing wetlands and saline lands, liming acidic soils, implementing irrigation in areas of insufficient moisture.

Under further consideration are the following issues: the essence of the "soil" notion, time and conditions of its formation, and characteristics of its key property - soil fertility, on which the successful farming activity mainly depends.

1.1. 1 Plant life and soil

It is common knowledge that light, heat, air, water and nutrients are needed for normal plant growth and development. They are called plant growth and development factors.

The sun gives **light and heat**. Its rays carry a significant amount of energy to the Earth. The sun emits energy equal to 10,000 horsepower per hectare per second.

Without light and heat, terrestrial plants cannot exist. These factors are necessary for plants to create a green substance in the leaves – chlorophyll, thanks to which complex organic compounds – starch, sugar, fiber, fat, proteins and others – are formed in the process of photosynthesis.

However, man is not yet able to regulate the flow of light and heat in field conditions. It adapts to nature, reducing or increasing the number of plants per unit area.

Undoubtedly, plants need **air**, mainly the carbon dioxide contained in it. The components of carbon dioxide – carbon and oxygen – are the most important elements of complex organic compounds. Another element needed for their formation in a leaf is hydrogen. It enters the leaves together with moisture from the soil. In addition to carbon and oxygen, the air contains huge reserves of nitrogen (78%) needed by plants for the formation of protein compounds. However, gaseous nitrogen from the atmosphere is hardly available to them: it comes to plants mainly from the soil in the form of nitrogen salts soluble in water.

Thus, **water and nutrients** coming from the soil are also necessary factors for plant life.

Hydrogen contained in water is necessary for the creation of starch, sugar, fiber and other complex organic compounds in plants. By evaporating from the leaves, water facilitates plant cooling in hot weather and prevents plant cells from overheating. It is also necessary for the life of soil microorganisms.

The composition of all plant organs includes water in large quantities. For example, plant leaves contain from 60 to 80% of it. During its life, each plant needs a huge amount of moisture, which it absorbs through the roots and evaporates through the leaves.

Wheat, for example, uses more than 300 tons of water to create one ton of dry matter. And the total amount consumed by agricultural plants during the growing season is on average 2-4 thousand tons per hectare.

Therefore, to obtain a high yield, it is very important that the soil has a sufficient supply of moisture.

If you burn a plant, volatile substances containing carbon, hydrogen, oxygen, nitrogen will be released from it, and ash will remain.

It contains mineral or ash nutrients – phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese and many other elements. Some of them are needed by plants in very small doses, so they are called trace elements. These are boron, manganese, copper, molybdenum, zinc, cobalt, etc.

The total reserves of nutrients in the soil can be very significant. This applies not only to black soils. Any soil can provide high yields for several decades, and depending on the reserves of some nutrients, for hundreds of years. But not all nutrients are in the form of salts available to plants. Most of them are in an insoluble, inaccessible form for plants, and therefore most soils need to be replenished with easily soluble nutrients in the form of various fertilizers.

The question arises: how were soils created and their fertility developed in natural conditions? It all started with the destruction of rocks. The earth's crust consists of many rocks.

The most common massive crystalline rocks are granites, diorites, basalts and others. All of them were formed from magma. These rocks contain oxides of silicon, aluminum, magnesium, sodium, potassium, iron, and calcium.

The most common minerals in the earth's crust are quartz, orthoclase, and mica. Many minerals contain nutrients that plants need.

Many rocks and minerals contain nutrients for plants, but they are in an inaccessible form. In addition, water and air cannot penetrate solid stone blocks.

Rocks in natural conditions do not remain unchanged: under the influence of water, air, and temperature fluctuations, they are subject to destruction. At the same time, small particles are separated from the rock, it becomes looser, water and air freely penetrate into it. Such a destroyed rock is called **marl**.

With further destruction of the rock, its particles become smaller. Over time, they begin to retain water, and then absorb it.

Marl, formed as a result of the destruction of rocks, still cannot be called soil: it still does not contain nutrients in a form available to plants. All these mixtures of large and small mineral particles, which are formed during the destruction of rocks, are called parent rocks, because with the appearance of living organisms in nature, soil with its new quality – **fertility** – was formed on these rocks.

For many millions of years before the appearance of life on Earth, the rocks of the Earth's crust were constantly exposed to destruction under the influence of water, air, and temperature fluctuations. This process of rock destruction is called **weathering**, and the causes of rock destruction are called weathering agents.

Water has great destructive power, both in liquid and solid state. It is estimated that 518 thousand cubic kilometers of water evaporate from the surface of all seas, oceans, rivers and lakes annually. This huge mass of water returns to the Earth in the form of precipitation, feeding streams and rivers. Flowing down the slopes, it destroys pieces of rocks lying on the banks and carries them further down. This force is especially huge in waterfalls, where water falls from a great height. Small particles of sand and silt are deposited in riverbeds in the form of sand sediments and silt. As a result, the rivers become shallower, their mouths get filled with silt, sand islands and deltas with a huge number of arms are formed, and many rivers change their course.

Solid water destroys rocks and minerals much more strongly. In places where the snow does not have time to melt during the summer, it gradually compacts and turns into ice.

Ice features fluidity, it moves slowly from the mountains to the valleys. However, having a huge moving mass, the glacier on its way creates potholes and deep hollows, destroys mountain ledges, forming stones, sand and clay. These products of glaciers' destructive activity are sometimes transported to considerable distances, during movement they are sorted by size, some rocks are mixed with others and deposit in the form of mounds, ridges and hills, which are called **moraines**. Moraines consist mainly of boulder clays, loams and sands.

These glacier deposits served as parent rocks for most of the soils of our country.

More significant destruction occurs under the influence of **rainwater**. Getting into the crevices of stone blocks in winter, water turns into ice, which, when expanded, destroys the stones.

Water acts as a destroyer not only mechanically, but also chemically, especially if acids or salts are dissolved in it.

In nature, water usually contains small amounts of carbonic, nitrous, and nitric acids. As a result of the action of water and carbon dioxide, for example, easily soluble compounds of potash and kaolinite, which are part of clay, are formed from the mineral orthoclase.

Wind has great destructive power. Soft rocks (limestones, sandstones, etc.) are more susceptible to weathering. The wind carries particles of sand, dust, creating dunes, barchans, hilly sands and other deposits.

Rocks are also severely destroyed as a result of temperature **fluctuations**. This destruction is much more intense in areas with a sharp change of heat and cold during the day (continental climate). In deserts and mountainous areas, the rocks heat up a lot at day time, while the minerals that make up the rock do not expand from the heat in the same way. As a result of such expansion, cracks are formed, which increase during the rainfall and rock cooling at night due to different degree of mineral compression.

Water enters the cracks that have appeared, which contributes to even greater destruction of rocks.

Before the development of life on the Earth, there was no soil, the land was covered with dead layers of products resulting from destruction of various rocks and marine sediments.

Easily soluble salts contained in these products of rock weathering were washed away by water and carried into rivers, lakes, seas and oceans. When rivers and seas dried up, water-soluble compounds thickened, became saturated, and crystallize in the form of various salts. This is how layers of different types of salts were created.

Millions of years passed and in many places, as a result of rock-forming processes, the bottom of the seas and oceans rose and became land, while sedimentary rocks came to the surface to get again exposed to weathering. Easily soluble salts were again released due to weathering, and again water washed them out of loose rocks and carried into the rivers, seas and oceans.

This is how the ***great or geological circulation of substances*** in nature took place before the appearance of living organisms on the Earth.

With the development of plants and animals on the Earth, the ***small or biological circulation of substances*** joined the great one. Living organisms that developed on the parent rocks began to intercept and absorb nutrients formed from the rock weathering, creating organic substances during that process.

At the same time, the process of destruction of dead organic matter with the formation of easily soluble nutrients took place. ***Thus, thanks to***

the small circulation of plant nutrients in the soil, its fertility is constantly maintained.

As a result of the vital functions of plants and animals, new sedimentary rocks appeared in the earth's crust. These include limestone, chalk, coal, oil shale and others.

Humans play a huge role in soil formation and the circulation of substances in nature. Using modern technology, man undermines mountains, layers of rocks, changes riverbeds, processes the upper layer of the earth with tools, contributing to the grinding of mineral fragments in the soil, increasing the reserves of water and air in the soil, regulating the temperature regime, etc.

Human production activity has a significant impact on soil-forming processes and soil fertility.

1.1.2 The role of living organisms in soil formation

Rocks changed their properties during weathering. The more small particles were accumulated in them, the looser the rock became and the better air and water retained by small particles penetrated it.

Thus, the first condition for fertility appeared in the destroyed parent rock – ***the ability to absorb and retain water as well as to be permeable to air***.

However, this parent rock did not contain a supply of easily soluble nutrient minerals. Only with the appearance of microorganisms and higher plants (vascular plants) on the products of rock destruction, the parent rock acquires another condition for fertility – ***the ability to accumulate mineral substances.***

On bare rocks, certain types of ***bacteria*** can assimilate nitrogen and carbon from the air. ***Lichens***, undemanding to water and nutrition, settle in the cracks and hollows of stones. Bacteria, lichens, mosses and other organisms that settle on stones and debris absorb nutrients from the air and directly from the stones thanks to the ability to release acidic compounds in the process of life.

Even the simplest organisms have a selective ability to nutrients, leaving them after dying in the surface layers of the rock thus ensuring the better development of subsequent organisms.

The products of rock destruction – clay, loam, sandy loam, sandy and other deposits – contain, except for nitrogen, all the nutrients necessary for the life of higher green plants. But the destroyed parent rocks contain very few soluble nutrients; in addition, the nutrients are dispersed in this rock over a considerable space. By absorbing nutrients, plants develop a significant root system.

Plant roots have a selective absorption capacity, which consists in the fact that plants absorb the elements they need with water.

Elements of salts that are not used by plants also enter the roots together with water, but they are not spent on the formation of organic compounds in the cells. When the concentration of salts in the cell sap of the root and in the soil solution is equalized, the absorption of salts by the root stops.

Thus, plant roots gradually obtain the nutrients they need from different places of the parent rock, developing a powerful root system. At the same time, the soil is penetrated by thick and thin roots of plants in all directions. The roots of perennial grasses penetrate to a depth of 5 meters or more. Clover, lupine, beetroot, sunflower, vetch, barley, wheat, rye develop their roots deep into the soil and parent rock up to 2.5-3 meters. The roots of woody plants cover a huge layer of parent rocks, using nutrients from deep layers.

After the plants die, all the nutrients in the stems, leaves, and fruit remain on the surface of the soil or in its upper layers, where most of the dead roots are deposited. As a result of the activity of microorganisms that decompose dead organic residues, the upper layers are enriched with nutrients every year.

Various animals participate in soil formation – earthworms, insects, which enrich the upper layers of the soil with their residues, mix organic residues with mineral particles of the soil and, dying off, increase the content of humus in the soil.

Earthworms, which feed on fallen leaves, stems, and dead plant roots, do a tremendous job creating soil fertility.

It has been established that earthworms, due to their significant accumulation, can pass through their body up to 10 tons of soil mass on 1 hectare per year, while creating a network of channels in the soil. In these channels there is a lot of excrement containing nutrients.

Along the paths made by earthworms, water and air penetrate deep into the soil. In these passages, plant roots encounter weak resistance from soil particles and find an environment rich in oxygen, water, and nutrients, which promotes their development.

Various earthworms, insects, their larvae and caterpillars also improve soil fertility, but some of them are pests of cultivated plants.

As a result of the vital activity of plants and earthworms, the upper layers of the soil are enriched not only with mineral nutrients, but also with humus.

1.1.3 Soil humus and its importance

In any soil, two processes occur simultaneously. The first one is the breakdown of complex organic compounds into simple ones. It is called the process of ***mineralization of organic substances***. The second process is the ***formation of humus***.

The formation of humus is a very complicated process. It occurs under the influence of oxidizing enzymes, which are released by many microorganisms. During this process, proteins, fats, carbohydrates of organic substances are split, and the resulting products react with the mineral part of the soil, creating humus in the form of organo-mineral compounds containing nitrogen.

Humic and crenic acids are distinguished in humus. ***Humic acids*** are in the form of a black or brown liquid. In the presence of calcium, magnesium, iron, and aluminum in the soil, humic acids form salts that do not dissolve in water.

Combined with monovalent cations (potassium, sodium, ammonium), humic acid produces soluble salts that are easily released from the soil.

Crenic acids (fulvic acids) are of yellow or light brown color. Their salts dissolve well in water. Crenic acids differ from humic acids in a very acidic reaction. They are able to dissolve the mineral part of the soil. At the same time, many nutrients move to the lower layers together with water. This movement of nutrients is observed in sod-podzolic soils, where a lot of crenic acids accumulate during the decomposition of forest litter by fungi.

In chornozems, more humic acids accumulate in the humic substances of the soil. Thus, soil properties depend not only on the amount of humus in them, but also on its quality. The best quality is observed in the humus of those chornozems, where the ratio of humic acids to crenic acids is equal to or more than one.

This combination of humic acids is most favorable for soil fertility. In sod-podzolic soils, humic acids are twice as low as in chornozems.

The soils of our country contain different amounts of humus. In the northern regions of Ukraine, sod-podzolic soils, which contain 1-3% humus, prevail, while in the soils of the forest-steppe, its content is 4-6%. The most humus is found in chornozems, which have a dark color caused by humus substances, to a depth of more than a meter. Wetlands can contain a large amount of humic substances, but their quality differs significantly from that of the humus of ordinary soils, especially chornozems.

The podzolic soils of the northern regions of Ukraine are the least supplied with humus.

Farmers have long noted the high fertility of soils containing a large amount of humus, as well as the positive effect of manure on soil fertility.

In the process of decomposition of the dead plant and animal remains, nutrients are released from them not immediately, but gradually. The process of decomposition of soil organic matter into humus with the formation of easily soluble salts necessary for plant nutrition takes place in favorable conditions requiring a short period of time – from 8 to10 weeks.

To sum up, the main source of nutrients for plants is soil organic matter. In cases when these substances are abundant, under favorable conditions for their mineralization, the supply of nutrients to plant roots will be sufficient and constant. The beneficial effect of humus on soil fertility is as follows:

- humus has a black or dark brown color, therefore the soil rich in it absorbs the heat rays of the sun more effectively and warms up better;

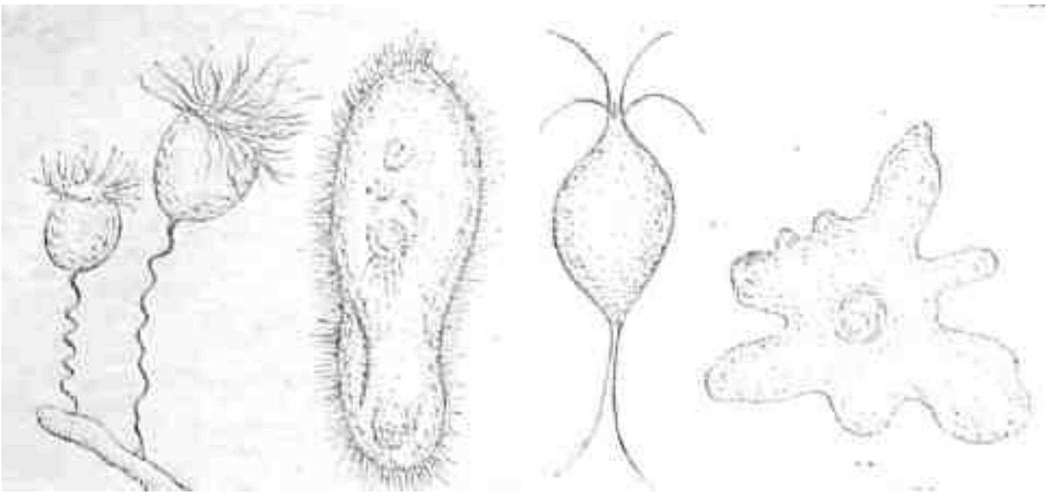
- humus has a high moisture content, therefore soils containing a significant amount of it retain more water;

-humus firmly glues mineral particles together, forming structural lumps in the soil. Structured soils are more fertile than structureless ones, they absorb water better and evaporate less of it. Structured soils contain air and are characterized by a more stable temperature regime. These features have a favorable effect on beneficial microorganisms' functioning, as a result of which the structural soil always contains more easily soluble nutrients.

The main work in the decomposition of organic substances leading to the formation of humus is performed by ***soil microorganisms***. These invisible creatures do a lot of work in the nutrient cycle.

1.1.4 The importance of microorganisms in the formation of soil fertility

The microscopic living world of the soil is very diverse. In the soil, along with plant remains, there are various living creatures. Some of them are large, shiny with many cilia around the edges. In shape, they resemble a slipper, that is why they were called slipper animalcules. Others do not have a specific shape, they constantly change when moving and become either round or with protrusions on the edges, which either lengthen or hide. These are amoebas, which means formless in Greek. Creatures with two flagella move quickly. These are flagellar ciliates (Fig. 1).



Vorticella Slipper animalcule Flagellar ciliate Amoeba

Fig. 1. The simplest unicellular soil organisms

The soil solution also contains single-celled (unicellular) creatures with two cilia. This living lump contains grains of green colors inside. This is a unicellular chlamydomonas plant, in the protoplasm of which there are chlorophyll grains. Therefore, these plants are sensitive to light and quickly gather in places that are more brightly lit. It is due to chlamydomonas that stagnant water in a neglected pond turns green.

Most of the single-celled organisms we can see belong to the group of protozoa (simplest organisms). The protozoa content in the soil depends on the amount of organic substances and moisture in it. There can be about two million of them in 1 gram of soil. Protozoa mainly live in the upper layers of the soil. Along with unicellular organisms, various microscopic algae live in the soil.

Blue-green algae often multiply in huge numbers on the surface of the soil, causing it to turn green.

Science has proven that about 30 types of blue-green algae are capable of binding nitrogen from the air. These algae are especially important for rice fields, where due to excess moisture, other microorganisms that absorb nitrogen from the air do not develop well.

All these protozoa and microscopic algae are less numerous than bacteria, actinomycetes, fungi, viruses and bacteriophages.

Bacteria reproduce by fission. Every 20 minutes, two individuals are formed from one. Within 6 hours, under favorable conditions, one bacterium could produce a 50-thousand offspring, and within a day, one bacterium can replicate billions of similar organisms.

However, despite the greater ability of bacteria to reproduce, overpopulation does not occur, because the soil contains a limited supply of nutrients for them. In addition, billions of bacteria die from heat, cold and other adverse conditions, they are also eaten by the simplest organisms.

Bacteria densely inhabit the soil in its upper layers, but some species are found at a depth of about 5 meters.

In fertile soils rich in organic substances, the bacterial population is very numerous and diverse. 1 gram of soil contains 3-4 or more billions of different types of bacteria. Only in a 25-centimeter layer of soil, the total mass of microbial bodies can reach 3 tons per hectare or more. The viability of bacteria is amazing. Many bacteria under unfavorable conditions (for example, when the soil dries out) form spores, that is, they are able to cover themselves with a dense shell (cyst) and thus maintain their viability for more than 100 years. When moistened with water, the dense surface layer swells, and the bacterium awakens to life again (Fig. 2, 3, 4).

Bacteria play a significant role in increasing soil fertility. Thus, a group of nitrogen-fixing bacteria, which use nitrogen from the air for their life, is of great importance for the accumulation of nitrogen in the soil. Nodules with nodule bacteria (Fig. 5), absorbing nitrogen from the air are formed on the roots of clover, vetch, alfalfa and other leguminous crops. After dying off, up to 200 kilograms of nitrogen remain in the soil on 1 hectare of leguminous crops.

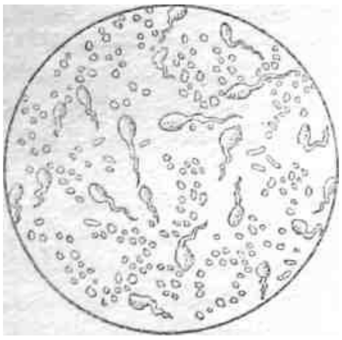
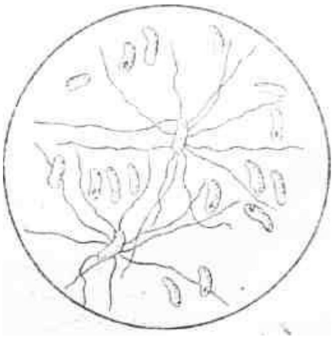
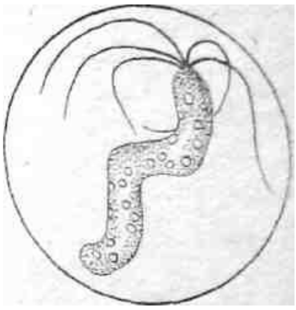
  

Fig. 2. Nitrifying bacteria Fig. 3. Ammonifying bacteria Fig. 4. Sulfur bacteria

Under irrigation conditions, alfalfa can accumulate up to 300 kilograms of nitrogen per hectare in the soil. Thus, one hectare of leguminous crops can provide nitrogen nutrition for two subsequent crop rotations.

In addition to nodule bacteria, other microorganisms live in the soil and assimilate nitrogen directly from the atmosphere. These include azotobacter, which can accumulate up to 15 kilograms of nitrogen per hectare in the soil, and some species of actinomycetes and microscopic fungi.

There are soil bacteria that convert insoluble compounds of phosphorus, sulfur, iron and other elements into a form available to plants.

Fungi take an active part in the decomposition of organic substances, especially the remains of woody vegetation. Their play a great role in the decomposition of fiber. Fungi are the first to settle on fresh organic matter, but later they are replaced by bacteria.

Many types of fungi coexist with the roots of higher plants, especially trees. Together with the thin roots of plants, fungi form a mycorrhiza. Fungi use sugar and other hydrocarbon compounds from the roots and, in turn, provide plants with nitrogen released as a result of the decomposition of soil humus and forest litter - leaves, needles, branches, etc.

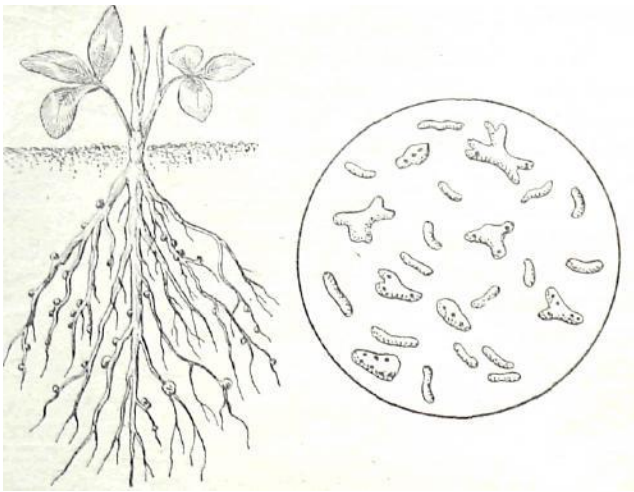


Fig. 5. Nodule bacteria

The rate of decomposition of organic residues depends on their access to water and air, on the temperature and reaction of the environment. The optimal combination of these factors in the soil is of great importance. If there is an excess of water in the soil, there will be no room for air displaced from the soil pores by water. Conversely, if the soil contains a lot of air and little water, the rate of decomposition of organic matter will decrease due to a lack of moisture. The fact is that the rapid decomposition of organic residues is ensured by a special group of soil microorganisms that belong to aerobes. This group consists of a variety of bacteria, fungi and other microorganisms, different in terms of nutritional requirements, but equally demanding air oxygen. Air oxygen is necessary for their life and activity. These microorganisms also require sufficient soil moisture, because their life dies out in dry soil.

Most aerobic microbes reproduce better at a temperature of 20-30°C. If the temperature rises and falls, their vital activity fades.

An important condition for the effective performance of aerobic microbes is the reaction of the environment in which the microorganisms live. Many of them cannot withstand a strongly acidic environment. Acid humus is a very unfavorable environment for most aerobic bacteria. That is why the rate of decomposition of organic compounds under conditions of soil liming increases significantly, because lime reduces the acidity of the soil and creates a favorable neutral environment.

Another, less numerous group of microorganisms belongs to anaerobes, that is, to such organisms that do not need air oxygen to sustain life. They extract it by decomposing various oxygen-containing compounds.

Decomposition of organic substances by anaerobic microorganisms proceeds slowly, due to the fact that these microbes do not need air oxygen. Most of them can live in colder and more acidic soils containing an excess of water.

That is why the anaerobic process is more pronounced in swamp soils than in soils with normal moisture. In ordinary soils, anaerobes are located in deep, dense subsoil layers, or in the arable layer with temporary excess soil moisture.

There is a close relationship and interdependence between various microorganisms in their development. As a result of the combined action of fungi and bacteria, complex organic substances are gradually transformed into mineral compounds suitable for feeding higher plants. There is also a close relationship between higher plants and microorganisms.

Increased microbiological activity is observed in the zone of the root system near the root hairs (rhizosphere zone). Microbes settle on dead cells of roots, root covers, and also use root secretions of plants. On the other hand, microbes can help plant roots absorb various nutrients by secreting enzymes, and other compounds that break down organic matter.

1.1.5 The role of microbes in the mineralization of soil organic matter

The final products of the mineralization of organic substances, resulting from aerobic microorganisms' functioning, are different. Organic compounds containing carbon are decomposed into carbon dioxide and water as a result of the activity of microbes.

Decomposition of protein substances is much more difficult. Protein is a food source for many bacteria and fungi. As a result of their activity, a complex protein molecule is split into simpler amino acid molecules, then the first product of mineralization is formed – ammonia. This process is called **ammonification.**

Most of it is released into the air, a small amount is absorbed by soil colloids, some ammonia reacts with acids, forming nutritious ammonia salts, and some is absorbed by bacteria and used to build proteins in their cells. Only a small amount of ammonia is oxidized by nitrite bacteria to nitric acid, which is further oxidized by nitrate bacteria to nitric acid. This process is called ***nitrification***.

The resulting nitric acid can form salts (nitrates) in the soil. When reacting with lime, it replaces hydrogen with calcium and forms calcium nitrate, its reaction with potassium chloride leads to the formation of potassium nitrate, and sodium nitrate appears as a result of nitric acid reacting with kitchen salt. These salts are nitrogenous mineral fertilizers for higher plants.

Phosphorus-containing organic substances also undergo a complex transformation process. Various microorganisms turn them into phosphoric anhydrite, and then into orthophosphoric acid, which can also form various nutrient salts in the soil, replacing its hydrogen with calcium, sodium, ammonia and other bases.

One of these compounds, contained in superphosphate, is easily soluble in water and is immediately absorbed by higher plants, another dissolves in slight acids, and the third one turns into sparingly soluble iron or aluminum salts.

Microorganisms (sulphur bacteria) convert organic sulfur into hydrogen sulfide gas, then into sulfuric acid, which can form various salts in the soil.

In the process of decomposition of organic substances into final mineral products, numerous intermediate products of the decomposition of organic substances are formed. Among them are organic acids: acetic, malic, oxalic, lactic, valerian, citric, butyric and others.

At the same time, along with useful decay processes, there are also those that lead to the loss of compounds suitable for plant nutrition. Thus, as a result of nitrification, nitric acid and its salts (nitrates) are formed in the soil. However, the nitrogen of these salts can be lost under the influence of denitrifying bacteria. This process is called ***denitrification.*** Denitrifying bacteria develop in the soil containing a large amount of fresh organic matter with poor air access and the presence of ready mineral nitrogen compounds. As a result of the activity of these microorganisms, nitrogen can be released from the saltpeter in the form of gaseous nitrogen. For denitrifiers, anaerobic living conditions are more favorable than aerobic ones. This process is enhanced by excess moisture in the soil.

Applying fresh straw manure (rich in fiber) to the soil can cause a rapid denitrification process with a large loss of already formed nitrates. This is important to consider in the farming practice.

The decomposition of organic substances in anaerobic conditions leads to the formation of mainly volatile, gaseous products of carbon, nitrogen, phosphorus, and sulfur. Carbon is released in the form of methane, nitrogen - in the form of free nitrogen, phosphorus - in the form of phosphorous hydrogen, sulfur - in the form of hydrogen sulfide. At the same time, many non-oxidized compounds accumulate in the soil.

Anaerobic process usually prevails in swamp soils due to excess water and lack of air.

Decomposition of organic matter in anaerobic conditions is many times slower than that occurring in aerobic conditions. At the same time, there remain larger reserves of poorly decomposed organic matter, which usually has an acidic reaction. In peatlands, organic matter decomposes so weakly that it is possible to easily determine from which plants the organic mat was formed.

In any soil, if it does not have excess water, both processes – aerobic and anaerobic – take place simultaneously:. Even in the upper soil layers, where there is a significant amount of air oxygen, along with aerobes, anaerobic processes take place along with aerobic ones inside the structural lumps when they are saturated with moisture. Anaerobic microorganisms predominate in the lower soil horizons.

In addition to the end products of organic substance decomposition in the soil as a result of the vital activity of aerobes and anaerobes, humus accumulates, which is difficult for microorganisms to decompose.

The arable layer of chornozem soil contains a significant amount of nutrients capable of ensuring a high yield of all crops. However, this significant supply is mainly contained in humus, which with the help of microorganisms can annually provide only a small amount of readily available nutrients. Soil humus is a rich source from which plants can obtain all nutrients with the help of microbes for a long time.

Many technological techniques developed by science and practice increase the activity of microbes and enhance the decomposition of humus. Such techniques include: soil cultivation, application of bacterial fertilizers, irrigation and drainage of lands, etc.

However, the most important methods of technology are those that, along with the consumption of reserves contained in humus, create conditions that contribute to the increase of organic matter reserve in the soil.

When adding manure, compost and other organic fertilizers to the soil, the reserves of organic matter in the soil increase, the activity of microbes becomes several times more effective than in unfertilized soil. At the same time, a supply of fresh humus – a reliable reserve of nutrients – is created. In addition, fresh humus, penetrating the structural lumps of the soil, gives them high resistance against water erosion.

Green manure has a positive effect on soil fertility, especially on sandy and loamy soils poor in organic matter. Lupine, seradella and other leguminous crops under conditions of plowing their green mass replenish the reserves of organic matter in the soil and strengthen microbiological activity in it. Liming of acidic soils contributes to the creation of a favorable reaction for nodule bacteria, nitrogen-fixing and other microorganisms that increase nutrient reserves in the soil.

Mineral fertilizers also enhance the microbiological activity of the soil, because many soils lack nutrients for bacteria and fungi.

To manage soil fertility, one must learn to regulate microbiological processes in the soil.

1.1.6 Mechanical composition of soil

During rocks weathering and soil formation, particles of different sizes and shapes (mechanical elements) accumulate in the parent rocks and soil. They create the mechanical composition of the parent rock or soil. It affects those soil properties, which are important for soil fertility.

Large fragments of more than 3 millimeters in size, are called ***stones***; particles from 3 to 1 millimeter are referred to as ***gravel***; and from 1 to 0.05 millimeters - ***sand***. These particles make up the soil skeleton, the smaller ones form fine soil. It includes dust particles (coarse, medium and fine) with a diameter of 0.05 to 0.001 millimeters.

Particles smaller than 0.001 millimeter belong to silt - coarse and fine. The particles of the latter have a size from 0.0005 to 0.0001 millimeters.

Stones and gravel almost do not retain the falling precipitation and are not able to raise water to the surface. In addition, these fragments, if they contain nutrients, are practically unavailable to plants. Soils containing more than 10% of stones are called ***very stony***. They are found in mountainous areas.

In many northern regions of the country, large boulders that were deposited during the Ice Age can often be seen in moraine clays and loams. They prevent soil cultivation, plant care, and harvesting.

Sand particles pass water well, but at the same time, they can retain a small amount of water. Sand particles mainly consist of quartz (the mineral).

Dust has the ability to retain water in significant quantities. Some parts of it also consist of quartz.

Silty particles are able to retain a significant amount of water. They are rich in compounds of iron, aluminum, calcium, magnesium, phosphorus and other nutrients. This is the most active part of the soil, where nutrients are in a form easily accessible to plants.

However, silt particles are very diverse in size and chemical composition, so they have different properties. There are many silty particles whose diameter is 10,000 times smaller than one millimeter. This part of the silt containing particles sized from 0.0001 to 0.000001 millimeters is classified as ***soil colloids***, which are of great importance in the life of the soil.

Particles smaller than 0.01 millimeter are called "***physical clay***", those larger than 0.01 millimeter – "***physical sand***".

Depending on the content of clay and sand particles in the soil, they are called clayey, loamy, and sandy.

Stony soils are improved by adding clay, silt, as well as peat and other organic fertilizers. Silt increases the moisture content of these soils, reduces the leaching of valuable small particles and easily soluble nutrient salts from them.

Sandy soils pass water well, but absorb it poorly. They heat up quickly during the day and cool down quickly at night. Their nutrient content is not significant.

Clayey soils are able to absorb a large amount of water, but with a small content of humus and lime, they swell greatly, do not allow water and air into the deep layers, that is, they become unsuitable for plants:

water stagnates on the surface, displacing air, plant roots and soil microorganisms suffer from a lack of oxygen.

In drought clayey soils are able to dry out a lot, forming a significant number of cracks that tear the roots of cultivated plants and cause the soil to dry out to an even greater depth.

Loamy soils have good properties. They contain enough moisture and air, which, in turn, promotes the increased activity of various microorganisms, which inhance the reserves of easily soluble nutrients in the soil.

Clay chornozems have the best properties, because they contain significant reserves of organic substances (humus) and lime, which improve the properties of clay.

The mechanical composition of the soil can be approximately determined by simple methods. When wetting lumps of sandy and loamy soil and rubbing them between your fingers, you immediately feel the roughness from the presence of large particles. Loamy and clayey soils, on the contrary, give a velvety feeling. Neither a ball nor a cord can be formed from sandy soil, even when moistened. The ball made from sandy soil, cracks, but the cord does not form at all. A lump of moistened clayey soil can be easily rolled into a thin cord and curved into a ring without cracks at the bends. The cord made from loamy soil can also be curved into a ring, but many cracks will form in the places of the bend.

The mechanical composition of the soil affects not only the yield of plants, but also the methods of its cultivation and fertilization.

Therefore, when studying soils in the farm, it is necessary to elaborate a soil map for indicating their mechanical composition in each field of crop rotation, because methods of soil cultivation and fertilizer application are applied taking into account the mechanical composition.

1.1.7 Colloids and soil fertility

The size of soil ***colloids*** is different. Large colloids have a diameter of less than one ten-thousandth of a millimeter, the smallest - one millionth of a millimeter, and their size is much larger than molecules. Molecules are so small that they easily penetrate through the pores of animal and plant tissue, that is, they are capable of diffusion. Colloidal particles are gigantic compared to molecules. They consist of hundreds or thousands of molecules and therefore cannot penetrate through the pores of plant and animal tissue, that is, through the walls of root hairs or plant cells, so they are not nutrients for plants. This task is performed by molecular solutions that are formed in the soil when various salts are dissolved in water.

Colloids play a significant role in creating soil fertility. Of particular value are ***organic colloids*** that have a strong adhesive property (κόλλα in Ancient Greek means “glue”) and feature a more complex chemical composition. Along with mineral and organic substances, there are also organo-mineral colloids in the soil, which are formed when organic and mineral substances are combined in the process of soil formation.

It is worth noting that the finer the soil particles, the more they retain water and absorb nutrients, preventing them from being washed away. Clay soils, enriched with small silt particles, absorb more water than sandy soils, which contain a small amount of silt particles. This is explained by the fact that particles’ surface per unit mass (specific surface) increases as a result of their grinding.

In addition to solid particles, the soil contains water with salts dissolved in it (soil solution) and air. Water is a molecular solution. Upon contact with solid soil particles, water molecules are attracted to them, forming a thin film. Therefore, the more small particles in the soil, the larger the surface they form and the more moisture they retain.

That is why clayey and loamy soils are more moisture-rich than sandy and loamy-sandy soils.

Small silt particles and especially colloids are also of great importance in the absorption of nutrients from the soil solution. Any soil is endowed with this property to some extent. Its absence would lead to precipitations’ removing the most valuable part of the soil - its colloids, soluble nutrients - from the arable layer in a short period of time. Only coarse soil particles (stones, gravel, sand, dust), the fertility of which is negligible, would remain in it,.

Such impoverishment of the soil with nutrients and colloidal particles is most often observed in sandy soils, especially in areas of excessive moisture.

1.1.8 Peculiarities of absorption of nutrients by the soil

In addition to solid particles, soil contains water and air. However, there is no pure water in nature. Even rainwater (when vaporous moisture is transformed into a droplet-liquid state) contains a small amount of nitrous and nitric acids, and when falling on the ground, it is contaminated with dusty particles in the air. Thus, the water which falls on the soil is not pure, it is a solution containing a number of soluble and insoluble compounds. In addition, drops of water, penetrating deep into the soil, dissolve a significant amount of salts contained in it.

Having a huge surface, colloidal particles attract this soil solution to themselves, firmly keeping nutrients in this way.

Even in ancient times, polluted water was purified by passing it through a layer of soil that retained dyes, microorganisms and many chemical compounds.

Many foreign scientists attempted to find out the ability of the soil to absorb various substances. However, the doctrine of the absorption capacity of soils was developed in detail by the prominent scientist K. K. Hedroits (1923).

Absorption capacity of the soil is a very complex phenomenon.

A drop of water can contain thousands of colloidal particles. When it rains and water penetrates deep into the soil, colloids can be transferred to sub-arable layers. Such removal of colloidal particles by water occurs in stony, sandy, and loamy soils, which reduces their fertility.

Colloids are stored better in loamy and clayey soils, because these soils are more difficult to pass water, and they also contain many times more colloids. Colloids are even better stored in loamy and clayey chornozems, which contain a lot of calcium and magnesium salts. There are almost no separate colloids in these soils, they are all connected in flaky sediments by calcium salts. These sediments together with clay (silty) particles create dams in the soil pores. Thus, not only free colloidal particles are mechanically retained, but also fine silt particles, that is, the most valuable part of the soil. Such retention of small particles and colloids in the soil is called mechanical absorption.

As mentioned above, colloids consist of a huge number of molecules. Molecules located on the outer part of a colloidal particle have surface tension - a force capable of attracting molecular particles from the solution. Surface tension is an insignificant value for one colloid, but multiplied by the huge surface of numerous colloids, it reaches significant dimensions.

When colloids collide with the soil solution, the molecules of the latter are attracted to their surface, each particle of which has a layer of the soil solution, which is strongly held by the colloidal particles. This force is especially large on the surface of colloids. The soil, attracting the soil solution to small particles of silt and colloids, physically retains nutrients dissolved in soil moisture and prevents their leaching. This type of absorption is called ***physical or molecular absorption (adsorption***).

Along with solutions, soil particles can also attract molecules of vaporous moisture from the air and various gaseous substances.

Near the surface of the colloid there is a zone of greatest pressure. Many salts dissolved in groundwater, being in the high pressure zone, increase their solubility, while in the attracted film located near the surface of the colloid, the salt solution will have the highest concentration. The farther from the colloid, the weaker the concentration of the solution. This type of absorption capacity is called ***positive molecular absorption***. If the solubility of the salts of the soil solution decreases with increasing pressure, the inverse concentration of these salts in the solution film is observed: the smallest near the colloid, and the largest towards the periphery. This phenomenon is called ***negative molecular absorption.***

Salts of nitric acid have negative molecular absorption, so they are easily washed out of the soil, as if repelling from colloidal particles.

Physical absorption is of great importance to prevent leaching of nutrient salts from the soil. However, exchange reactions between the salts present in the film and substances on the surface of the colloid may occur in the solution film attracted to the colloid.

The solution concentration may decrease due to the formation of poorly soluble compounds that are not washed out of the soil.

Chemically, the soil absorbs salts of phosphoric, carbonic and partially sulfuric acids well. Nitrogen compounds cannot be chemically absorbed because they do not form poorly soluble compounds in the soil.

In addition to the specified types of absorption capacity, nutrients in the soil can be absorbed biologically.

Biological absorption refers to the absorption of ready-made nutrients by the microorganisms inhabiting the soil, which, destroying organic substances into mineral compounds, use them as nutrients for their life. The larger the soil population, the more nutrients are absorbed biologically. However, these losses of nutrients are temporary, because when microorganisms die, nutrients are mineralized again and enter the general circulation. In any case, this absorption of nutrients does not impair soil fertility.

The absorption capacity of different soils depends primarily on the amount of the finest silt particles, mineral and especially organic colloids in the soil. This part of the soil is called ***the soil absorbing complex***. The more small and smallest particles are in the soil, the stronger it manifests its absorption capacity.

However, the strength of the absorbing complex also depends on the content in the smallest particles of such elements as calcium, magnesium, iron and others. The absorption complex, which contains a lot of absorbed calcium and magnesium, is of particular value. K. K. Hedroits called it ***saturated***. If the absorbing complex has little calcium and magnesium, but a lot of absorbed hydrogen, it will be ***unsaturated***.

Black soils have a saturated complex, while podzolic soils have an unsaturated one. There are very few organic colloids in the podzolic clay soil due to the fact that its absorbing complex contains a lot of absorbed hydrogen. This soil has an acidic reaction of the soil solution, its structure is not, it forms a crust from the rain. Such soil has little air and is poorly permeable to water. To improve the properties of clayey podzolic soil, it is necessary to increase the reserves of organic substances in it and squeeze out absorbed hydrogen from the absorbing complex, replacing it with calcium and magnesium. Practically, this means that higher doses of organic fertilizers should be used for such soils and lime should be applied in a dose that will ensure a slightly acidic reaction of the soil solution and improve its structure.

Clay chornozems have better properties: a strong structure, good water, air and thermal properties and a neutral reaction of the soil solution. Thanks to its absorption capacity, the soil contains nutrient solutions of different concentrations, which makes it possible for different plants with different nutrient requirements to grow normally on the same soil.

The strength of the soil solution is regulated with the help of absorption capacity. As plants absorb calcium, potassium, ammonia, and other salts from the soil solution, these elements enter the soil solution from the absorbed state, providing normal plant nutrition.

When applying fertilizers, it is necessary to take into account the absorption capacity of the soil. Nitrogen fertilizers should not be applied long before sowing and especially in areas with a lot of precipitation, because nitrogen compounds (except for ammonia) are not absorbed by the soil.

It is not recommended to apply significant doses of mineral fertilizers to sandy soils, because during the drought, solutions of a strong concentration, harmful to cultivated plants, can be formed in the soil, and during the rainy season, all the salts of nitric acid (nitrates) will be washed away.

1.1.9 Soil solution reaction and its significance for the formation of agricultural crop yield

The reaction of soil can be acidic, neutral and alkaline.

Salts and acids are known to able to disintegrate in aqueous solution under the influence of weak electrical forces into ions with a positive electrical charge, called cations, and ions with a negative electrical charge, called anions.

Under the action of electric forces, a water molecule can disintegrate into a hydrogen cation (H^+) and a hydroxyl anion (OH^-), and in distilled water the number of H^+ ions is equal to the number of OH^- anions, therefore such water has a neutral reaction. If acids are added to this neutral solution, this equilibrium will be disturbed. Hydrogen ions (H^+) will predominate in the solution, and the reaction of the solution will become acidic. Adding alkali (NaOH, KOH) to a neutral solution will change the reaction of the solution to alkaline. The more acid or alkali is added to the solution, the more the degree of acidity or alkalinity of the solution is increased.

The amount of hydrogen ions in the soil can be determined chemically, marking their content with the pH sign. The value of pH (concentration of hydrogen ions) is expressed by the following indicators: for an acidic reaction (when hydrogen ions predominate in the soil solution) such indicators as 1, 2, 3, 4, 5, 6 are used, and the higher the number, the lower the acidity; number 7 shows that the number of hydrogen ions and OH anions in the solution is equal (H = OH); numbers 8 and 9 indicate the superiority of OH^- anions over H^+ ions in the solution, i.e. as the number rises, the alkalinity of the soil increases.

According to the value of pH, soils are divided into strongly acidic (pH 3.0-4.5), acidic (pH 4.6-5.5), weakly acidic (pH 5.6-6.5), neutral (pH 7.0) , alkaline (pH 7-8), and strongly alkaline (pH 8-9).

The highest soil acidity is expressed by pH values of 3.0 and 3.5. With such acidity, all cultivated plants grow poorly. Such acidity of the soil solution is rare. Acidity corresponding to pH 4.0-4.5 is also strong. It is unfavorable for most cultivated plants, especially for clover, alfalfa, wheat, sugar beet, and barley. Of all leguminous crops, only lupine tolerates it.

Most cultivated plants require a slightly acidic (pH 6.0-6.5), neutral (pH 7.0), or slightly alkaline (pH 7.2-7.5) reaction of the soil solution for their normal development.

However, a close to neutral or neutral reaction can only be in the soil, whose absorbing complex is saturated with calcium and magnesium. Soils featuring a lot of hydrogen in the absorbing complex always have an acidic reaction of the soil solution, which due to the application of acidic fertilizers can increase to such an extent that it becomes harmful to cultivated plants. If potassium salt is applied to the soil, which has weak acidity, and whose absorbing complex is saturated with calcium, then the acidity in the soil solution will not increase, the solution will remain neutral, because instead of hydrogen, potassium will push out calcium from the surface of the colloidal particles. The solution will contain calcium chloride, not hydrochloric acid.

To increase the fertility of acidic soils, they are limed, that is, a lot of calcium is applied to the soil, which displaces hydrogen or absorbed aluminum from the surface of the colloids and forms salts in the soil.

For different soils, the dose of lime depends on their degree of acidity and mechanical composition.

There are three types of soil acidity: actual, exchange and hydrolytic.

The acidity of the soil solution, or water extract from the soil, is called ***active acidity***. With strong active acidity, the pH of the water extract is equal to 3. Determination of the amount of lime per hectare required to neutralize this acidity of the soil solution shows that its dose is insignificant (about 30 kg). However, when this amount of lime is applied to the soil, the soil solution becomes acidic again after some time due to the fact that there is a lot of absorbed hydrogen in the soil absorbing complex of acidic soils. This hydrogen absorbed by the colloidal particles has a double effect. One part of it which is the most mobile is easily displaced into the solution by various neutral salts, for example, potassium chloride, the other is not displaced.

Hydrogen displaced by potassium chloride forms the so-called ***exchangeable*** acidity. In order to find out whether the soil needs liming, not actual, but exchangeable acidity is determined.

Part of the hydrogen remaining in the absorbing complex can be displaced only during the action of an alkaline salt, such as sodium acetic acid, on the soil.

The acidity formed by this hydrogen is called ***hydrolytic***. Based on its value, the exact dose of lime per hectare is calculated. To neutralize 1 milligram of hydrogen acidity in 100 grams of soil, 1.5 tons of lime are needed per hectare (each milligram of hydrogen requires 500 milligrams of lime for its neutralization; the weight of a 20-centimeter layer of soil on 1 hectare is about 3,000 tons). So, if the hydrolytic acidity is equal to 4 m.-eq., the full dose of lime will be 4x1.5 = 6.0 t/ha.

Doses of lime for clayey and loamy soils are always higher than those for sandy and loamy-sandy soils, which contain very few colloids and silty particles, due to which their absorbing complex has a small capacity: compared to clayey and loamy soils it contains many times less absorbed bases and hydrogen.

Podzolic soils are characterized by hydrolytic, exchangeable and active acidity, that is, the soil solution of these soils has an acidic reaction.

Some chornozems (podzolized soils) have neither active nor exchangeable acidity, but their absorbing complex, along with calcium and magnesium, has absorbed hydrogen, which determines their hydrolytic acidity. Phosphorite flour (fertilizer mineral) dissolves well on such chornozems. Its effect on the crop is similar to that of superphosphate. Soils with a lot of absorbed sodium in the absorbing complex have an alkaline reaction. Their fertility is low.

1.1.10 Soil structure and its significance

Any soil consists of particles – sand, dust, silt and colloids. These particles are not separated in the soil, but glued together in lumps that are difficult to distinguish with the naked eye. These lumps with a diameter of less than 0.25 millimeters are referred to the microstructure (fine structure) group. Lumps having a diameter from 0.25 to 10 millimeters belong to the macrostructure (large structure) group. The best soil structure that provides favorable plant properties is granular or lumpy. It is characteristic of clayey and loamy chornozems, which contain a large amount of calcium and magnesium salts in the parent material. The diameter of most structural lumps of these soils is 3-5 millimeters. They are not affected by rain for a long time and do not form crusts on the surface. Such a structure is called strong, in contrast to the weak structure of podzolic soils, the lumps of which are easily destroyed by rain.

Science has proven that the formation of the structure is closely related to the properties of soil colloids, in particular, organic colloids that are part of humus.

Colloid particles carry a positive or negative charge, therefore, some of them belong to positive and others to negative colloids. When colloids of the same group (two positive or two negative) meet in aqueous solutions, they repel each other. If different colloids collide, they are attracted to each other and fall out of the solution in the form of a precipitate. In a separate state, colloids are called sols (sol), and the precipitate formed as a result of colloids' combination is called gel. The precipitated gel loses its electric charge and becomes neutral.

Mutual coagulation of colloids with opposite charge occurs rarely, because most soil colloids have a negative charge. Therefore, in the soil, colloids coagulate more often if various salts and acids dissolved in soil moisture act on them. Salts and acids are able to coagulate colloids very actively and form a lot of gel in the soil. Gel precipitations glue particles of silt and dust into microscopic lumps, creating a microstructure. As mentioned above, organic colloids of humus have special stickiness.

However, the resulting gels can easily turn back into salts. At the same time, structural lumps are easily washed away with water. This occurs when colloids are coagulated by acids or salts such as sodium chloride and potassium chloride. Strong structural lumps are formed when the coagulation of colloids occurs under the influence of calcium and magnesium salts. The strength of the coagulating cation depends on its valency and the atomic mass of the chemical element. Monovalent cations (Na, K, NH4) are weak coagulants. An exception is the coagulating monovalent hydrogen cation, the effect of which is similar to that of divalent cations (Ca and Mg). However, the gels obtained under the influence of the hydrogen cation are very weak.

Anions of salts and acids can cause coagulation of colloids carrying a positive electric charge. However, there are usually very few positively charged colloids in the soil, so the role of anions in coagulation is insignificant.

A special place is occupied by the hydroxyl anion (OH), which prevents the coagulation of colloids. It causes the process of reverse coagulation (decoagulation), i.e. it helps to transform gels into sols. As a result, the soil loses its structure, compacts and deteriorates its water, air and thermal properties.

That is why in soils whose parent materials contain a lot of lime, colloids ensure strong gels that do not dissolve in water, and the structure of these soils is strong. The same soils, whose parent materials contain a lot of sodium salts (table salt, soda), do not form a strong structure. They include solonchaks and solonetzs.

The coarse soil structure (macrostructure) occurs mainly with the participation of perennial and annual herbaceous vegetation. Grasses develop a dense network of roots that penetrate the soil in all directions. They push and compress soil particles. There are especially many roots in the upper layers, where there are the most nutrients. When the roots die and are decomposed by microorganisms, humus rich in organic colloids is formed. Thus, year after year, the number of cracks and root paths in the soil increases, humus reserves rise, coagulation and structure formation are strengthened.

During cultivation, such soil breaks up into larger lumps (3-5 mm), and acquire a dark or gray color, depending on the amount of humus contained in it.

It should be noted that this soil structure is formed only on loamy and clay soils, where there are many silty and colloidal particles of mineral origin. There are few such particles in sandy soil, and therefore only microstructural lumps can form in it in a very small amount. These soils are called structureless.

Leguminous types of grass – clover, alfalfa, safflower and others, whose roots penetrate deep into the subsoil layers, absorbing a lot of calcium – play a significant role in structure formation. As a result, after the death of roots and the formation of organic colloids, the coagulation of the latter occurs under the influence of calcium salts. Gels are formed in the soil, which do not turn into sols under the action of water, which contributes to the formation of a strong soil structure. In addition, leguminous types of grass enrich the soil with nitrogen.

A lumpy or granular soil structure is of great industrial importance. Structural soils are looser and easier to cultivate. These soils contain more water and air, and have an even temperature regime without jumps. All this creates favorable conditions for the functioning of microorganisms, which ensure a constant supply of necessary nutrients to living plants.

To improve the properties of soils with a weak structure, it is necessary to increase humus reserves in them. Application of organic and mineral fertilizers, sowing of clover, alfalfa, lupine and other leguminous crops, liming of acidic soils, proper tillage are the main ways to improve the soil structure and increase its strength.

1.1.11 Soil moisture and yield

Water is necessary for a plant throughout its life. The seed contains a small amount of it (10-15%), so all life processes in it proceed very slowly. At a humidity of 10-15%, the grain does not germinate, and only with an increase in its moisture content and a rise in temperature it swells and begins to germinate. A sprout appears, the green substance chlorophyll is formed in the leaves under the influence of light and heat, the plant begins to demand more and more water and nutrients every hour.

Different plants consume different amounts of moisture during their lifetime. For example, millet, corn, and potatoes use no more than 500 kilograms of dry matter to produce one kilogram of dry matter, while wheat, flax, beets, and other crops use twice and sometimes three times more.

Each plant has a so-called critical period of life in relation to the presence of moisture in the soil. In cereals, for example, this period coincides with tillering and earing. In corn, it begins 10 days before the panicle appears out and lasts for 20 or more days.

Grain crops lose 2,000-3,000 tons of water to produce an average crop yield, but no more than 0.2% of this amount is used to form the mass of plants, the rest is evaporated by the leaves.

Stopping the access of water to the leaves, even for a short period of time, causes significant damage to the plant. Prolonged drought reduces the yield, and sometimes leads to the complete death of plants. In order to obtain a high yield, it is necessary to increase the reserves of moisture in the soil and to prevent unproductive evaporation.

Water consumption does not depend on the type and variety of the plant or air temperature. It is based on the amount of easily soluble nutrients in the soil. The more of them, the less the plant spends water on evaporation. Thus, on well-fertilized fields, plants use it more sparingly.

Any soil has pores into which atmospheric air containing water vapor penetrates. When the soil air cools, this vapor-like moisture turns into a droplet-liquid state, water droplets form the so-called intrasoil dew. This water can be absorbed by plant roots, but its reserves are insignificant.

Vapor-like water moves from top to bottom in the summer, and from the lower to the upper layers in the winter, that is, from warmer to colder layers. Its molecules settle on the surface of soil particles. This soil moisture is called hygroscopic. The more silty particles and humus in the soil, the more hygroscopic moisture it contains (Fig. 6).

The maximum hygroscopicity of the soil corresponds to such a state of its humidity, at which it absorbs the largest amount of water from air saturated with vapors. Hygroscopic moisture with a huge force (several thousand atmospheres) is contained on the surface of solid particles and can be separated only by long-term drying at a temperature of 105-110°C. Hygroscopic moisture is inaccessible to plant roots. Sands (0.5%), light loamy soils (3%), heavy loams (6.5), loamy chornozems (8%) have the lowest maximum hygroscopicity, peat soils (more than 18%) have the highest one.

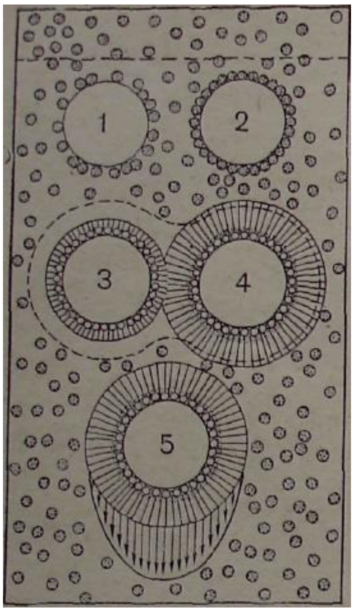


Fig. 6. Forms of soil moisture (according to S.I. Lebedev):

1 - incomplete hygroscopic moisture around the soil particle; 2 - full hygroscopic moisture; 3 and 4 - film moisture; 5 - gravity moisture. Small circles - vaporous moisture.

Plants begin to wither even before the water supply in the soil decreases to hygroscopic humidity. Research has established that most cultivated plants wither at a soil moisture level equal to 1.5 times the amount of maximum hygroscopicity. If the hygroscopic humidity is equal to 2%, wilting of plants begins in the soil at 3% humidity. This amount of water in the soil is called dead stock. In clay soils, the dead moisture reserve is 10-15% of the soil mass, while in sandy soils this indicator is 1-2%. Thus, at the same humidity, for example 20%, in sandy soils there will be 18-19% of useful moisture, and in clay soils - only 5-10%.

In addition to hygroscopic moisture, the soil contains film moisture. During precipitation, a water film of several layers of water can be formed around soil particles. This is film water. The soil also holds it with great force, and therefore, like hygroscopic water, it is unavailable to plants. Film water can move from soil particles with a thick film of water to soil particles with a thin film of water. They can attract a layer of water in the form of a film of a certain thickness, as far as surface tension forces allow. Excess moisture, not attracted to the soil particles, forms the so-called capillary moisture, which moves in the same way as internal soil dew obtained from the cooling of vaporous moisture along thin (no more than 0.1 millimeters) gaps between soil particles.

Through such gaps, water moves from wetter to drier layers. The more intense the evaporation from the soil surface, the more moisture is supplied through the capillaries from the lower, wetter layers and, therefore, the faster and to a greater depth the soil layer can dry.

In any soil, along with the capillary spaces between the soil particles, there are wide, large spaces that can be occupied by water if all the capillaries are already filled with it. This water is called gravitational water. It moves down under the influence of gravity. On sandy soils, where the spaces between the particles are particularly large, it can penetrate into deep layers.

Capillary and gravitational water is the main source of moisture for plants, as only these types of water can be used by plant roots and microorganisms.

Gravitational moisture penetrating into the deep layers of the soil can be retained by dense layers of clay and other rocks. This is how groundwater is formed, which sometimes rises through capillaries into the upper layers.

The soil has the property of passing precipitation from the upper layers to the lower ones. This property is called **water permeability**. The more gravel and sand particles in the soil, the better its water permeability. Conversely, the more dust and silt particles the soil contains, the finer the spaces between these particles, the more friction the water overcomes during its movement and the harder it is for it to move down. When the soil is dense, the movement of water stops. That is why sandy soils have high water permeability while clay soils feature low one.

Soil structure is also of great importance for its water permeability. Black soils with a granular or lumpy structure that does not damaged by water are more permeable than structureless, disintegrated and denser soils.

Solonetz soils also have poor water permeability. Under the influence of precipitation they form a dense mass that does not allow water to pass through.

A good soil should not only have high water permeability, but also absorb and retain a significant amount of moisture. Only in this case, a significant supply of water is created in the soil during precipitation or snow melting. This ability is called **moisture capacity**. The more silty particles and humus the soil contains, the higher its moisture content and, conversely, the more sand it contains, the lower its moisture content. Peat soils, which contain a large amount of organic substances, have the highest moisture capacity.

If the soil is saturated with water as much as possible that is all the pores (non-capillary and capillary) are filled, one, having taken into account the absorbed water, can determine the full or **maximum moisture capacity** of the soil.

Soil moisture, at which only its capillary spaces are filled with water, is called **capillary moisture capacity**.

Soil moisture equal to 50-60% of its full moisture capacity is considered the best for most cultivated plants. In this case, 50-60% of soil pores will be filled with water, and the rest - with air.

Capillarity is the ability of the soil to lift water through the thin spaces between the soil particles (capillaries) from the lower, wetter layers to the upper, drier ones. This property of the soil is of great importance in the life of plants. During a drought, for example, water from the moist lower horizons (ground water) can rise and moisten the dry upper layer of the soil. The height at which the water rises depends on the capillary size. In sandy soils, which contain a significant number of large particles with wide non-capillary spaces between them, water rises faster than in clay or loamy soils with narrow spaces, but to a small height (30-60 centimeters). Capillary rise of water in the loamy soil can reach 3-4 meters or more. However, the more silty particles the soil contains, the slower the rise of moisture through the capillaries. If highly compacted, clay soils containing little humus and lime may have a moist layer at a certain depth, but its moisture is transferred so slowly to the upper dry layers of the soil that plants practically do not use it.

The power with which water rises also depends on soil structure. The soil with a broken structure, which contains a significant amount of dust, will lift water higher, but more slowly. Therefore, it is important to have a good lumpy structure in the upper part of the soil. The denser lower layers of the soil will transfer water through capillaries to the upper loose layer, which has wide gaps between the structural lumps. Water cannot rise high through them, due to which its evaporation from the soil is insignificant. When the structural top layer is compacted with rollers, the lumps are brought together and the gaps between them are reduced. In this case, the capillary rise of water increases, it reaches the upper layers of the soil. Therefore, in those cases when the upper layers of the soil dry out a lot before or after sowing, it is rolled, which contributes to raising moisture from the lower layers to the seeds and obtaining good sprouts.

During heavy rains, a dense crust with high capillarity can form even on soils with a strong structure (chornozems). Because of it, water can evaporate in a significant amount through the capillaries. To prevent soil from drying out, it is necessary to destroy the crust, creating a lumpy layer on the soil surface. This layer will have non-capillary (wide) gaps not allowing water to rise high.

The **terrain (topography)** affects the amount of evaporation. Greater evaporation is characteristic of the undulating topography of the area. Dry wind carries away more water than that saturated with it. Soil covered with a layer of peat, manure, leaves and other organic residues evaporates less water. A huge amount of it is used by weeds.

1.1.12 Soil air

No matter how tightly the mechanical soil particles (sand, dust, silt, etc.) are packed, pores or gaps filled with air and water always remain between them. The total number of all these pores in a certain volume of soil is called **soil porosity**. The more silty and colloidal particles the soil contains, the higher its overall porosity. In any soil there are large pores (between large mineral particles of soil and structural lumps) and small ones (between small particles and inside structural lumps).

Small pores make up capillary porosity, large pores are characteristic of non-capillary one. Together they form the overall porosity. In structural soils, it makes up 50-70% of the soil volume.

Non-capillary porosity is especially large in structural soils. The more structured the soil, the more large pores or pores between structural lumps it contains. Any soil loosening contributes to an increase in non-capillary porosity and, conversely, its compaction increases its capillary porosity.

The most favorable conditions are created for plants and microorganisms when the non-capillary porosity in the soil is more than half of the total. In this case, air penetrates into the soil mainly through wide pores, while the capillary spaces are almost always filled with water.

With a lack of air in the soil, the development of plant roots is inhibited due to a lack of oxygen. In addition, the aerobic decomposition of organic substances stops and the content of available mineral substances in the soil decreases sharply.

In sandy soils, there is a lot of air, which penetrates to a considerable depth. However, they have little water, so only due to frequent precipitation a favorable ratio between water and air can be created and aerobic microorganisms can vigorously decompose organic substances. During the dry season, there is an excess of air and little water in the sandy soil; soil life freezes, plant roots are suppressed due to the presence of strong salt solutions or due to lack of water and nutrients.

The best air and water regimes are created in sandy, loamy soils and especially in loamy and clayey chornozems with a good structure. There is a lot of air between the large structural lumps. Heated warm soil air, rich in carbon dioxide and with little oxygen content, is exchanged for dense cold atmospheric air, rich in oxygen. This phenomenon is called **soil gas exchange**.

Dense structureless soils dry out to a greater depth during a drought. At this time, the capillaries are filled with air, which prevents the penetration of precipitation into the deep layers of the soil. The ratio between water and air in dense disintegrated soils is of great importance. If there is water in the capillaries, it does not let air into the soil; and vice versa, the air contained in the capillaries prevents the penetration of water into the soil.

This phenomenon is not characteristic of soils with a strong lumpy structure, where there are wide, non-capillary spaces between the structural lumps with larger reserves of air. Inside the structural lumps between the soil particles, there are many capillary pores filled with water.

To improve gas exchange in structureless podzolic clay or loamy soils, it is necessary to loosen the soil more often to prevent the formation of a soil crust on the surface, as well as apply organic fertilizers and liming methods to acidic soils more often.

Wetlands have excess water and an insufficient amount of air, which contributes to the development of the anaerobic process of organic substance decomposition. Cultivated plants on such soils experience a lack of oxygen and nutrients. Therefore, in order to increase the fertility of marshy and swampy soils, first and foremost it is necessary to drain them and to lime acidic soils in order to create favorable conditions for aerobic microorganisms' functioning.

1.1.13 Soil heat

Plants and microorganisms can develop well only under the conditions of certain soil temperature. Different soils have different ability to heat up and cool down, that is, they have different temperature regime.

The absorption of solar heat depends on the soil color. Light podzolic soils absorb less heat than dark ones (dark gray, black). So, the more humus the soil contains, the more heat it absorbs. Soil fertilized with manure will be warmer than that unfertilized, chornozem will be warmer than podzolic soil, which has a whitish-gray color. The southern slopes of fields warm up better than the northern ones.

The degree of soil heating also depends on its moisture content. The more water the soil contains, the slower it warms up. This is explained by the fact that water has a large heat capacity. As a result, although overmoistened (clay) soils absorb a lot of heat during the day, but their temperature rises slowly. At night, the soil gives off a lot of absorbed heat and cools down a lot. Such soils are classified as cold.

Sandy soils contain little moisture. They can get very hot during the day. Too high temperature suppresses plants, especially sprouts and young fragile crops, which cannot withstand a high concentration of salts in the soil solution and tissue overheating with a lack of water in the cells.

Structural soils rich in humus, especially chornozems, have the best thermal regimes. Thanks to the dark color, they absorb a lot of heat, they cool down more slowly at night, because there is a lot of air between the structural lumps, which does not conduct heat well. Plants and soil microorganisms develop poorly under sharp temperature fluctuations.

Soils covered with a thick layer of snow freeze to a lesser depth. This is explained by the weak thermal conductivity of snow, which contains a lot of air. Temperature fluctuations are insignificant under the snow cover. Detention of snow in the fields in the winter helps to preserve winter crops from freezing, in addition, in arid areas, it increases the moisture reserves in the soil.

Regulation of soil heat is necessary for creating the best living conditions for plants and microorganisms. The seeds of many cultivated plants germinate at low temperatures (clover, alfalfa – at +1°C, wheat – at +3°C, sugar beet – at +4°-5°C). But with growth and development, their need for heat increases. Most plants and microorganisms develop better at a soil temperature of +20 - + 25°C. High and low temperatures reduce the activity of many microorganisms and impair the growth and development of plants.

The amount of light and heat reaching the earth depends on the geographical latitude of the area and the number of sunny days.

In order to create a favorable thermal regime in the soil, snow retention is carried out, intercrops are sown for protecting heat-loving vegetable crops from cold winds, excessively wet soils are drained, and the soil is enriched with organic substances. Sowing on excessively moistened heavy soils is carried out on ridges, the soil crust is destroyed on the crops, and the soils covered with physical crusts in the interrows are more often loosened. A very important measure is mulching which implies covering the soil surface with humus, peat, and compost. It creates a dark top layer that warms up better. In the northern regions, the rows of crops must be directed from north to south, in the southern regions, it is not recommended to create a wavy soil surface, because it dries out and overheats.

1.1.14 Mineral nutrition of plants

Soil is an environment from which a plant absorbs various nutrients in the form of mineral salts dissolved in water. From the soil, the plant mainly absorbs easily soluble salts of nitrogen, phosphorus, potassium, calcium, magnesium, sulfur and iron, as well as trace elements needed in very small doses. These include boron, manganese, copper, molybdenum, zinc, cobalt and others.

Most soils often lack nitrogen, phosphorus and potassium.

Each nutrient plays a specific role in the plant development. Hence, their importance for obtaining a stable harvest is not the same.

Nitrogen is part of proteins, amino acids and other compounds which are components of the protoplasm of plant cells and microorganisms. Without nitrogen there is no protein, without protein there is no life. The air contains significant reserves of this element (4/5 by volume), but of such a huge amount, only a small part enters the soil together with rain in the form of nitrous and nitric acids. The main suppliers of nitrogen are microorganisms contained in the soil and leguminous plants.

The insufficient amount of nitrogen has the following consequences: plant leaves acquire a yellow-green color, plant stems become thin, and the protein content in the crop decreases. The main reserves of nitrogen are in soil organic matter, therefore the soils containing a small amount of it are poor in nitrogen.

Phosphorus is part of the cell nucleus in the form of complex proteins – nucleoproteins, phytin and others. The largest amount of phosphorus is found in plant fruit. If it is insufficient, the growth and development of young plants ares delayed, and small grains with poor hereditary qualities are obtained. The phosphorus content in the soil is usually low. However, it is higher in those types of soil which contain more silty particles and humus.

Potassium is of great importance for the accumulation and movement of carbohydrates (starch, sugars) in plants. It increases the resistance of crops against damage and diseases. There is more potassium in stems and leaves of plants. In case of its deficiency, the lower leaves begin to turn yellow from the tips, then turn brown and die. At the same time, little starch accumulates in potato tubers, and sugar in sugar beet roots. Sandy and marshy soils (peatlands) contain little potassium. In strongly podzolic acidic soils, calcium and magnesium contents are sometimes very low.

Calcium neutralizes the action of some harmful organic compounds, eliminates excess hydrogen, iron, manganese, and aluminum in plants.

Magnesium is part of chlorophyll (the green pigment in leaves) and takes part in carbon assimilation by plants.

Iron is necessary for the formation of chlorophyll in plant leaves and for respiration (it is part of respiratory enzymes).

Sulfur is contained in proteins. Cabbage, rutabaga, mustard and other brassica have an increased need for this element.

Such microelement as **boron** improves oxygen supply to plants, increases the activity of some enzymes, and plays a significant role in plant fertilization and fruiting. With a lack of boron, the growth points of plants die off, weak flowering and flower falling are observed. In flax, for example, stem tops dry out (flax bacteriosis), in beets and rutabagas, the young inner leaves turn black and rot (black rot).

Manganese takes part in the oxidation of ferrous iron into ferric iron, it is also part of enzymes.

Other microelements necessary for the life of plants are **molybdenum, copper, zinc,** and **cobalt**.

It has been established that it takes ammonia nitrogen 10-15 minutes to transform in the roots of plants into amino acids, which move to above-ground organs and are necessary for the creation of proteins in the plant.

With the help of labeled atoms, it has established that phosphorus from superphosphate is very quickly absorbed and moves inside the plant.

When the oat root comes into contact with a superphosphate grain, labeled phosphorus is detected in the leaves after 20 minutes.

It has been found that it is more expedient to apply superphosphate in small doses together with the seeds in the rows, because in the initial period of development, the weak root system of plants better assimilates phosphorus from easily soluble salts. The strengthened root will easily absorb phosphorus from the soil reserves in the future.

Experiments with the potassium isotope have shown that potassium salts are very strongly absorbed by soil colloids, therefore it is advisable to apply most of the potassium fertilizers to the deep layers of the soil (especially in arid areas).

Clover gives a high yield on acidic soils in those cases when lime is applied near the seeds, because the young roots of this crop are particularly sensitive to soil acidity. Having strengthened, they tolerate a higher acidity of the soil solution.

Along with easily soluble salts, the soil contains nutrients in insoluble form in the form of various mineral and organic compounds.

The plant is able to use nutrients even from insoluble mineral compounds, because its root secretes substances whose action approximates the action of a 1-2 percent acetic acid solution. Acidic secretions of the roots turn many water-insoluble compounds into solution.

Through the use of radioactive phosphorus, the possibility of plants' assimilating phosphorus in a small amount from organic - phosphorus-containing compounds (sugar phosphates, glycerophosphates) has been proven.

Plants develop a huge root system. It is necessary for them to absorb nutrients by the roots at a very low concentration of solutions.

In ordinary non-saline soils, the solt concentration is low, that is, only tenths of a gram of soluble substances are contained in a liter of solution. If a liter of solution contains 3-5 grams of salts, cultivated plants cannot develop on such soil – they die because of the strong solution concentration.

Soda (sodium carbonate) (Na2CO3) and table salt (NaCl) are especially harmful to cultivated plants. These substences, along with the harmful effect on the plant roots, reduce the strength of the soil structural formations and contribute to its compaction.

Thus, the growth and development of plants are closely related to the composition and properties of the solution found among the solid particles of the soil. These are usually easily soluble salts of nitrogen, phosphorus, potassium, calcium, sodium, as well as chloride, sulfuric acid and other salts. In addition, this solution contains soil colloids, humic acids and their salts, amino acids, alcohols, ethers and many other compounds.

In the northern regions, with a large amount of precipitation, the soil solution of most soils has an acidic reaction, because these soils are highly leached and contain little absorbed calcium and magnesium. In the zone of gray forest soils, it has a slightly acidic reaction in the upper layer and a neutral (and sometimes slightly alkaline) reaction at a considerable depth in the calcareous horizon.

In the soils of the steppe and forest-steppe zones with poor precipitations, where moisture evaporation is almost equal to their amount, the solution reaction in the upper layers is slightly acidic, neutral or slightly alkaline; in the lower layers, the alkalinity of the solution increases.

To increase soil fertility, it is necessary to correctly regulate the composition of the soil solution and its reaction. This is achieved by using different fertilizers taking into account the properties of the soil. For example, it is better to apply alkaline or neutral fertilizers – phosphorite flour, slag, urea and others – to soils with strong acidity. Acidic fertilizers can increase the acidity of the soil solution and the effect of their application will be insignificant. It is also effective to lime such soils and fertilize them with manure, compost and other organic fertilizers. Acidic fertilizers (superphosphate, ammonium sulfate, and others) work better on soils featuring an alkaline reaction of the soil solution.

When treating acidic soils with ammonium sulfate, which increases soil acidity, it is necessary to add 1.3 centners of ground limestone per 1 fertilizer centner.

Appropriate soil tests performed in the laboratory allow for estimating whether plants are provided with sufficient nitrogen, phosphorus and potassium. With the help of these tests it is possible to determine the amount of nitrogen available to plants in 100 grams of soil. If it is less than 4 milligrams, the soil is very poor in this nutrient; the content of more than 6 milligrams (for vegetable crops, more than 12 milligrams) gives grounds to state that the soil is well supplied with this element.

The need for phosphoric fertilizers can be determined based on the test results. The soil containing less than 8 milligrams of available phosphorus in 100 grams is considered poorly supplied with phosphorus salts. If the content of available phosphorus is more than 15 milligrams (for vegetables more than 30 milligrams) in 100 grams of soil, it shows that the soil is sufficiently supplied with this nutrient.

The low availability of potassium salts in the soil is indicated by its less than 7-milligram content in 100 grams of soil (for vegetable crops, less than 15 milligrams).

More than 10 milligrams of potassium (for vegetable crops - more than 20 milligrams) in 100 grams of soil evidence its high availability in the soil.

Usually, when the soil contains high doses of nutrients, fertilizers are not applied to it and farmers only sometimes have to feed plants. For the correct use of fertilizers in each field, it is necessary to regularly conduct soil tests for the content of available nutrients in it.

1.1.15 Stocks of nutrients in different soils

Polissia. The main soil types of the zone are sod-podzolic, gray and dark-gray forest soils. They feature an acidic reaction of the soil solution and a low nutrient availability. The humus content in the arable layer is 1-2%, and its reserves in the 0-100 cm layer are 100-200 t/ha.

Arable land is mainly represented by soils with a low content of nutrients, which primarily concerns mobile forms of nitrogen, phosphorus and potassium. To obtain high yields of agricultural crops, it is necessary to apply mineral and organic fertilizers and to lime acidic soils.

Forest steppe. Deep humus soils with good natural fertility prevail here. Typical chornozems occupy more than 50%, and podzolic soils occupy about 40% of arable land. Humus reserves in a meter-long layer of typical chornozem podzolized soil and dark gray soil 500-600 t/ha, 400-450 t/ha, and 300-400 t/ha respectively.

In general, forest steppe soils have a neutral and slightly acidic reaction of the soil solution, an average level of availability of phosphorus and potassium, and a fairly high effective fertility.

Steppe. The main soils of the zone are ordinary chornozems, southern and dark-chestnut saline soils. They have a neutral or slightly alkaline reaction. Humus reserves in a meter layer in ordinary chornozems amount to 330-600 t/ha, in southern chornozems – to 300-400 t/ha and in dark chestnut soils – to 250-300 t/ha.

As a rule, most of them have a high potential level of fertility, but the arid climate quite often does not contribute to the maximum use of agrochemical factors for obtaining stable and high yields of agricultural crops.

Thus, as a whole the arable lands of Ukraine are characterized by a low level of nutrient reserves in the soils of the Polissia zone. It gradually increases in the northwest to southeast direction, moving from the average level in the Forest Steppe zone to the high potassium one in the Steppe zone.

The nutrient content of the soil accurately characterizes the degree of their cultivation however, it does not yet provide evidence of how fertility will change in the future. The answer to this question can be obtained with the help of calculating the balance of nutrients in farming.

1.1.16 Characteristics of the main types of soils

Plants need light, heat, air, water and nutrients throughout their life to produce high yields. The main factors related to soil are water and nutrients.

The ability of the soil to provide the plant with the required amount of water and nutrients is called **fertility**.

Natural and artificial soil fertility are distinguished. The first one depends on the conditions of soil formation and is determined by the total supply of nutrients and other plant life conditions. Natural soil fertility is characteristic only for virgin soils that have not been subjected to human influence.

Artificial fertility is the result of human activity, its impact on the soil under the conditions of agricultural crop growing. Currently, there are few virgin lands, and the fertility of cultivated soils is significantly different from that of virgin lands.

When using soil, people often talk about effective fertility, which is determined by the yield indicator and depends on the natural and artificial fertility of the soil. If the soil is processed correctly, it accumulates more easily soluble nutrients than the one that was processed incorrectly. In the first case, effective soil fertility will be better, and the yield will be higher. Effective soil fertility depends on technical progress in agriculture.

The task of agricultural production is to create high effective fertility on any soil and to ensure its growth. All measures related to increasing effective soil fertility should create the most favorable conditions for the development of cultivated plants.

Soils with extremely different properties are formed on the earth’s surface. This variety depends on soil-forming rocks, climate, flora and fauna, and topography.

Soils are formed on different **parent rocks** (parent materials), which differ from each other in mechanical and chemical composition. Soils formed on sandy rocks are poorer in nutrients than those formed on clayey and loamy rocks. Compared to carbonate-free (acidic) parent rocks, parent (loamy or clayey) rocks containing a lot of calcium carbonate and magnesium salts (carbonate rocks) feature richer soil formation. Saline soils with low fertility are formed on parent rocks containing a lot of sulfuric acid and chloride salts. Thus, the composition and properties of the parent rock significantly affect soil fertility.

Climate greatly affects the soil-forming process. The nature of vegetation, and therefore the quality and amount of humus, depends on the amount of precipitation, air temperature, wind, water evaporation from the soil. The migration of salts in the soil, which are either leached into the groundwater or rise with the groundwater to the upper layers of the soil, causing their salinization, is related to the precipitations and the degree of evaporation.

The most important factor in soil formation is **plant and animal life**. Thus, annual and perennial grasses differ from woody vegetation in a particularly branched root system that lies in the upper layers of the soil. Part of these roots die off, annually replenishing humus reserves in the soil, as a result of which its structure improves, which increases the reserves of water and nutrients. Perennial woody vegetation absorbs water and nutrients from deep layers of parent material. Every year, a small part of roots, branches, needles (or leaves) of the trees die. Naturally, such vegetation cannot accumulate a lot of humus. Therefore, the soils which used to have woody vegetation are less fertile than those on which grasses have grown for a long time. The development of a significant amount of moss on the soil contributes to its waterlogging.

Microorganisms take part in the destruction of complex organic compounds to simple mineral salts. They also contribute to the formation and accumulation of humus in the soil, the amount of which depends on soil fertility.

Terrain (topography) also affects the course of soil formation. For example, soil moisture is lower in elevated areas, and groundwater can lie deeper than in lower areas of the terrain, where waterlogging is often observed due to its proximity. Slope exposure and steepness affect the humidity and thermal regime of the soil. For instance, the southern and southwestern slopes warm up better. On steep slopes, small soil particles are washed away more intensively, which leads to deterioration of soil fertility.

The soils of trenches, small elevations and holes on the field surface have a different water, air and thermal regime than those located on other topography element, therefore, they feature a different fertility.

All these factors of soil formation act simultaneously and affect each other. Any soil changes over time, acquiring new properties and qualities. Soils of one type under the influence of the specified conditions may subsequently turn into soils of another type. For instance, with an increase in precipitation and a decrease in temperature, chornozems can turn into forest-steppe gray soils, and then into podzolic soils, and, conversely, with an increase in heat and a decrease in the amount of precipitation and subsequent development of meadow and steppe grasses on the soil, over time, podzolic soils primarily those located on loamy parent material, rich in lime, can become chornozems.

However, along with natural factors, a significant role in changing the soil-forming process currently belongs to man, his production activity, which can be positive or negative.

Proper tillage, using mineral and organic fertilizers, liming of acidic soils, applying gypsum to saline soils, drainage, irrigation and other measures improve the natural properties of soils.

As a result of the combined effect of soil formation factors over many centuries, the parent rock has changed its appearance and properties. If you dig a deep vertical section, you can see different soil layers, or horizons. In some soils, these layers stand out quite clearly, in others - they are hardly noticeable.

Soils have horizons marked by Latin letters. On the top there is the humus horizon A (H), which contains more organic substances and has a darker color. In chornozems, this horizon has a dark, almost black color, in chestnut soils it is brown, in forest-steppe soils it is gray, in podzolic ones – light gray.

Below is the transitional illuvial horizon B (HP). It can be divided into subhorizons B1, B2, etc. In chornozem soils, the transition from horizon A to horizon B is so gradual that it is difficult to establish the border of the transition from one horizon to another.

Horizon C represents the parent rock, little changed by the soil-forming process.

Horizon D represents the underlying rock that has not been affected by the soil-forming process.

In the horizons of some soils, there are inclusions in the form of plant and animal remains, rock fragments, shell remains, calcareous deposits, veins, etc. In soils saturated with calcium and magnesium, this horizon often becomes calcareous under the influence of hydrochloric acid (chornozems, carbonate soils).

Soils are divided into types, subtypes, genera, kinds and varieties.

A type combines those soils that were formed in zonal natural conditions, have similarities in the soil-forming process, and are characterized mainly by the same properties. For instance, the main types of the Polissia soils are sod-podzolic, marshy, and gray forest soils. The Forest Steppe zone isrich in black soils, chestnut soils, gray soils, red soils, solonchaks, solonetzs, and alluvial soils. Within the same type, there may be soils that differ slightly in appearance and properties. Such soils belong to subtypes. For example, the following subtypes are encountered among the podzolic soils: gley-podzolic, podzolic, sod-podzolic, and others. However, there is an even greater variety of soils in nature, which is due to the variety of natural conditions in which the soil-forming process takes place. Thus, genera, kinds and varieties are distinguished among subtypes.

A genus reflects the soil profile nature, which is determined by the peculiarity of the soil-forming rocks. For instance, soils belonging to the podzolic type have the following genera of soils: normal, residual carbonate, incompletely formed, and others, as well as various kinds that differ in the degree of podzolization, the depth of the podzolized horizon, the content of humus in the upper layer, etc.

A variety indicates the mechanical composition of the soil (clayey, loamy, sandy, sandy-loamy, etc.).

When characterizing the soil, it is necessary to indicate to which type, subtype, genus, kind and variety this or that soil belongs. For example: ordinary strongly podzolic, light loamy soil on moraine heavy carbonate-free loam. The word “podzolic” indicates the type of soil, “ordinary” – the genus, “strongly podzolic” – the species, “light loamy” – the mechanical composition of the soil. However, the description of the soil will be incomplete if the rock underlies it is not indicated.

In the given example, the underlying rock of the upper soil layer is moraine (glacial) heavy loam, very poor in calcium and magnesium salts (non-carbonate rock).

Soil types on the globe are distributed in fairly regular bands (zones). Their arrangement was established by V.V. Dokuchaev.

In each zone, one or another type of soil prevails. However, there also can be found soils of another type, which are called intrazonal.

The following soil zones are located on the territory of Ukraine:

1. Polissia where podzolic and marsh soils prevail.

2. Forest-steppe where predominantly gray forest soils are found.

3. Steppe where ordinary and southern chornozems prevail.

4. Dry steppe, or the zone of dry steppes where predominantly dark chestnut and chestnut soils are found.

5. Soils of mountainous regions.

Sod-podzolic soils are found most often in areas of mixed forest plantations. In these forests, meadow and forest grasses settle in the meadows when the tree species change. They create sod (turf) and enrich the soil with humus.

Deep turf soils with a loamy mechanical composition have the best fertility. They have a fairly thick humus horizon (A1) (up to 20 centimeters), weak acidity (pH 5.5-6.5), because they contain from 2.5 to 4% humus and a significant amount of calcium and magnesium salts, as well as easily soluble nutrients. The podzolic horizon is weakly expressed in these soils.

However, the best soils in this zone are turf ones (turf meadow and turf-carbonate). They are formed on parent rocks rich in calcium and magnesium.

Fig. 7. Profile of sod-podzolic soil

These soils lie under mixed forests with moss-grass cover. The humus horizon of sod-saturated soils has a thickness of 8-15 centimeters and a humus content of 6-9%.

Turf-carbonate soils developing on the rocks which are richer in calcium and magnesium carbonates (limestones, dolomites, carbonate moraine, etc.) feature neutral reaction. They do not have a podzolic horizon, its reaction with acid (calcareous) can be detected even in the A1 horizon. Sod-carbonate typical soils contain a large amount of humus (from 5 to 22%). Sod-carbonate leached soils contain from 3 to 10% of humus. Sod-carbonate podzolized soils have minor signs of podzolization (lightening in the lower part of the humus horizon) and slightly acidic (pH 5.6-6.5) reaction of the soil solution. Calcareous reaction with acid is observed in the B horizon.

Turf soils have high fertility. Their structure is similar to that of dark gray soils of the forest-steppe zone, but it is stronger, because the absorbing complex is largely saturated with calcium and magnesium.

The given distribution also applies to virgin soils, because after plowing it can be difficult to establish the degree of development of sod and podzol formation processes.

For a long time, many soils have been under the influence of human activity, which has changed their natural properties. Depending on the level of effective fertility, sod-podzolic soils can be divided into three groups: cultivated, medium cultivated and poorly cultivated.

Cultivated soils have a powerful arable layer of more than 20 centimeters, they are characterized by a good lumpy strong structure, the podzolic horizon is either absent or extremely weakly expressed. These soils contain 2-3% humus, their acidity is low (pH 5.5-6.0 and more).

Medium-cultivated soils have a layer thickness of about 20 centimeters, they are characterized by a weaker structure, contain about 2% humus, and their acidity is higher (pH 5.0).

Poorly cultivated soils have the arable layer of less than 20 centimeters, a weak structure, a well defined podzolic horizon (A2), less than 2% of humus content, high acidity (pH 4.0-4.5). To increase the fertility of podzolic soils, it is necessary to apply a number of agrotechnical measures.

A significant role is played by organic fertilizers, which contribute to the accumulation of nutrients and humus in the soil, thanks to which the color of the soil changes, its thermal regime is improved, and microbiological activity is strengthened. The acids formed from the decomposition of organic substances contribute to better weathering of the mineral part of the soil, and difficult-to-dissolve nutrients are converted into forms available to the plant.

Organic colloids formed during the decomposition of organic fertilizers contribute to the formation of a strong structure, which improves the water, air and thermal regimes of the soil.

For sandy soils, organic fertilizers are of particular importance, because these soils contain very little nutrients, especially nitrogen.

Fertility of sandy soils can be improved by growing green manure crops (lupine, seradella, vetch) on them, the green mass of which is plowed. Lupine is especially valuable for improving the fertility of sands. It enriches the soil with nitrogen thanks to the bacteria living on its roots. Lupine not only improves the properties of the arable layer, enriching it with humus and lime, but also significantly cultivates the deep layers of the subsoil, because its roots penetrate into the subsoil layers to a depth of 3-4 meters. The hardpan layer penetrated by the lupine roots loosens, the oxygen which oxidizes the oxidizing compounds of this horizon moves deeply along the paths of its roots.

Podzolic soils with an acidic reaction of the soil solution should be limed. Lime and organic substances help reduce acidity, improve the microbiological activity of the soil and stimulate accumulation of nutrients in it.

Strongly podzolized soils are extremely poor in all nutrients, in particular, in nitrogen (as they contain little humus). In addition, sandy and loamy soils contain very little potassium. Application of mineral fertilizers to these soils increases their fertility to a great extent.

In addition to nitrogen, phosphorus and potassium fertilizers, many podzolic soils need trace elements - boron, manganese, cobalt, copper, molybdenum and others.

In the system of measures aimed at increasing the fertility of uncultivated sod-podzolic soils, an important technique is the gradual deepening of the plow layer during the fall tillage for spring crops.

Applying this technique requires attention and caution when treating those soils whose podzolic horizon (L2) is close to the surface. On such soils, the depth of plowing must be gradually increased in the fall due to the podzolic layer, while organic and mineral fertilizers, as well as liming, must be applied. Excessively moistened soils must be drained, because plants and microbes do not develop well due to a lack of oxygen in the soil.

Marsh soils occupy a significant part of the territory, and their placement is interzonal in nature. They develop in two ways: as a result of waterlogging of land (most swamps) and eutrophication of water bodies caused by increase in phytoplankton productivity.

Very often in nature there is waterlogging of the soil from groundwater, the exit of which to the surface is observed in lowlands, in river floodplains, at the foot of slopes and in other places.

Soils become waterlogged much more often as a result of precipitation. This is facilitated by the land topography and mechanical composition of the soil.

On the plains featuring absence of drainage, water accumulates on the surface, in particular, in those places where the soil and subsoil are clayey or loamy, which are characterized by low water permeability.

Excess surface water is usually observed in areas where its evaporation is much lower than the amount of precipitation that falls per year.

Soil waterlogging is facilitated by the formation of a dense, thick soil layer, which is almost waterproof; in podzolic soils, as well as the destruction of forests in areas with excess moisture.

There is little air in the soil containing excess water. As a result, an anaerobic process of decomposition of organic substances develops.

During this process, which procedes slowly, organic substances are not completely destroyed, and the nutrients and salts necessary for plants do not accumulate in the soil. On the contrary, many organic acids are formed, which inhibit the activity of aerobic bacteria and fungi.

As a result, a lot of coarse, undecomposed organic matter in the form of peat accumulates in the soil every year. Peat further retains water on the surface, preventing air from penetrating to the roots of plants.

Such conditions are unfavorable for sparse bushy meadow grasses such as timothy, festuca pratensis (meadow fescue), and dactylis (cocksfoot grass). They gradually die off, and their place is taken by dense grasses - nardus stricta (matgrass) and festuca ovina (sheep’s fescue). In these cereals, the tiller node lies above the soil surface (where there is a lot of air). In addition, their roots have mycorrhiza, which helps them absorb nutrients from hard-to-reach compounds. But they form hillocks, retain even more runoff of atmospheric water, increase snow accumulation, shade the soil and reduce evaporation. This creates an even greater excess of moisture and a lack of nutrients, which contributes to the displacement of dense grasses. They are replaced by swamp plants - sedges, bog mosses, shrub vegetation.

The growth of the peat mass is slow. For instance, a layer of peat with a thickness of no more than 2 meters can accumulate in a thousand years. There are peatlands with a peat thickness of more than 10 meters.

Any swamp soil consists of two horizons. Under the upper peat horizon, the mineral one lies. It contains a significant amount of non-oxidized products (ferrous iron, manganese, phosphorus and other compounds). They give the mineral horizon a peculiar grey-blue-green color. This horizon is referred to a gumbo one.

The peat layer of swamp soils in the lower part decomposes better and has a black color. The closer it is to the surface, the more brown-colored organic residues that have not decomposed it contains.

The processes of waterlogging of reservoirs and the formation of peatlands in their place begin with their eutrophication caused by increase in reeds, water lilies, algae and other plants.

At the bottom of eutrophic lakes, ponds, and river floodplains, layers of mineral silt mixed with the dead remains of living organisms (especially molluscs, algae) are deposited. **Sapropel deposits** are formed. In deep places, with a long process of the reservoir eutrophication, these deposits reach a thickness of several meters. The remains of vegetation that used to inhabit the shores of reservoirs are decomposed under the conditions of an anaerobic process, leaving an annual supply of organic substances that have not decomposed in the form of peat.

Sapropel contains many nutrients, therefore it is used as a fertilizer. It is especially valuable for sandy and loamy soils, because it contains a large amount of silt, which has a lot of organic colloids. Sapropels are rich in lime, consequently they reduce soil acidity.

Swamps and swampy soils are a significant reserve for obtaining high and stable crop yields. However, their disadvantage is excess soil moisture.

High cro yields can be obtained on drained swamps as a result of carrying out proper drainage operations and applying proper mineral fertilizers.

Most **peat-swamp soils** are poor in potassium and phosphorus. They contain a lot of nitrogen, however normal conditions for the decomposition of organic substances by microbes and providing plants with mineral nitrogen salts can only be created by proper drainage and cultivation techniques.

Peat-swamp soils often lack trace elements - boron, manganese, copper, molybdenum, and cobalt. Due to the lack of the copper, the development of flax, hemp, peas, root crops and other crops is significantly suppressed. With insufficient copper, the leaves and stems of grain crops turn yellow, the plants acquire high tillering rate, without forming ears. The lack of molybdenum strongly affects the development of leguminous crops (nodules do not develop on the roots of plants).

Despite the fact that marshy and swampy soils are rich in organic matter, the application of small doses of manure, feces, and various composts inhances the microbiological activity of these soils and increases the yield of all crops. These organic fertilizers are also of particular value because, in addition to the main nutrients, they contain all trace elements in the dose required for plants.

Many swamp soils have an acidic reaction (pH 4.3-4.5), so liming is an important measure in the development of such swamps. Such soils include swamp and peat soils.

If the ground or spring waters, with the participation of which the swamp soil was formed, brought with them a lot of calcium and magnesium, the organic matter of such swamps acquired a neutral or slightly alkaline reaction (pH 7.0 - 7.5). The peat of such bogs is a valuable fertilizer for acidic podzolic soils.

Soils of lowland swamps most often have a weakly acidic or neutral reaction and do not require liming. It is advisable to use acidic peat as bedding for livestock.

It is better to apply phosphorite flour on acidic swamp soils before liming, so that the acids in the peat displace part of the calcium from the phosphorite flour and convert the phosphorus compounds into an easily soluble form.

Soils of the forest-steppe zone

The soils of the forest-steppe zone occupy an intermediate position between chornozems and sod-podzolic soils. The forest-steppe has been inhabited by man since ancient times, because the climatic and soil conditions here are more favorable than in Polissia.

Until now, scientists argue about the conditions under which soil formation took place in the Forest Steppe zone. Some believe that the steppe vegetation displaced the forest from this zone, that is, that the steppe encroached on the forest, while the soils formed under the broad-leaved forests under the influence of the steppe vegetation turned into chornozems. Others are of the opinion that the forest in the forest-steppe displaced the steppe vegetation and penetrated into the zone of chornozems. Such regeneration of chornozems is called **degradation**.

The majority of scientists are inclined to the fact that both the penetration of the steppe into the forest zone and the penetration of the forest into the steppe zone are possible in this area.

However, in this zone, especially thanks to human activity, a significant amount of thickets and forest lands have been destroyed.

The forest-steppe zone stretches in a relatively narrow strip from west to east. The climate here is less humid. Forests and shrubs occupy a quarter of the territory. Birch, ash, maple, oak and other hardwoods grow in the forests.

The soils of the Forest Steppe zone were formed mainly on loess loams, which contain a significant amount of calcium and magnesium.

These soils have been under the influence of deciduous forests and meadow grasses for many centuries. Fallen leaves enriched the soil with calcium, magnesium, phosphorus, nitrogen, potassium and other nutrients, therefore podzol formation is weak in the forest-steppe conditions. When the forest underwent thinning, its place was occupied by meadow grasses – phleum (timothy), alopecurus (foxtail), thin leg, meadow-grass. They have many roots that penetrate the soil to a depth of up to 1 meter.

These grasses contribute to the accumulation of a significant amount of humus in both the upper and lower horizons, which enhances the formation of soil structure and promotes a significant supply of nutrients.

On non-carbonate rocks, woodlands lasted longer. Among the soils of the forest-steppe zone, there are still some small areas of sod-podzolic soils.

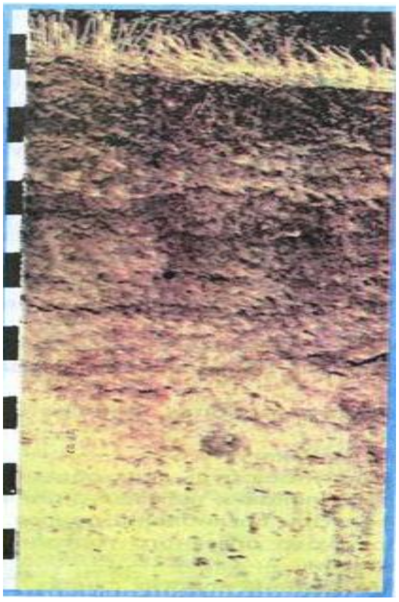


Fig. 8 Profile of gray podzolized soil

Typical for the forest-steppe zone are gray forest soils, which are divided into three subtypes: light gray, gray and dark gray, with varying degrees of podozilization.

Light gray forest soils are characterized by low fertility. They contain 1.5-3% humus, their humus horizon is not thick (15-25 centimeters), the soil solution reaction is acidic (pH 4.5-5.0).

Gray soils contain 3-5% humus, their arable layer is up to 25-40 centimeters.

Dark gray soils are better in terms of fertility. They are similar to chornozems. They contain more than 7-8% humus. The plow layer has a thickness of 40 to 60 centimeters. The soil solution reaction is slightly acidic, close to neutral.

In gray forest soils, instead of the podzolic layer, there is a gray lumpy layer consisting of structural lumps (granular-nut structure), on the edges of which siliceous powder is observed.

This indicates the traces of the podzolization process.

Currently, the forest-steppe area has a very undulating topography, it is crossed by arroyos and gullies. Arroy and gully soils are heavily washed away and their fertility is low. The best soils occupy even elevated places or floodplains.

The fertility of forest-steppe soils is much higher than that of sod-podzolic soils, but many forest-steppe soils are heavily washed, contain little humus, their structure is weak, the soil is easily washed away by rains, forming a crust.

Fig. 9. Profile of dark gray podzolized soil

These soils have a low content of humus, so organic fertilizers significantly increase their fertility. It is necessary to apply liming to acidic soils, especially to heavily washed ones. All types of soil of the Forest-

Steppe zone, in particular, those with a thin humus horizon, require carrying out fall plowing with soil deepening technique and simultaneous introduction of organic and mineral fertilizers, which is expected to give a high effect. Special attention should be paid to the accumulation of moisture in the soil, using snow retention and other measures, as well as to the prevention of water erosion.

Sowing a mixture of perennial grasses is of great importance in restoring the fertility of heavily eroded soils located on steep slopes. The roots of perennial grasses protect the soil from further erosion and enrich it with humus and nutrients.

Long-term liming of washed soils; plowing the fields, even those with a slight slope, across the slopes; planting forest, fruit and berry trees on the slopes; fertilizing the soil; as well as carrying out measures to accumulate and retain moisture in the soil contribute to increasing the fertility of the forest-steppe soils.

Black soils (chornozem**) of forest-steppe and steppe zones.**

Since ancient times, these soils have attracted the attention of the farmer who, when plowing virgin land in this zone in wet years, obtained high yields of the most valuable crop – wheat.

Many scientists were also interested in chornozem soils. They tried to unravel the mystery of the origin of these soils and study their properties.

M.V. Lomonosov was the first to make a correct statement about the origin of these soils.

The origin and properties of chornozem were deeply studied by V.V. Dokuchaev, who proved that chornozems had been formed under the cover of meadow and steppe vegetation on different parent rocks.

In this zone, the annual amount of precipitation ranges from 350 to 500 millimeters.

In the steppe zone, winters have little snow, and summers are hot and dry. In many places, evaporation of water per year exceeds the amount of precipitation. This is also facilitated by the uneven distribution of precipitation, due to the fact that most of it falls during the hot summer months. That is why the steppe zone belongs to the region of natural moisture. A significant supply of moisture can be found only in spring and early summer. During this period, various meadow and steppe grasses, most of which have a short growing season, grow especially well,. They ripen quickly and in the middle of summer, when there is very little moisture in the soil, they begin to die.

Black soils were formed on loess, loess-like loams and other rocks under the cover of perennial herbaceous vegetation. Over many millennia of development on the mother rock, the highly branched root system of various meadow and steppe grasses has changed it, enriching it with humus and nutrients.

The parent rocks of most chornozems contain a lot of calcium and magnesium salts. Their significant reserves contributed to the formation of a strong granular and lumpy structure in the humus layer with a prevalence of structural lumps having a diameter of 2 to 3 millimeters. There is a lot of air between these lumps. When precipitation falls in spring and summer, an aerobic process of decomposition of dead organic residues develops in the soil, as a result of which many mineral nutrients and humic acids accumulate, which form poorly soluble calcium and magnesium salts in the soil.

As a result of the annual dying of various meadow and steppe grasses, new humus deposits occurred. Thus, for thousands of years, chornozems were enriched with humus, accumulating nutrients for plants in a large layer of soil. In these soils, particularly favorable conditions were created for the life activity of various microbes, and this process subsides only during periods of severe drought, during soil overwetting in autumn and a sharp drop in temperature in winter.

The formation of chornozems was largely facilitated by the numerous earth-boring scarab beetles that inhabited the humus layer in the recent past, when the steppes were still in an unplowed state and only a small part of them was cultivated by farmers. Such virgin feather grass steppes, which were beautifully described by M.V. Hohol, can hardly be found now. Insignificant areas of the natural steppe have been preserved only in the Askania-Nova reserve. Black soils (chornozems) are characterized by the following features. They have a dark-colored, thick humus horizon with a significant (from 4 to 15% and higher) humus content. The transition from the upper horizon to the lower one is gradual. The soils are saturated with calcium and magnesium, they have a granular or fine-grained structure, a neutral or slightly acidic reaction. These soils are characterized by a high absorption capacity, they have favorable water, air and thermal properties, and a significant supply of easily soluble nutrients, in particular, nitrogen.

Chornozems are divided into several subtypes. The most common of them are podzolized and leached, typical (thick and with a high humus content), ordinary, southern, and Azov.

Podzolized and leached chornozems are sometimes combined into a group of northern black soils**.**. These soils occupy the wetter northern regions of the black soil zone and the southern regions of the Forest Steppe zone. Their structure is similar to that of dark gray soils of the Forest Steppe. In podzolized and leached black soils, their calcareous horizon created under the action of hydrochloric acid is observed only in deep layers, their absorbing complex contains a certain amount of absorbed hydrogen ion.

Fig. 10. Profile of podzolized chornozem

This soil type has a slightly acidic reaction of the soil solution and a weaker lumpy structure than ordinary black soils. The thickness of the humus horizon does not exceed 100 centimeters. Humus content is 4-6%.

Typical chornozems are located in the western regions of the forest-steppe zone. These are highly fertile soils. They have a thick humus horizon (1-1.5 m), contain 8-10% or more humus in the upper soil layer, their soil solution reaction is neutral (pH 6.8-7.0). The soil has a granular or fine-grained structure, its absorbing complex is saturated with calcium and magnesium. These soils' calcareous horizon formed due to hydrochloric acid lies at the border of horizons A and B, which indicates a significant content of calcium and magnesium carbonates in them.

Fig. 11. Profile of typical chornozem

Ordinary chornozems are found mainly in the steppe zone on the elevated terrain elements. They have a smaller thickness of the humus horizon (65-90 centimeters), and contain up to 7-9% humus. Their calcareous horizon is formed at a depth of 50-60 centimeters due to reacting with hydrochloric acid. The reaction of the soil solution is neutral (pH 7.0).

Southern chornozems occupy mainly the arid southern regions of the zone, where about 350-400 millimeters of precipitation falls per year, and their evaporation is very strong. The humus horizon of southern chornozems is of small thickness (45-65 centimeters).

The steppe vegetation in these areas is more uniform and consists mainly of southern feather grass and other plants that have a short development cycle. Decomposition of dead remains occurs rapidly in dry and hot conditions, so the soil contains a small amount of humus (4-6%).

As a result of weak soil moisture saturation, calcium and magnesium carbonates accumulate in the upper horizon, so its calcareous line is formed on the surface due to hydrochloric acid action. In terms of fertility, these soils are equal to ordinary chornozems.

The Azov chornozem contains 4-6% humus, but the thickness of the its humus horizon reaches 120-200 centimeters.

The soil's calcareous horizon formed due to hydrochloric acid action lies in the surface layer because it contains a lot of calcium and magnesium carbonates. The reaction of the soil solution is slightly alkaline. These chornozems feature high fertility.

Most chornozem soils are clayey, loamy, and less often sandy by mechanical composition. Fertility of sandy chornozems is much lower than that of clayey and loamy soils, because they contain little humus, have a weak structure, and are not able to absorb and retain a significant amount of precipitation in the arable layer. Their absorptive capacity is low, and the nutrients formed in them are washed out of the soil.

In many areas of the chornozem zone, the plain is crossed by arroyos and gullies as a result of water erosion. In the southern and southeastern regions, the fertility of chornozems is greatly affected by wind erosion.

Currently, in our country, measures are being taken to prevent the development of water and wind erosion of soils, including chornozems.

Application of fertilizers is an important measure to improve the fertility of chernozems and increase the yield of agricultural crops. Among mineral fertilizers, phosphoric ones are of particular importance. Many chernozems (especially sandy soils) respond well to potassium fertilizers. Despite the huge reserves of humus and, therefore, the high content of nitrogen, applying small doses of nitrogen fertilizers in many cases is highly effective. Manure, composts and other organic fertilizers applied to all chernozem soils contribute to increased yields.

Soils of dry steppes

These soils occupy the territory located south of the chernozems. Even less precipitation falls here (200-350 millimeters), and more moisture evaporates.

With climate change, unfavorable conditions for the development of meadow and steppe vegetation were created in the steppe. Gradually, perennial grasses and leguminous plants disappeared. They were replaced by festuca valesiaca, poa (meadow-grass), stipa (feather grass), bulbous meadow-grass and other drought-resistant plants, whose seeds ripen before the onset of summer droughts. As the climate becomes drier to the south, the steppe grass gets thinner. It consists mainly of absinthium (wormwood), bassia scoparia (ragweed) and other drought-resistant plants.

Due to the weak development of grasses, their rapid dying and decomposition in aerobic conditions, the soils of this zone contain little humus.

In the dry steppes, chestnut and brown soils prevail. They lie on various rocks - clays, loams, sandy deposits that came to the surface as a result of the shallowing of the seas, or on deposits of loess and loess-like loams.

The territory is a plain with many small dips and hills. In low places, a large amount of various salts, washed from elevated areas, often accumulates.

Chestnut soils have a humus horizon, with a thickness of 25 to 60 centimeters and humus content of 1.5 to 5%.

Dark chestnut soils containing 3 to 5% humus are considered the best soils. The thickness of their humus layer is from 40 to 60 centimeters. The humus horizon contains a lot of calcium salts, magnesium and a small amount of sodium and potassium salts, due to which the structure of these soils is not very strong.

The reaction of the soil solution of dark chestnut soils is weakly alkaline (pH 7.2-7.5). They contain no less nutrients than southern black soils. Under irrigation conditions, high yields are obtained on these soils.

Chestnut and light chestnut soils occupy the southern, drier part. They are poorer in organic matter, feature higher salinity than dark chestnut soils, and give unstable harvests due to the arid climate.

Solonchaks lie in the form of spots among chestnut, brown,and gray soils.

These soils are located on the site of former lakes, lagoons or in lowlands, where a significant amount of salt leached from elevated places is concentrated. As a result, a strong concentration of salts is created in the soil solution of solonchaks, which is very harmful to cultivated plants.

The parent rock, which contains a lot of soluble salts, can be the cause of strong soil salinity. During evaporation, these salts rise to the upper layers of the soil and concentrate there. Salinization also occurs when the wind carries salts from salt water bodies or seas deep into the mainland.

Solonchaks contain a lot of calcium, magnesium, and sodium salts. The absorbing complex of these soils is saturated with sodium and calcium. The thickness of the humus horizon varies from 10 to 60 centimeters, and the humus content is from 1 to 5%. Soil solution reaction of solonchaks is alkaline (pH 8-9). Sodium carbonate and sodium chloride are especially harmful while calcium carbonate and calcium sulfate are almost harmless. The salt content in solonchaks often reaches 3-5%, and in some, the most saline ones – 50% of the total mass of dry soil. By the content of various salts, salt marshes are divided into: chloride, sulfate, carbonate, and sodium.

In some solonchaks, there is so much Glauber's salt that when a man is walking on the surface of the soil permeated with its crystals in dry areas his feet sink into the soil. Such solonchaks are called loose.

To use solonchaks for agricultural purposes, it is necessary to remove excess salts from them by washing, and drain the water containing an increased concentration of salts into the drainage system.

Soil salinization can occur with poorly managed irrigation on irrigated lands. Such soil salinization is called **secondary**.

To increase solonchak productivity during irrigation, it is necessary to apply nitrogen and phosphorus fertilizers.

Solonetz soils are found among chernozem, chestnut and brown soils. Their upper layer (up to 10 centimeters) is colored gray and has a leafy structure. Below this layer there is a compacted layer of dark brown color, which sometimes has a columnar structure and is particularly dense, because it contains up to 20% or more of absorbed sodium. When wet, this layer is almost impermeable to water.

The reaction of solonetz soil solution is alkaline (pH 9.0 and higher). These soils are structureless, easily flooded, contain many salts harmful to cultivated plants, especially soda, which deteriorates the soil structure.

Black soil solonetzs lie among chornozems in steppe trenches. From above, these soils have a loose layer from 3 to 25 centimeters. Beneath it lies a strongly compacted solonetz horizon. This layer contains a lot of colloids, which swell when the soil is moistened and do not let water into the lower horizons. Water stagnates on the solonetz surface in the spring, which prevents timely tillage. After the evaporation of water, the black soil solonetz dries up quickly, and the soil solonetz layer is covered with deep cracks.

To improve solonetz soils, gypsum is applied in order to displace sodium from the soil absorbing complex, replacing it with calcium. When the gypsum layer is close, it is recommended to carry out deep plowing as a result of which gypsum will mix it with the plowed layer. This technique is called **gypsum self-application.**

Assessment Questions

1. Explain how soils were created in nature.
2. What is soil fertility and how did it develop?
3. How does the process of rock destruction occur?
4. What is marl?
5. Specify the reasons that cause the destruction of rocks.
6. What is weathering?
7. List the weathering agents.
8. Explain the concept of “great geological circulation of substances in nature” before the appearance of living organisms on earth.

9. What is “small, or biological circulation of substances”?
10. Specify the role of living organisms in soil formation.
11. Name the first condition for the formation of soil fertility.
12. What is the role of higher green plants in soil formation?
13. What is humus? What does it mean for soil fertility?
14. What is the beneficial effect of humus on soil fertility?
15. List the types of organisms living in the soil. Specify their role in the formation of soil fertility.
16. Name the simplest unicellular organisms living in the soil.
17. What are the conditions necessary for rapid mineralization of soil organic matter?
18. The role of microbes in the mineralization of soil organic matter.
19. Specify the path of transformation of nitrogen-containing and phosphorus-containing compounds during the decomposition of organic substances.
20. What determines the quality of humus?
21. What types of acids are released from humus?
22. Explain the difference between humic and crenic acids.
23. Explain how soils were created in nature.
24. Name the factors of plant growth and development, specify their role.
25. What is the importance of water in the life of plants?
26. Temperature factor in the life of plants.
27. Light, its importance for the growth and development of plants.
28. What elements create the mechanical composition of the soil?
29. Indicate the role ofvarious mechanical elements in soil fertility.
30. In what state is water in the soil?
31. What types of water in the soil are available for plants?
32. What is soil permeability?
33. What is soil moisture capacity?
34. What is the role of each factor in the soil-forming process?
35. What agricultural methods contribute to improving the properties of podzolic soils and increasing their fertility?

Test

1. The great circulation of substances in nature is:
1. Geological
2. Biological
3. Chemical
4. Organic

2. Small circulation of substances in nature is:
1. Physical
2. Geological
3. Organic
4. Biological

3. Mineralization is:
1. Ability to absorb and retain water
2. Formation of humus
3. Decomposition of complex organic compounds into simple ones
4. Ability to accumulate mineral substances

4. The content of humus in the soil contributes to:
1. Absorption of sunlight
2. Decrease in moisture content
3. Improvement of soil warming
4. Deterioration of the thermal regime

5. Anaerobes are microorganisms that develop in:
1. Oxygen environment
2. Overmoistened soils
3. Oxygen-free environment
4. Dry soils

6. Aerobes are microorganisms that require:
1. Sufficient soil moisture
2. Demanding air for oxygen

3. Insufficient soil moisture
4. Not demanding on oxygen

7. Ammonification is the decomposition of protein substances into:
1. Nitric acid
2. Ammonia
3. Nitric acid
4. Amino acids

8. Nitrification is the formation of:
1. Ammonia salts
2. Nitrous acid
3. Nitric acid
4. Nitrates

9. Denitrification is a decomposition process that leads to:
1. Losses of nitrogenous substances
2. Accumulation of nitrogen mineral compounds
3. Release of gaseous nitrogen
4. Losses of soil nitrates

10. The denitrification process is enhanced by:
1. Excess moisture in the soil
2. Creation of aerobic conditions
3. Minimum content of mineral nitrogen
4. Application of fresh straw manure

11. “Physical clay” has particles:
1. Smaller than 0.01 mm
2. Larger than 0.01 mm
3. 0.1 mm in size
4. 0.001 mm in size

12. “Physical sand” has particles:

1. 0.001 mm in size
2. 0.01 mm in size
3. Larger than 0.01 mm
4. Smaller than 0.01 mm

13. From the list of pH indicators, choose the one characteristic for acidic soils:

1.3.0 - 4.5
2.4,6-5,5
3.5,6-6,5
4.6.5-7.0

14. From the list of pH indicators, choose the one characteristic for alkaline soils:

1.5,6-6,5
2.6.5-7.0
3.7.0-8.0
4.8.0-9.0

15. The absorbing complex of neutral soils is saturated with:

1. Hydrogen
2. Calcium
3. Magnesium
4. Potassium

16. The absorbing complex of acidic soils is saturated with:

1. Calcium
2. Hydrogen
3. Magnesium
4. Aluminum

17. Specify the type of moisture unavailable to plants:

1. Capillary
2. Hygroscopic

3. Film
4. Gravitational

18. The main source of moisture for plants is:
1. Film
2. Capillary
3. Hygroscopic
4. Gravitational

19. When the soil is very dry, before (or after) sowing, farmers carry out:
1. Harrowing
2. Packing
3. Slotting
4. Cultivation

20. Under the conditions of insufficient amount of air in the soil:
1. The content of available mineral substances increases
2. The development of plant roots is inhibited
3. The content of available mineral substances decreases
4. Decomposition of organic substances stops

21. The formation of a soil crust is prevented by:
1. Soil loosening
2. Soil compaction
3. Application of organic fertilizers
4. Gypsum application

22. Increasing the fertility of wetland soils is facilitated by:
1. Slotting
2. Liming
3. Application of manure
4. Draining

23. The best thermal regime is manifested in the following soil types:
1. Not sufficiently moisturized
2. Rich in humus
3. Overmoistened
4. Structural

24. Soil mulching is:
1. Loosening of the soil surface layer
2. Covering the soil surface with straw
3. Plowing plant residues
4. Compaction of the soil surface

25. The main soils of the Polissia zone are:
1. Typical chornozems
2. Sod-podzolic soils
3. Chestnut soils
4. Forest gray soils

26. The main soils of the Forest Steppe zone are:
1. Sod-podzolic soils
2. Typical chornozems
3. Chestnut soils
4. Podzolic chornozems

27. To improve solonetzs, farmers use:
1. Liming
2. Gypsym application
3. Composting
4. Deep plowing

28. To reduce the acidity of podzolic soil, farmers use:
1. Gypsym application
2. Liming
3. Mulching

4. Composting

29. Marsh soils are formed as a result of:
1. Evaporation of water
2. Waterlogging of land
3. Drying
4. Eutrophication of water bodies

30. To increase the yield of crops on drained swamps, farmers use:
1. Cultivation of green manure
2. Application of organic fertilizers
3. Application of mineral fertilizers
4. Regulation of the water regime

31. To restore the fertility of heavily washed soils on slopes, farmers use:
1. Sowing perennial grasses
2. Plowing along the slope
3. Sowing annual crops
4. Tillage across the slope

1.2 AGRICULTURE

1.2.1 Farming systems and crop rotation

The farming system is a complex of interconnected agrotechnical, land development, managerial and economic measures that ensure intensive and most rational use of agricultural lands, growing high yields of various crops and increasing soil fertility.

The main issues of the farming system are as follows:

1. Arrangement of the farmland territory and development of a rational structure of cultivated areas in accordance with its specialization and natural and economic conditions.

2. Implementation and development of scientifically based crop rotations.

3. Implementation of the proper soil cultivation system.

4. Rational use of fertilizers. Develipment of crop fertilization systems.

5. Application of the system of measures to combat weeds, pests, and diseases of agricultural crops.

6. Introduction of new highly productive varieties and hybrids.

7. Implementation of land amelioration measures: irrigation, drainage, gypsum application, liming, planting of field protection strips, etc.

8. Measures to combat water and wind erosion.

Agricultural systems developed and changed in accordance with the development of the productive forces of society, its socio-economic features and scientific and technological progress.

According to the degree of intensity, farming systems are divided into primitive, extensive and intensive.

The primitive system is characterized by using a small amount of land crops (no more than 25%).

The primitive fallow system typical for the primitive communal society implied that soil fertility could be restored due to natural processes. The land plot was left fallow, and new ones were developed.

The slash-and-burn system was widespread in the northern forest areas, where the land was plowed for crops after plowing or burning the forest.

The fallow system of agriculture replaced the primitive fallow one as the area of plowed virgin lands increased. With the establishment of private land ownership, the possibility of further plowing the land decreased. It became necessary to return to previously abandoned lands. Farmers used land that had not been cultivated for 10-20 years (fallow land). Under the influence of perennial herbaceous vegetation, soil fertility was restored within 10-15 years. The area, which had not been cultivated for a long time, was called a fallow.

Extensive farming systems were characterized by the fact that most of the land suitable for agricultural production were plowed and used mainly for grain crops. Farmers began to restore soil fertility using steam cultivation, sowing of herbs, application of fertilizers, use of more advanced equipment. The extensive systems of agriculture include steam, grain-grass, and grass-field farming.

Three-field system replaced the fallow one. As the population grew, the need for food increased. Therefore, the long fallow period was reduced to one year. The concept of fallow-field was introduced. Such a field remained unsown for only one year. Gradually, a permanent arable farmland was created with a three-field crop rotation: fallow-winter-spring. But there was no clean fallow in the fallow field, as cows grazed there. Such a field was called toloka. Under such a system, grain yield was low and amounted to 7-8 centners per hectare.

The fallow system did not satisfy animal husbandry either. Farmers began to introduce a grain fallow one.

The green manure system is a sub-type of the fallow one. It was introduced more than 2 thousand years BC. Under that farming system, soil fertility improved due to farmers' growning plants for green manure in a steam field.

Winter rye, mustard, seradella, lupine, etc. were sown for green manure.

In the grain-grass system (improved grain), at least ½ of the arable land was occupied by grain crops, 20-30% - by perennial grasses, and 15-

25% - by bare fallow.

The grass-field farming system was developed at the beginning of the 20th century by Academician V. Yu. Williams. Under such a system, at least ½ of the arable land is occupied by perennial grasses, which have a monopoly role in restoring soil fertility.

Extensive farming systems have been replaced by **intensive** ones. Their characteristic feature is a more efficient use of land and a higher output per area unit. Under such systems, grain crops take the main place in crop rotations. Industrial, leguminous and high-yielding fodder crops are grown on large areas.

Intensive farming systems include grain-row, grain-fallow-row, row, and crop rotation ones.

The crop rotation system of agriculture emerged in the countries of Western Europe at the end of the 18th century as a result of the transition from a three-field crop rotation to a four-field crop rotation, which was characterized by the presence of perennial grasses and row crops and the absence of bare fallows. Crop rotation, as the basis of the crop rotation system of agriculture, successfully solves one of the most important tasks of agronomy - increasing soil fertility.

The grain-row system is characterized by the absence of bare fallow and the 60-70% share of cereals in the structure of the sown areas. The rest of the area is allocated for row crops, fodder and other crops. Post-harvest crops are widely introduced. Special attention is paid to the application of fertilizers and taking agrotechnical measures aimed at increasing soil fertility and protecting it from erosion.

The grain-fallow-row farming system is based on the predominance of grain and row crops with the presence of one or two fields devoted to bare fallow. This system is used in arid areas, where bare fallow plays an important role in soil moisture conservation and weed control.

The row system is characterized by the fact that more than half of the area is cultivated with row crops. There are no bare fallows in this system. Repeated and intermediate crop planting plans are widely used. This is the most intensive system of agriculture which is used mainly in specialized farms.

CROP ROTATION IN THE POLISSIA ZONE

Crop rotation is a scientifically based alternation of agricultural crops and fallows in time and on the territory.

Alternation in time is an annual or periodic change of crops and fallows on a specific field.

Alternation on the territory means that the land area of crop rotation is divided into fields on which crops are grown every year (alternately). On each field, crops alternate in time.

The basis of crop rotation is the scientifically substantiated structure of sown areas.

The structure of sown areas is the ratio of sown areas of various agricultural crops and fallows, expressed in percentage to the total area of the crop rotation. It is developed in accordance with the specialization of the farm.

Different agricultural crops have different effects on soil properties over a long period of time, therefore, when allocating crops in the crop rotation system, one should follow a certain order of their alteration, selecting the best predecessors for each crop.

A predecessor is a crop or pair that occupied a given field in the previous year.

A fallow is a field on which no crops are grown for a certain period of time and which is kept clear of weeds. Fallows are divided into **bare, occupied, green manure** and **intercrop** ones.

A bare fallow is a field on which no crops are grown during the growing season and which is kept clear of weeds.

According to the terms of the main cultivation of the soil, bare fallows are divided into **black** and **early** ones.

Black fallow is a bare fallow, the processing of which begins in the summer or in the fall after harvesting the predecessor.

Early fallow is a bare fallow, the main processing of which begins in the spring of the following year after harvesting the predecessor in autumn.

Black fallows are more effective than early ones.

The climate of Polissia is moderately continental with the sum of optimal temperatures amounting to 2500 °C. It features 550-700 mm of precipitation per year, 65-70% of which falls in the warm period of the year. This zone is characterized by a great variety of soils. Arable lands are represented mainly by sod-podzolic soils of various degrees of cohesion – sandy, clay-sandy, loamy -sandy, loamy.

The soils are poor in the content of humus and mobile forms of phosphorus and potassium, have an acidic reaction of the soil solution and low natural fertility. It is impossible to raise the productivity of agricultural crops here without increasing the potential and effective soil fertility, i.e. without applying a sufficient amount of organic and mineral fertilizers, liming and draining overmoistened lands, implementing crop rotations with a high proportion of perennial grasses and legumes.

The intensification of agriculture through the concentration of production should take into account natural conditions, combine the structure of sown areas with the production of fodder on natural lands. In the Polissia zone, land management has been carried out, a system of crop rotation has been introduced and mastered. It needs to be improved in accordance with new production conditions, farm specialization, concentration of production of livestock products. Post-harvest sowing has also been introduced in this region.

Repeated sowing of a crop is its cultivation in the same field for two years. A crop grown on the same field for more than two years is called permanent.

Monoculture is the permanent cultivation of only one crop on the farm. Such practice leads to a decreas in the crop yield. The negative effect of monoculture and repeated sowing can be reduced by applying fertilizers, carrying out proper tillage, and using pesticides to control weeds, diseases and pests.

According to the reaction to the permanent sowing technique, crops are divided into the following groups:

- the most sensitive (flax, legumes, beets, spring cereals);
- moderately sensitive (winter cereals, corn);

- insensitive (potatoes, hemp, rice, tobacco, cotton).

In Ukraine, the main crops occupy the entire vegetation period, so there are 90-110 days, during which it is possible to grow intermediate crops. Depending on the period of cultivation, time and sowing method, the following groups of intermediate crops are distinguished:

- post-mowing crops - grown after harvesting crops for green fodder;
- post-harvest crops - grown and harvested after harvesting the main early grain crop in the current year;
- intermediate crops - sown under the cover of the main crop and harvested in the fall of the current year;
- winter intermediate crops - sown after harvesting the main crop and harvested in the spring of the following year before sowing the main crop.

The harvest of intermediate crops is mostly used for fodder (green mass, silage, hay, and green manure).

Post-mowing and post-harvest sowing contribute to the intensification of fodder production, increasing soil fertility and economic indicators of arable land use. The climatic conditions of Polissia make it possible to obtain a second crop harvest on the same field. For post-mowing crops, the duration of cultivation is 105-130 days, and for post-harvest ones - 95-100 days. The most productive crops that provide early spring output of green mass are winter wheat, rye and rapeseed, and among the post- mowing crops - corn, lupine and their mixtures with peas, oats, as well as sunflower, millet, buckwheat, potatoes, oilseed radish. Thus, according to the data of the Institute of Agriculture of the Ukrainian Academy of Sciences, on average for 3 years, during the spring planting period, the yield of early potatoes was 155 c/ha, and after harvesting clover – 140 c/ha, , the yield of the following winter wheat amounted to 36.9 c/ha and 35.2 c/ha respectively, but the output of fodder units in the field with dense crops was 1.9 times higher.

For post-harvest planting, crops that are less demanding in heat and more resistant to frost are used - peas, vetch, lupine, oats, winter rapeseed, turnips, etc. At the same time, it is desirable to sow leguminous and cereal components in the form of mixtures. Sowing of intermediate crops should be carried out immediately after harvesting the predecessors.

This makes it possible to use the moisture of the upper layers of the soil, to get timely seedlings, and to increase the vegetation period of intermediate crops.

In order to obtain a high yield of intermediate and subsequent crops in the crop rotation system it is necessary to apply organic and mineral fertilizers, especially when growing potatoes, root crops, corn, cereal crops and their mixtures with legumes.

Post-harvest crops should be introduced not only as a reserve for increasing the production of green and juicy fodder, but also for using them as green manure and improving the fertility of Polissia soils.

The structure of sown areas and crop rotation schemes based on the specialization of farms

Farms of various forms of ownership in the Polissia zone specialize mainly in the production of potatoes, flax and fodder; in animal husbandry - in the production of milk and beef. The production of grain is focused on the maximum meeting of food and fodder needs.

The structure of cultivated areas in Polissia varies depending on the farm specialization, production concentration and soil conditions.

For collective farms specializing in cattle-potato-flax production the most productive are grain-potato-flax crop rotations, with the following ratio: grain – up to 50-52%, potatoes — 10-15%, flaxn — 9 -12%, fodder crops — up to 25 - 28%. This crop rotation scheme provides the following yield per 1 hectar of arable land: 14-16 centners of grain, 21-32 centners of potatoes, 46-50 centners of fodder and 4.0 — 4.5 centners of digestible protein.

Indicative schemes of crop rotation for farms specializing in cattle-potato-flax production

I-1 — clover for two mowings; 2 — winter wheat; 3 — flax, 4 — winter post-harvest crops; 5 — potatoes; 6 — barley; 7 — corn for silage, root crops; 8 — oats, barley with clover intercropping.

II. 1 — perennial herbs; 2 — flax; 3 — winter wheat; 4 — potatoes; 5 — barley; 6 — corn for silage and green fodder; 7 — winter rye; 8 — lupine, root crops, annual grasses + post-mowing crops, 9 — oats; winter crops intercropped with perennial grass mixtures.

III-1 — clover; 2 — winter wheat; 3 — flax; 4 — winter, post-harvest crops; 5 — potatoes; 6 — corn for silage, lupine; 7 – barley, oats intercropped with clover.

For the Western Polissia, which is characterized by sufficient moisture and mainly sod-podzolic soils with a light mechanical composition, the following crop rotation is recommended:

I. 1 - annual grasses, lupine, 2 - winter rye + post-harvest crops, 3 - flax-dovgunets + post-harvest crops, 4 - row crops - potatoes, etc., 5 - winter and spring cereals.

II.2 - lupine for green fodder; 2 - winter rye + post-harvest crops; 3 – potatoes; 4 - corn for silage; 5 potatoes; 6- oats.

Polissia farms are well provided with natural fodder lands, therefore the structure of sown areas can be different even with the same specialization, which makes it necessary to specify it taking into account natural conditions. In addition to fodder production on meadows and pastures, it is necessary to grow fodder crops on field lands. On more fertile sod-podzolic and gray forest sandy and loamy soils, good yields are given by perennial leguminous grasses and their mixtures with poa (meadow-grasses). On fertilized lands, alfalfa has high productivity, providing high yields for three years.

For potato-grain-livestock farms, the following crop rotation scheme can be recommended: 45-55% grain, 20-25% potatoes, and 20-25% fodder crops. As a result of applying this technique, farmers can obtain 13 - 17 centners of grain, 42 - 60 centners of potatoes, 46 - 52 centners of fodder, 3.8 — 4.5 centners of digestible protein from 1 hectare of arable land.

I - 1 - clover for two mowings; 2 - winter wheat + post-harvest crops; 3 – potatoes; 4 - corn for silage and green fodder, lupine; 5 – winter cereals; 6 – potatoes; 7 - spring cereals intercropped with clover.

II - 1- clover for two mowings; 2 - winter wheat; C – potatoes; 4 -

winter rye; 5 - corn for silage and green fodder; 6 - winter cereals + post-harvest crops; 7 – potatoes; 8 — spring cereals intercropped with clover.

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CROP ROTATION OF THE FOREST STEPPE ZONE

The forest-steppe zone occupies the central part of the country and makes up more than a third of its territory. 37% of the area sown with cereals is concentrated here (including 34% of winter wheat, 41% of spring barley, 27% of corn, 81% of sugar beets, 35% of vegetable crops). In addition to these crops, millet, buckwheat, potatoes, and fodder crops are grown here. In this zone, especially in the right-bank part, natural conditions are favorable for the introduction of repeated crops (post-mowing and post-harvest crops).

Due to its large length from west to east, the zone is characterized by heterogeneity of soil, climate and weather conditions. In particular, three sub-zones are clearly distinguished by moisture: the western one — of sufficient moisture (580 — 600 mm of precipitation per year), the central part — of unstable moisture (480 — 500 mm, including 30 — 37% more than 400 mm), the eastern and southern-eastern ones — of insufficient moisture (400 — 450 mm, every third year is dry). In these subzones, the water regime of the soil is formed differently. In the zone of sufficient moisture, it is favorable in most years – droughts are rare and short-term, water reserves in the soil are quickly restored, black fallows as a means of accumulating moisture in the soil have no advantages over occupied allows. On the contrary, in the zones of unstable and insufficient moisture, due to increased insolation and air temperatures, the supply of water to plants becomes of primary importance. Therefore, the significance of fallows, including black ones, in enhancing the moisture supply to the crops sown within the crop rotation scheme increases immensely.

The heterogeneity of the natural conditions of the forest-steppe zone determines the peculiarities of the composition and alternation of crops in crop rotations in different areas of the zone. Therefore, the question of elaborating crop rotations should be solved differently, according to the sub-zones of moisture.

Sufficient moisture subzone

Optimum conditions for growing agricultural crops based on the crop rotation scheme are provided by allocating a certain crop after the best predecessor and the optimal period of return to the previous place of cultivation.

The structure of sown areas and crop rotation schemes for farms of various specializations

Long-term research conducted by academic institutions has shown that the highest profitability is provided by crop rotations with perennial grasses, saturated with grain crops up to 50-60% (including winter wheat 20-30%, barley, peas, corn - 10% each), row crops up to 40% (of which 20% is sugar beet and 20% - corn).

Such crop rotations ensure harvesting 98 — 102 centners of fodder, 28 — 29 centners of grain, and 93 — 96 tons of root crops from 1 hectar of the crop rotation area at a relatively low production cost. It is expedient to introduce them in mixed-crop farms of various forms of ownership.

Approximate crop rotation schemes for the subzone of sufficient moisture

For grain, beet and livestock farms:

10-field crop rotations:

I.1 — clover for two mowings; 2 — winter wheat; 3 — sugar beets; 4 — peas; 5 — winter wheat + post-harvest; 6 — corn for silage; 7 — winter wheat; 8 — sugar beets, potatoes, buckwheat; 9 — corn for grain; 10 — barley intercropped with clover.

II. 1 — clover for two mowings; 2 — winter wheat; C — sugar beets; 4 — corn for silage; 5 — winter wheat; 6 — corn for grain, sugar beets; 7 - peas; 8 - winter wheat; 9 — sugar beets; 10 — barley intercropped with clover.

III. 1 — clover for one mowing; 2 — winter wheat; 3 — sugar beets; 4 — corn for grain; 5 — peas; 6 — winter wheat; 7 — sugar beets; 8 — corn for green fodder and silage; 9 — winter wheat, winter rye.

8-field crop rotations

1 — clover; 2 — winter wheat; 3 — sugar beets; 4 — corn for grain and silage; 5 — peas; 6 — winter wheat; 7 — sugar beets; 8 — barley intercropped with clover.

7-field crop rotation

1 — perennial and annual grasses; 2 — winter wheat; 3 — sugar beets; 4 — peas; 5 — winter wheat; 6 — sugar beets; 7 — barley intercropped with clover, corn.

Most farms are highly specialized. The justification of specialization and arrangement of the land territory in them should be carried out by specialists of the Institute of Land Management, taking into account the recommendations of academic institutions.

If the commercial products of the farm are grain, raw sugar, milk and meat, the following crop rotation schemes can be recommended:

I. 1 — clover; 2 — winter wheat; 3 — sugar beets; 4 — corn for grain and silage, buckwheat.

II. 1 — perennial herbs, peas, buckwheat; 2 — winter wheat; 3 — sugar beets, barley, corn.

III. 1 — perennial herbs, peas; 2 — winter wheat; C — sugar beets; 4 — barley + perennial herbs, corn for silage.

Such crop rotations are highly profitable.

Milk and beef production farms re recommended to introduce crop field rotations with alfalfa (20-35%), saturated with grains up to 30-45%, including winter wheat 10-20%, peas, barley, corn - up to 10%

Such crop rotations provide 89-101 centners of cheap fodder units and 9-10 centners of digestible protein from 1 hectar of crop rotation area.

The structure of cultivated areas of farms is determined by the adopted specialization and soil and climatic conditions.

In farms specializing in the production of livestock products, the structure of sown areas depends on the structure of fodder. In this respect, the set of corns should be small.

The structure of sown areas and crop rotation schemes for farms of various specializations

Modern agricultural production is characterized by the complexity of its forms and includes large (both multi-branch and highly specialized) farms, associations of peasant farms, small peasant farms.

The most typical specialization of large collective farms in the specified subzones is grain production, beet growing, and animal husbandry. Crop rotations of 55-60% cereals (including 25-30% winter wheat), 15-20% sugar beets, and 23-25% fodder crops should be recommended for these farms. Such crop rotations provide an average yield of grain amounting to 36 — 41 centners/ha, sugar beet — 345 — 500 centners /ha; as well as the following output from 1 hectare of arable land: 20 — 24 grain, 11 — 15 centners of sugar, 81 — 96 centners of fodder units and 7 — 8.2 centners of digestible protein. Under the insufficient moisture conditions, sugar beets in the crop rotation should be returned to the previous place no earlier than in three to four years, and 3-5% of the arable land should be allotted to black fallow in the crop rotation.

For farms specializing in the production of grain-forage, pork and poultry, it is advisable to have 65-70% of grain crops, 15-20% of sugar beets, and 10-20% of fodder crops. Crop rotations saturated with fodder crops provide an average grain yield of 36-45 centners/ha, sugar beet — 400-500 centners /ha; output from 1 hectare of arable land: 25-30 centners of grain, 64-98 centners of fodder units, 7-9 centners of digestible protein.

Farms specializing in milk and meat production, and heifer rearing are recommended the following ration in the crop rotation structure: cereals - 45-50%, sugar beets - 15-20%, fodder crops - 30-40%.

Crop rotations for farms specializing in grain, beet and animal husbandry

Subzone of unstable hydration

I. 1 — perennial herbs for one mowing; 2 — winter wheat; 3 — sugar beets; 4 — corn for grain; 5 — peas; 6 — winter wheat; 7 — sugar beets; 8 — corn for silage and green fodder; 9 — winter wheat and rye +

postharvest; 10 — barley, oats, millet with perennial herbs.

II. 1 — perennial and annual grasses; 2 — winter wheat; C — sugar beets; 4 — corn for grain; 5 — peas; 6 — winter wheat; 7 — sugar beets, sunflower, potatoes; 8— corn for silage, buckwheat (after sugar beets); 9 — winter: wheat, rye, barley, post-harvest; 10 — barley, millet, oats with perennial herbs.

III. 1 — perennial and annual grasses; 2 — winter wheat; C — sugar beets; 4 — corn for grain and silage; 5 — peas, buckwheat; 6 — winter wheat; 7 — sugar beets; 8 — barley, oats with perennial herbs.

VI. 1 — perennial grasses (0.5 field), millet, oats; 2 — perennial herbs (0.5 fields), buckwheat; 3 — winter wheat; 4 — sugar beets, potatoes, fodder roots; 5 — corn for grain; 6 — peas; 7 — winter wheat; 8 — sugar beets; 9 — corn for silage and green fodder; 10 — barley, oats with perennial grasses, winter wheat + post-harvest crops.

Subzone of insufficient hydration

I. 1 — black and early occupied fallow; 2 — winter wheat; 3 — sugar beets; 4 — barley, oats, millet intercropped with perennial grasses; 5 — perennial herbs; 6 — winter wheat; 7 — sugar beets, fodder roots; 8 — peas, corn for silage; 9 — winter wheat; 10 — corn for grain, sunflower.

II. 1 — black and occupied fallow; 2 — winter wheat; 3 — sugar beets; 4 — annual crops for green fodder and silage; 5 — winter wheat and rye; 6 — corn for grain; 7 — spring crops intercropped with perennial grasses; 8 — perennial herbs; 9 — winter wheat; 10 — sugar beets, sunflower, corn.

The area of specialization – pork and poultry products

I. 1 — perennial herbs; 2 — winter wheat; 3 — sugar beets; 4 — corn for grain; 5 — pea (chinnas); 6 — winter wheat; 7 — sugar beets, corn for grain, fodder root crops, millet, potatoes; 8 — annual grasses for fodder and silage; 9 — winter wheat + postharvest for fodder; 10 — barley intercropped with perennial herbs.

II. 1 — perennial and annual grasses; 2 — winter wheat; C — sugar beets, fodder roots; 4 — corn for grain and silage; 5 — corn for grain; 6 — peas (chinnas); 7 — winter wheat; 8 — winter rye, millet, oats, buckwheat; 9 — barley intercropped with perennial herbs.

Area of specialization —
milk and beef production, heifer rearing

Subzone of unstable hydration

I. 1 — perennial herbs; 2 — perennial herbs; 3 — winter wheat + post-harvest crops for fodder; 4 — sugar beets; 5 — legumes, mixtures of legumes with oats for green fodder and silage; 6 — winter wheat; 7 — sugar beets; 8 — corn for grain and silage, buckwheat; 9 — corn for silage and green fodder, winter crops for green fodder (after corn for silage and buckwheat) + post-harvest crops, annual grasses for green fodder; 10 — barley, oats, millet intercropped with a mixture of alfalfa and clover or pure alfalfa.

II. 1 — alfalfa; 2 — alfalfa; 3 — winter wheat; 4— sugar beets; 5 — corn for grain; 6 — corn for grain and silage; 7 — legumes; 8 — winter wheat; 9 — sugar beets; 10 — barley, oats, millet intercropped with perennial grasses.

Subzone of insufficient hydration

I. 1 — black fallow; 2 — winter wheat; 3 — sugar beets; 4 — barley, millet with alfalfa or onobrychis; 5— onobrychis and alfalfa; 6 — winter wheat, alfalfa; 7 — winter rye and wheat; 8 — corn for grain; 9 — corn for silage, legumes; 10 - sunflower.

II. 1 — black and early occupied fallow; 2 — winter wheat; 3 — sugar beets; 4 — annual crops for green fodder and early silage, peas; 5 — winter wheat; 6 — corn of milk-wax maturity; 7- spring crops intercropped with perennial grasses.

Indicative crop rotation schemes for peasant farms
For small-scale farms in the subzone of unstable and insufficient moisture:

Different specializations of peasant farms require the implementation of appropriate crop rotations.

a) For farms specializing in the cultivation of food / fodder grain and sugar beets.

I. I — perennial herbs; 2 — winter wheat; 3 — sugar beets; 4 — corn for grain; 5 — barley intercropped with perennial herbs.

P. 1 — peas; 2 — winter wheat; 3 — sugar beets; 4 — corn; 5 — corn.

III. 1 — peas; 2 — winter wheat; 3 — corn for grain; 4 — barley.

IV. 1 — corn for silage; 2 — winter wheat; 3 — corn; 4 — corn.

V. 1 - peas; 2 — corn; 3 — corn; 4 — barley;

b) For the cultivation of cereals and grains:

I. 1 — peas; 2 — winter wheat; 3 — buckwheat; 4 — barley.

II. 1 — peas; 2 — winter wheat; 3 — millet; 4 — barley;

c) For farms producing pork: .

I. 1 — soy, peas; 2 — corn; 3 — corn; 4 — barley.

Approximate fodder rotation schemes for farms specializing in milk and meat production, and heifer rearing

For gray podzolized medium loamy soils. According to the Institute of Fodder of the Ukrainian Academy of Sciences and Vinnytsia State Agricultural Institute (1983 — 1992), in farms with a relatively low livestock density (80 out of 130 conventional heads per 100 ha of arable land), the most appropriate structure of the sown areas of specialized fodder rotation should include 50-57% of fodder crops (including at least 20% of perennial grasses), about 50% of grain and leguminous crops, 14-20% of intermediate crops for green fodder. For such farms, the following fodder rotation schemes are offered:

a) 1, 2 — alfalfa + bromus; 3 — corn for grain; 4— corn for green fodder + post-harvest crops; 5 — grains and legumes; 6 — winter intermediates + corn for silage; 7 — vetch-oats + perennial herbs;

b) 1, 2 — clover +meadow fescue; 3 — corn for grain; 4 — corn for green fodder + post-harvest crops; 5— barley + clover; 6 — intermediate clover + corn for silage; 7 — vetch-oats + perennial herbs.

When developing specialized fodder crop rotations, farms with a high concentration of livestock (130-200 heads per 100 hectares of arable land), should allocate 72% of the sown area to fodder crops (including perennial grasses - 28-35%), 28% - to grain crops.

These farms should have the following crop rotations:

a) 1, 2 — alfalfa; 3 — corn for grain; 4 — corn + Sudan grass for green fodder; 5 — barley; 6 — winter intermediates + corn for silage; 7 — vetch-oats + alfalfa;

b) 1, 2, 3 — alfalfa + bromus; 4 — corn for grain; 5 — barley; 6 — corn + fodder beans for silage; 7 — vetch-oats + perennial herbs.

On dark gray podsolized soils:

1,2 — alfalfa; 3 — corn for grain; 4 — peas for grain; 5 — winter wheat + intermediate winter crops; 6 — winter intermediates + corn with Sudan grass for silage; 7 — spring barley for grain; 8 — alfalfa (pure sowing).

On typical low-humus chornozems:

1. 1 — clover; 2 — winter wheat + post-harvest intermediates; 3 — corn for grain, root crops; 4 — vetch-oats + annual ryegrass; 5 — barley for grain + sowing of intermediate winter crops; 6 — winter intermediates + corn for silage; 7 — barley + clover.

CROP ROTATION OF THE STEPPE ZONE

Agriculture of the Steppe zone specializes in grain production. The main field crops are winter wheat, corn, barley, and sunflower which belongs to industrial crops. Therefore, the Steppe zone is considered one of the most important areas for the production of food and fodder grain and sunflower seeds.

Because of the insufficient amount of natural fodder lands in the region and their low productivity, field fodder production, in particular, crops of perennial grasses, corn for silage and green fodder, root crops, melons, etc., are of crucial importance.

The lack of sufficient precipitation at elevated temperatures in the steppe zone leads to a sharp decrease in air humidity, increased evaporation, and, as a result, to atmospheric and soil droughts. Therefore, one of the main tasks of agriculture in the steppe zone is the accumulation of moisture in the soil and its rational use. It is solved by applying various agrotechniques, the most effective of which are black fallow and the selection of highly productive drought-resistant varieties of agricultural crops.

Schemes of different crop rotations for farms of different areas of specialization and forms of ownership

Based on the research carried out by scientific institutions, it is possible to recommend rational crop rotations both for large farms, where it is possible to introduce multi-field crop rotations, and for farms, where the limited amount of land under cultivation requires the use of crop rotations with a small set of crops and a short rotation term.

For farms producing pork and poultry products

Southern regions

I. 1 — black and occupied fallow; 2 — winter wheat; Z — corn for grain; 4 — spring crops; 5 — legumes; 6 — winter wheat; 7 — barley intercropped with perennial grasses (0.5 of the field); 8 — leguminous crops, perennial grasses; 9 — winter wheat; 10 - sunflower, corn for grain.

II. 1 — black and occupied fallow; 2 — winter wheat; 3 — corn for grain; 4 — barley with undersowing on 0.5 fields of perennial herbs; 5 — perennial herbs, legumes; 6 — winter wheat; 7 — sunflower, corn for grain.

Northern regions

I. 1 — black and occupied fallow; 2 — winter wheat; 3 — sugar beets; 4 — barley intercripped with perennial grasses; 5 — perennial herbs; 6—winter wheat; 7—corn for grain; 8 – leguminous crops, corn for grain; 9 — spring crops; 10—sunflower, corn for grain.

II. 1—black and occupied fallow; 2—winter wheat; 3—sugar beets, corn for grain; 4—barley intercripped with perennial grasses; 5—perennial herbs; 6—winter wheat; 7—maize for grain; 8—sunflower, corn for grain.

For grain-oil-cattle specialization farms

Southern regions

I. 1 — black fallow; 2 — winter wheat; 3 — corn for grain; 4 — barley intercripped with perennial herbs; 5 — perennial herbs; 6 — winter wheat; 7 — corn for silage; 8 — winter wheat; 9 — corn for grain, sunflower.

II. 1 — black and occupied fallow; 2 — winter wheat; 3 — corn for grain; 4 — barley intercripped with alfalfa (0.5 of the fields); 5 — corn for silage, legumes, alfalfa; 6 — winter wheat; 7 - sunflower.

Northern regions

I. 1 — black and occupied fallow; 2 — winter wheat; 3 — sugar beets, corn for grain; 4 — spring crops; 5 — corn for silage; 6 — winter wheat; 7 — corn for grain; 8 – peas; 9 — winter wheat; 10 – sunflower.

P. 1 — black and occupied fallow; 2 — winter wheat; 3 — sugar beets, corn for grain; 4 — corn for silage; 5 — barley, winter wheat; 6 — sunflower, corn for grain.

For farms producing milk and beef

Southern regions

I. -1 — black fallow; 2 — winter wheat; 3 — corn for grain; 4 — barley intercropped with onobrychis (0.5 of the field) and alfalfa (0.5 of the field); 5 — onobrychis and alfalfa; 6 — winter wheat; 7 — corn for silage and green fodder; 8 — winter wheat; 9 – sunflower.

II. 1 — black and occupied fallow; 2 — winter wheat; 3 — corn for grain; 4 — barley and corn for green fodder intercropped with perennial grasses; 5 — perennial herbs; 6 — winter wheat; 7 — sunflower, corn for grain.

Northern regions

I. 1 — black and occupied fallow; 2 — winter wheat; 3 — sugar beets, corn for grain; 4 — barley intercropped with alfalfa; 5, 6 — alfalfa; 7 — winter wheat; 8 — corn for grain; 9 — corn for silage, leguminous crops; 10 — winter wheat, barley, sunflower.

II. 1 — black and occupied fallow; 2 — winter wheat; 3 — sugar beets, corn for grain; 4 — barley intercropped with alfalfa; 5, 6 — alfalfa; 7 — winter wheat; 8 – sunflower, corn for grain.

For wheat and sunflower farms

Southern regions

I. 1 — black fallow; 2 — winter wheat; 3 — leguminous crops; 4— winter wheat; 5 — occupied fallow; 6 — winter wheat; 7- sunflower.

II. 1 — black fallow; 2 — winter wheat; 3 — b intercropped with onobrychis; 4 — onobrychis; 5 — winter wheat; 6 — occupied fallow, leguminous crops; 7 — winter wheat; 8 - sunflower.

Northern regions

I. 1 — black and occupied fallow; 2 — winter wheat; 3 — sugar beets; 4 — barley.

Crop alteration
in specialized corn crop rotations.

I. 1, 2, 3 — corn for grain; 4 — corn for silage; 5 - barley or winter wheat depending on weather conditions in autumn

I I .1, 2, 3 — corn for grain; 4 — corn for silage intercropped with alfalfa; 5 — alfalfa; 6 — winter wheat.

1U. 1, 2, 3 — corn for grain; 4 — soybeans; 5 — winter wheat or barley.

Rotation schemes recommended for farms

I – peas; 2, 3 — corn; 4 — barley.

II .1,2,3- corn, 4— winter wheat.

Sh. 1, 2, 3 — corn; 4 — soybeans.

IV. 1 — black or occupied fallow; 2 — winter wheat; 3 - peas,

4 — winter wheat; 5 — corn.

V. 1 — black fallow, 2, 3 — winter wheat; 4 — corn.

Assessment questions

1. Indicate the value of crop rotation.

2. Define the concepts: crop rotation, repeated sowing, unchanged crop, monoculture.

3. Name the crops that cause deterioration of soil fertility.

4. List the plants that improve soil fertility.

5. Name the factors causing the need for crop rotation.

6. Define the term "fallow". Classification of fallows.

7. Name the common fallow plants in relation to the soil and climatic zones.

8. What are the features of the positive influence of perennial

legumes on soil fertility.

9. Explain the positive agrotechnical significance of row crops.

10. What is the crop rotation classification based on?

11. List crop rotation schemes for farms of different forms of ownership in your zone.

Test tasks

1. Fallow, grass field and green manure systems refer to:

   1. Primitive systems
   2. Extensive systems.
   3. Intensive systems.
   4. Soil protection systems.

2. A crop grown in one place for more than 8 years is called:

   1. Repeated.
   2. Predecessor crop.
   3. Unchanged.
   4. Monoculture.

3. Intermediate crops are crops that:

   1. are grown several times a year.
   2. free the field is early.
   3. are grown on arable land during the period of time free from the cultivation of the main crop.
   4. are sown after growing the main crop.

4. Post-harvest culture is:

   1. grown on one field for 2-3 years.
   2. the only crop grown on the farm.
   3. is grown for a long time on one field.
   4. an intermediate crop grown in the same field after harvesting early cereals.

5. Repeated growing is the cultivation of a crop on the same field

during:

1. One year.
2. Two years.
3. More than two years.
4. Up to five years.

6. A permanent crop is growing a crop on the same field during:

1. One year.
2. More than two years.
3. Four years.
4. Three years.

7. Monoculture is:

1. Long time cultivation of a crop in one field.
2. Permanent cultivation of only one crop on the farm.
3. Continuous crop cultivation on one field.
4. Cultivation of crops on one field for 2-3 years.

8. Name the crops that cause deterioration of soil fertility:

1. Peas.
2. Wheat.
3. Sunflower.
4. Sorghum.

9. Indicate the correct definition of the term "fallow":

1. This is a field on which agricultural crops are grown.
2. This is a field on which agricultural crops are not grown for a certain time.
3. This is a field on which crops are not grown for a certain period and which is kept clear of weeds.
4. This is a field that is kept clear of weeds.

10. Crop rotation is an alternation of crops and a fallow:

1. On the territory.

2. In time.
3. In time and space.
4. During the growing season.

11. Specify the basis of crop rotation:
1. Ratio of cultures.
2. Ratio of cultures and fallows.
3. Structure of sown areas.
4. Structure of agricultural land.

12. The predecessor is:
1. a crop that is sown for several years on the same field.
2. a crop or fallow, occupying the field in the current year.
3. a crop or fallow that occupied the field in the previous year.
4. a crop sown beyond crop rotation.

1.2.2 Weeds, general characteristics, classification and measures to control them.

Weeds are any extraneous plants that grow in the field of one or another agricultural crop. Based on this, cultivated plants growing in in the fields of other cultivated plants can also be considered weeds. These are: barley - in spring wheat fields, rye - in winter wheat fields, etc. However, they do not cause a decrease in the yield of the main crop and do not deteriorate the quality of products, which is why they are called litterers. Weeds should be considered representatives of wild flora that grow in fields of cultivated plants. However, some representatives of wild flora are also used in agriculture. For example, white melilot (melilotus albus) and yellow melilot (melilotus officinalis) are considered pernicious weeds in field lands, while in fodder production they are valuable fodder plants. Couch grass (elymus repens) in hayfields and pastures is a valuable fodder plant, while in the fields of cultivated plants it is a pernicious weed, “fire of the fields” as translated from Latin.

Some groups of weeds have adapted to certain types of cultivated plants and, as a rule, cannot be found without them in nature. Thus, alfalfa and clover crop fields are littered with dodder (cuscuta); gray and green setarias most often clog fields of late spring grain crops.

Certain types of weeds are considered companions of certain cultivated plants. That is why they are called specialized. For example, wild oat is a typical pest of oats, rye brome (Bromus secalinus) – of rye, dodder – of alfalfa.

Weeds cause the deterioration of the growth and development conditions of cultivated plants and thereby cause a decrease in their productivity and a deterioration in the quality of products. The level of agricultural practices is largely determined by the degree of weed contamination of the soil. The direct negative effect of weeds on agricultural productivity consists in the following:

- they reduce soil fertility, using a significant amount of water and nutrients for their growth and development.

- compared to cultivated plants, weeds use 1.5 times more water and nutrients from the soil;

-weeds have a more powerful root system, as a result of which they are more competitive in terms of water and nutrient consumption compared to cultivated plants; using a significant amount of water, weeds create conditions of significant moisture deficit for cultivated plants;

– weedy vegetation forms a significant vegetative mass, which leads to shading and suppression of cultivated plants;

- weediness of the field leads to a decrease in the soil surface temperature by 1-2^{o} C, due to which microbiological activity is suppressed, plant vegetation is prolonged, especially in conditions of short days;

- weediness causes crop plants' lodging and complicates the harvesting of grain crops (wild buckwheat, field bindweed (convolvulus arvensis), etc.);

– in weedy crops, the quality of the harvest deteriorates (corncockle (Agrostemma), ryegrass (Lolium perenne), etc.);

– certain types of weeds are host plants for the development of many diseases and pests of agricultural crops. In particular, weeds of the cabbage (Brassicaceae) family contribute to the spread of cruciferous flea and such a disease as downy mildew;

- weeds significantly complicate the implementation of various technological methods: large-stemmed weeds (thistle, melilot, plume thistle) cause malfunctions of the knives of combine harvesters. Rhizome and root sprout types of weeding are the cause of increased costs for soil cultivation, which negatively affects the production cost. Thus, the protection of various crops from weeds is one of the primary tasks of agronomy.

Biological features of weeds

The development of measures related to cleaning the soil from weeds is impossible without taking into account their biology of growth and development.

The competitiveness of weeds is extremely high, ten times higher than that of cultivated plants and is based on the following:

- weed seeds do not germinate at the same time, have a long period of rest and are able to remain viable for a long time;

– some types of weeds have seeds that are difficult to differentiate from the seeds of cultivated plants (dodder (cuscuta) – from clover and alfalfa, common wild oat (avena fatua) – from oats);

- the fruit and seeds of certain weeds have special features for transporting them over considerable distances;

- weed seeds, passing through the digestive organs of animals and birds, preserve germination and re-clog the soil;

- weeds are extremely flexible as they can adjust to various environmental conditions; they are characterized by high frost and heat resistance, the ability to tolerate a decrease in temperature and its increase during the growing season. The relationship of cultivated plants and weeds with the environment is significantly influenced by natural factors: geographical location, topography, climate, soil cover, etc.

To a large extent, the development of cultivated plants and weeds is conditioned by human production activities. Separate biological groups of weeds are indicators of soil fertility, due to the fact that they are focused on by farmers developing a fertilization system.

It is worth noting that certain types of weeds react differently to climate conditions. Environment does not significantly affect setaria, white goosefoot (Chenopodium album), stellaria media (chickweed) and others. On the contrary, Johnson grass, Bermuda grass (cynodon dactylon) and other weeds that are common only in the southern regions are demanding to climatic conditions.

There is a different respond of weeds to fertilizers, especially nitrogen fertilizers. Weeds are divided into those that react positively to nitrogen (pale smartweed, white goosefoot) and those that react negatively (stellaria media (chickweed)). Weeds react differently to the application of phosphorus, potassium and other nutrients.

The species composition of weeds also depends significantly on the method of soil cultivation, crop rotation, and herbicides.

Thus, the weed control system should be based on predicting the possibilities of environmental changes that may occur under the influence of certain technological methods of growing agricultural crops.

Taking into account the biological features of weeds, their classification is based on the **following principles**:

- type of nutrition;
- nature of reproduction;
- lifespan;

This classification meets the requirements of practical agriculture. For the successful management of weed control, all their diversity is reduced to a certain system and, in accordance with the classification principles, united into taxological units.

The smallest classification unit of weedy vegetation is a biological type.

A biological type is a group of plants that are similar to each other in terms of nutrition, lifespan, and reproduction. Based on this, the whole variety of weeds is divided into the groups presented below.

By nutrition type:

- non-parasitic green plants;
- parasitic plants;
- semi-parasitic green plants.

By lifespan:

- annual;
- perennial

By the nature of reproduction:

- those that reproduce mainly by seeds and less vegetatively;
- those that reproduce mainly vegetatively and to a lesser extent by seeds.

The classification of weeds according to their biological groups is presented in Table 1.

Table 1

Classification of weeds (by I.P. Kotovrasov and V.G. Krykunov)

Parasitic plants		Non-parasitic (green) plants	
Total parasites	semiparasites	Annual Weedy Plants	Perennial weedy plants
Stem (cuscuta)	Root	1. Ephemerals 2. Spring: early late	1. Those that reproduce mainly by seeds and less vegetatively: with a fibrous root system; with a taproot system

Root (broomrape)		3.Overwintering 4. Winter 5. Biennial	2. Those that reproduce mainly vegetatively and less by seeds: - creepers; - bulbous; - root sprouts; - rhizome

According to the ecological principle, weeds are divided into field, meadow, vegetable garden, garden, swamp, ruderal, etc.

Parasitic weeds are plants that do not have chlorophyll, are not able to independently synthesize organic matter, therefore they feed on a green plant on which they parasitize. This group also includes plants that feed themselves for part of their life, that is, they have the ability to photosynthesize. Such plants are called semi-parasites. These weeds parasitize on the roots or stems of cultivated plants—alfalfa, clover, sugar beet, sunflower - and other weeds (absinthium).

Stem parasites parasitize on the host plant stems. A typical representative of this group is the field dodder, the shoots of which appear from a depth of up to 4 centimeters, the sprouts make circular movements, finding and covering the stem of the host plant. If the suckers (austoria) touch the host plant, their connection with the soil ceases and their parasitic existence begins.

Root parasites (broomrape) — parasitize on the roots of the host plant. They have very small seeds that are easily carried by the wind and remain in the soil for up to 5 years. The parasite’s germ penetrates deep into the root of the host plant, forms suckers, and thickens outside the root. A stem-flower grows on the upper part of the thickening, and additional roots with suckers appear on the lower part. Up to 50 broomrape flower stalks can be formed on the root of one sunflower plant. They cause the death of the sunflower plant even before the formation of its inflorescence.

To control plant parasites, it is very important to observe the following:

- crop rotation schemes;
- high-quality soil cultivation;
- seed cleaning;
- quarantine;
- use of herbicides.

According to the life span, green plants are divided into annual and perennial.

Annual weeds, in turn, are divided into: ephemerals, spring (early and late), overwintering, winter and biennial.

Ephemeras are plants with a short growing season, during which they can produce several generations, which causes a strong clogging of the field. The most typical representative is stellaria media (chickweed).

Spring early weeds are plants whose seeds germinate in early spring. These include: wild oat, white goosefoot, wild buckwheat and others.

Spring late weeds - a large group of weeds, the seeds of which germinate at elevated temperatures (6-7°C), seedlings appear in late spring. Vegetation ends in the second half of summer. They are common in vegetable and row crop fields. These include cockspur (echinochloa crus-galli), white and common amaranth, common ragweed (ambrosia artemisiifolia), salsola and others.

The system of measures to control them is based on compliance with the crop rotation scheme, rational methods of mechanical soil cultivation, especially layer-by-layer cultivation of bare fallow.

Overwintering weeds are plants for which overwintering conditions are not mandatory. If their seedlings appear in autumn, they develop a rosette of leaves and a root system, thanks to which they overwinter. In early spring, they continue growing and form seeds before the cultivated plant is harvested. If their seedlings appear in spring, the full cycle of development ends in the current growing year. This group includes pennycress (thlaspi), cornflower (centaurea cyanus), forking larkspur (consolida regalis) and others.

Winter weeds are in long-term conditions of a gradual decrease in temperature at the first stages of their development. In contrast to overwintering weeds, for which overwintering conditions are not mandatory, these conditions are necessary for winter weeds. Common representatives of this group are field frome (Bromus arvensis), rye brome (Bromus secalinus), common windgrass (apera spica-venti) and others.

The main measures to control winter weeds are as follows: compliance with the correct scheme of crop rotation, thorough cleaning of seed material, application of herbicides.

Perennial weeds are a large group of plants that reproduce both by vegetative organs and seeds. They are the most difficult to control.

Perennial weeds cause the most damage. Unlike annual weeds, each plant can produce several generations of seeds during its lifetime.

Common types of perennial weeds are: fibrous, taproot, bulbous, creeping, rhizome, and root sprout.

Fibrous root weeds have powerfully developed filamentous roots. They reproduce mainly by seeds. The vegetative method of reproduction is less common. This group includes broadleaf plantain (Plantago major), buttercup (Ranunculus acris), autumn dandelion (Taraxacum hybernum) and others.

Taproot weeds have elongated and thickened main roots. This group includes common chicory (cichorium intybus), absinthium (artemisia absinthium), sorrel and others.

Creeping weeds have slender stems that root at nodes. They reproduce by stem shoots. This group includes creeping buttercup (ranunculus repens), silverweed (argentina anserine), and ground-ivy (glechoma hederacea). Such weeds are destroyed by mechanical tillage.

Bulbous weeds are an extremely small group of plants. These include round-headed leek (allium rotundum), field garlic (allium oleraceum) and others. These plants form thickenings on the roots, or main underground shoots, in which a significant supply of nutrients accumulates, and from which new plants appear after wintering.

Seeds are stored in the soil for a long time, but germinate slowly. Bulbous weeds reproduce by seeds and bulbs formed in the lower part of the stem.

Rhizome weeds. This group of weeds reproduces mainly by rhizomes - modified underground stems. Rhizomes are divided by nodes into internodes. Buds covered with scales form in the nodes. A viable bud is a future independent plant with a fibrous root system. Such weeds are extremely viable, difficult to eradicate, and cause significant damage, reducing yields and impairing their quality. The most common representatives of this group are: couch grass (elymus repens), field horsetail (equisetum arvense), yarrow (achillea millefolium) and others.

An effective method of controlling them, developed by V.R. Williams, is “strangulation” (harrowing). During the cross-cultivation of the fields, the rhizomes are cut into small particles by heavy disk harrows with well-sharpened working tools.

Root sprouts weed. Buds are formed on the roots of these weeds, especially on their lateral branches, from which independent, subsidiary sprouts grow. Sprouts are formed during the entire growing season. In a short period of time, a large mass of young sprouts is formed from one plant, creating solid thickets that completely damage cultivated plants. Common representatives of this biological group are: plume thistle, field bindweed, knotweed (quarantine weed), green spurge and others.

To fight rhizome weeds, the **exhaustion method** is effective, which consists in repeatedly cutting their root system to a greater and greater depth as the rosettes appear.

Weed control measures

The basis of weed control is the timely and high-quality performance of all agricultural operations.

It is important to observe the established alteration of crops in crop rotation, to implement a scientifically based complex of preventive and exterminating measures.

Preventive measures consist in inspecting seed material in the system of seed control and quarantine services.

The seed material is inspected and analyzed in laboratory conditions, the quality of the seed material must meet the requirements of the standard, and relevant documents are issued for it.

Quarantine is the application of precautionary measures on introducing from outside or limiting the spread of weeds that are absent in the country, or that are particularly harmful to certain regions and countries. External and internal quarantines are carried out by a special quarantine inspection. In Ukraine, external quarantin is established for the following species: ragweed, iva axillaris purch, solanum elaeagnifolium, helianthus californicus.

Internal quarantine is established for the following species: common ragweed (ambrosia artemisiifolia), perennial ragweed, giant ragweed (ambrosia trifida), solanum rostratum, all types of field dodder, cenchrus pauciflorus benth, helianthus lenticularus.

Equipping combine harvesters with special devices for catching weed seeds is also a precautionary measure.

Grain fodder contaminated with weed seeds should be ground and steamed.

It is necessary to destroy weeds before they form seeds on roadsides, wastelands, field boundaries, field protection forest strips, alienation lands.

A special precaution against the spread of weeds is to observe the alternation of crops in the crop rotation.

Assessment questions

1. Define the concept of "weeds"
2. Name the main classification groups of weeds.
3. List the weeds with a rhizome type of root system.
4. List the weeds with a root sprout type of root system.
5. What groups of measures are used to remove weeds from agricultural crop fields?
6. List the main agrotechnical measures for weed control.

Test tasks

1. Choose parasitic weeds from the list of plants:
1. Couch grass.
2. Dodder
3. White goosefoot.
4. Broomrape.

2. Select spring weeds from the list of plants:
1. Thistle.
2. White goosefoot.
3. Forking larkspur.
4. Common wild oat.

3. Choose winter weeds from the list of plants:
1. Amaranth.
2. Cockspur (echinochloa crus-galli)
3. Thistle.
4. White melilot (melilotus albus).

4. Select overwintering weeds from the list of plants:
1. Cleavers (Galium aparine).
2. Cornflower.
3. Wild Buckwheat.
4. Forking larkspur.

5. Rhizome weeds include:

1. Field bindweed.
2. Couch grass.
3. Rumex acetosella.
4. Field horsetail.

6. An effective way to clean the field from rhizome weeds is:
1. The exhaustion method.
2. Deep ploughing.
3. The " strangulation" method
4. Disking.

7. An effective method of cleaning the field from root sprout weeds (thistles, field birch) is:
1. Deep ploughing.
2. Cultivation.
3. The " strangulation" method
4. Exhaustion method

1.2.3 Tillage

Tillage is a mechanical action on soil by the working parts of machines and tools, which should ensure:

- creating a loosened arable layer;
- regulation of water, air, heat and nutrient regimes of the soil;
- optimal conditions for the development of the root system of agricultural plants;
- destruction of weeds, pests and pathogens of cultivated plants;
- wrapping post-harvest residues, organic and mineral fertilizers in the soil;
- soil protection from water and wind erosion;
- ensuring the conditions for seed wrapping to the optimal depth;
- crop care.

The fulfillment of these tasks is ensured by the technological processes of soil cultivation: overturning, spudding, crumbling, mixing, leveling and ramming.

The upper, more fertile, but more dispersed part of the top-soil layer moves down, and the lower part is brought to the surface. Overturning of the top layer of soil is carried out with plows with shelves. This technological process provides wrapping of organic and mineral fertilizers, post-harvest residues, weed seeds, pathogens and pests of agricultural crops to the required depth.

To reduce the size of soil aggregates and change their relative location, loosening and crumbling are used, which helps to increase the porosity and decrease the density of the soil. Thanks to this, water and air permeability, the vital activity of aerobic microorganisms and the conditions for the development of plant roots are improved. Spudding the top layer of the soil creates a sealing layer at a certain depth, which is also destroyed, which protects the soil from drying out. This process is carried out with tillage tools.

Thanks to the mixing, a homogeneous layer of soil is created; fertilizers, lime, and gypsum are distributed in it evenly, which is necessary for the uniform growth and development of plants. The soil is mixed with **mills**. Leveling the soil surface with **harrows** and other tools reduces moisture evaporation, creates better conditions for sowing, plant care and harvesting.

Soil **ramming** is used to increase capillary porosity and reduce non-capillary porosity. It contributes to the optimal wrapping of seeds to the optimal depth, in arid conditions it reduces diffuse evaporation of moisture and prevents root damage and plant displacement. The soil is compacted with **rollers.**

Soil tillage technique is a one-time action on the soil by tillage machines and tools. The following methods of soil cultivation are carried out.

Ploughing ensures overturning, crumbling and loosening of the soil layer and pruning of the underground part of plants.

Ploughing is carried out in the established agrotechnical terms, under the condition of physical maturity of the soil, at a humidity of 40 - 60% of the lowest moisture content. That is, when the soil is not smeared, not sprayed and crumbles well. When ploughing overmoistened or overdried soil, large blocks are created.

The depth of ploughing depends on soil and climatic conditions, biological characteristics of cultivated crops, presence of weeds, etc. Ploughing up to a depth of 20 cm is called shallow, 20-24 cm – medium, more than 24 cm - deep, over 40 cm - plantage.

Ploughing to a depth of 28-30 cm is recommended for root crops, 25-27 cm - for corn, sunflower and vegetable crops, and 20-22 cm - for corn, etc.

Scuffling provides spudding, partial turning and mixing of the soil, trimming of weeds, wrapping of post-harvest residues, pests and pathogens of agricultural crops. It is carried out with **disc and share scuffers** to a depth of 4 to 14 cm after harvesting the previous crop.

Cultivation is a technique that provides loosening and mixing of the soil and trimming of weeds. It is done with **cultivators**.

Harrowing ensures spudding, mixing and leveling of the soil surface and partial destruction of weed seedlings and sprouts. Its main task is crushing lumps, destroying the soil crust, leveling ridges. Harrowing is carried out with spike-tooth, needle, disc, mesh and spring harrows.

Smoothing is carried out to level the surface of the field and partially loosen the top layer of the soil.

By **packing**, the soil is compacted, the blocks are crushed and the soil surface is leveled. It is used to combat plant bulging and wind shifting of seeds. Pre- and post-sowing packing in arid conditions contributes to the inflow of moisture from the lower layers of the soil to the upper ones and ensures better contact of seeds with the soil, which increases germination and accelerates growing.

Milling spudds and mixes the soil layer, which is processed during the development of swamp soils, improvement of meadows and pastures for post-harvest and post-mowing crops.

1.2.4 Tillage systems

The soil tillage system is a set of scientifically based tillage techniques for crops in crop rotation. The following tillage systems are classified: main (fall-plough), pre-sowing for spring and winter crops, post-sowing tillage and anti-erosion one.

Fall-plough tillage is carried out in the summer-autumn period. Its tasks include: preservation and accumulation of moisture from summer-autumn precipitation and spring meltwater, improvement of physical properties of the soil, creation of favorable conditions for the life of soil microorganisms, and accumulation of nutrients for plants. This is an effective method of combating weeds, pests and diseases of agricultural crops. The scheme of carrying out the main tillage changes depending on the predecessor.

Tillage after stubble precursors (wheat, rye, barley, oats, etc.) consists of husking the stubble-field and subsequent ploughing.

Scuffling is carried out immediately after harvesting crops, still on wet soil, which ensures good loosening of it and creates better conditions for rapid germination of weeds and high-quality ploughing.

If the field is clogged with annual weeds, scuffling is carried out at 6-8 cm, with perennial weeds - at 10-12 cm. If the field is clogged with heather, the soil is worked with disc tools in two directions to the depth of the main mass of rhizomes.

2-3 weeks after scuffling and emergence of weeds, the soil is plowed for frost. Early ploughing is considered more effective, which contributes to the improvement of thermal and water-air regimes, a more active microbiological process, and the accumulation of nutrients in a form available to plants.

Depending on the type of soil and biological characteristics of plants, the depth of ploughing varies. Ploughing is carried out to different depths - multi-depth ploughing creates optimal conditions for the development of cultivated plants and helps increase soil fertility.

Semi-steam fallow tillage is carried out in areas of sufficient moisture with a long autumn warm period. In August, the soil is plowed with simultaneous harrowing. As weeds germinate, the soil ramming is carried out two or three times more often then cultivation and harrowing.

Improved tillage is used to combat rhizome perennial weeds. It consists in post-harvest disking to a depth of 6-8 cm and surface (after 2-3 weeks) peeling with plowshare peelers to a depth of 12-14 cm with simultaneous harrowing. Autumn ploughing is carried out at the beginning of October - in the second half.

Pre-sowing soil tillage for spring crops consists of early spring spudding of the soil (closing of moisture) and cultivation soil before sowing (cultivation, deep spudding and rolling).

Closing the moisture is early spring harrowing of the sedge to preserve moisture in the soil. It is carried out by harrows in a unit with loops.

Pre-sowing soil tillage contributes to the creation of favorable conditions for seed wrapping and friendly germination. To perform these tasks, pre-sowing cultivation is carried out to the depth of seed wrapping with cultivators with cutting paws, which ensures uniform loosening of the soil and destruction of weed seedlings and rosettes, on heavy and moistened soils. Cultivation is carried out by cultivators with spudding paws. As a rule, one cultivation is carried out for early spring crops, two for late ones. The first - deeper, the second, before sowing, to the depth of seed wrapping. Cultivation is carried out with simultaneous harrowing. In areas with sufficient moisture, pre-sowing cultivation is carried out to a depth of 6-8 cm, on compacted soils - to a depth of 10-12 cm. Only in some cases, ploughing is carried out for late crops.

In order to ramm the soil, reduce the shine, level the surface and improve the water regime of the seed layer of the soil, a gap between pre-sowing treatment and sowing should not be allowed, as this leads to loss of moisture and weeding of crops.

Tillage for winter crops is carried out depending on the soil and climatic conditions, the predecessor and weed contamination of the soil.

1.2.5 Tillage in conditions of water and wind erosion

The basis of the fight against soil erosion is a set of agrotechnical, organizational, economic and meliorational measures.

The group of agrotechnical works includes tillage of the soil, which is aimed at retaining meltwater in the spring and rainwater in the summer.

On slopes, it is necessary to cultivate the soil across or in the horizontal direction. It has been proven that ploughing across a slope with a steepness of more than 30 times reduces soil erosion and increases the moisture reserve in a meter-long soil layer by 150-200 t/ha compared to longitudinal ploughing. With such ploughing, grain yield increases by 2-3 t/ha.

The choice of the method of tilling the soil to a certain depth is of great importance. Reversible shuttle plows are used on slopes steeper than 8°.

Effective and combined (staged) ploughing. To do this, one bottom with an elongated shelf is attached to the plow, which forms an earthen ridge. During such ploughing, the field alternates narrow earthen ridges with smooth wide strips that delay the flow of water. Effective and intermittent harrowing with a plow with special devices for intermittent harrowing and hilling of the autumn ploughing.

In water erosion control on meadows and pastures, an effective tool is a tamer, which is used to cut slits across the slope 50-60 cm deep. The melt water fills the slits, reducing the flow of water down the slopes. Grafting is carried out on crops of winter crops, perennial grasses and other crops.

The development of water erosion of the soil is prevented by tillage, when the stubble are left on the surface.

In arid areas, a wide variety of tillage is used to combat wind erosion. The main cause of wind erosion is the degradation of the vegetation cover of the soil and the scattering of its upper layer. Field ploughing with stubble wrapping causes the development of wind erosion. It has been established that stubble reduces the force of the wind, contributes to the accumulation of snow and reduces the freezing of the soil. To preserve the stubble during tillage, flat cutters-deep scarifier are used, which make it possible to keep up to 80% of the stubble on the surface and spud the soil well without spraying it.

For pre-sowing soil cultivation, a land clearer is used. Spring closing of moisture and autumn processing of stubble predecessors is carried out with a needle harrow. In crop rotations, it is necessary to use shelf, flat-cut and surface tillage of various depths. Scientists have proven that intensive cultivation, the use of heavy tractors and agricultural machines worsen the agrophysical properties of the soil and reduce its anti-erosion resistance. It has been established that each soil has its own density (volumetric mass of the soil), to which it is able to compact under the influence of its own weight, rainfall, during the operation of tractors, agricultural machines, etc. For most field plants, it is within 1.1-1.3 g/cm3. Optimal indicators of soil density vary depending on its mechanical composition, humus content, and biological characteristics of plants. In recent years, minimization of tillage has been implemented, the number of tillages has decreased.

There are the following main directions of minimization of cultivation - reduction of the amount and depth of soil cultivation:

- reducing the number and depth of tillage when growing winter and spring crops. For this, in the conditions of soil preparation for winter wheat after peas and corn for silage in conditions of high agricultural culture, surface cultivation is carried out instead of ploughing, which contributes to a greater accumulation of moisture in the arable layer, the appearance of friendly and well-developed seedlings, reduces the time and costs of preparation of the soil before sowing;
- reduction of the number of pre-sowing cultivations under the spring crop by autumn ploughing and carrying out surface treatment instead of ploughing during soil preparation for the spring crop;
- combining several operations in one process. For this, combined units are used, which combine the operations of pre-sowing cultivation, sowing, application of fertilizers and herbicides.
- minimization of soil tillage when caring for row crops and clean pairs due to the use of highly effective herbicides.

Assessment questions

1. Ground the concept of "tillage".
2. Describe the basis of the task of methods of soil cultivation (ploughing, scuffling, cultivation, harrowing, screeding, packing, milling).
3. What does the concept of "tillage system" include?
4. What are the features of soil cultivation in conditions of wind and

water erosion.

Test tasks

1. The main purpose of tillage is:

1. Creation of optimal soil conditions for the growth and development of agricultural crops.

2. Mutual movement of the upper and lower soil layers.

3. Regulation of water, thermal, nutritional regimes.

4. Ramming of the top layer of the soil.

5. Improving the physical properties of the soil.

2. Ploughing, as a measure of soil cultivation, includes the following processes:

1. Mixing.

2. Ramming and alignment.

3. Overturning.

4. All technological processes except ramming and leveling.

5. Spudding.

3. The set of science-based soil cultivation measures for crop rotation is:

1. Minimization of tillage.

2. Basic tillage.

3. Soil cultivation system.

4. Mechanical tillage of the soil.

5. None of the above.

4. The choice of tillage does not depend on:

1. Predecessor.

2. Soil and climatic conditions.

3. Clogging of the soil with weeds, pests, pathogens.

4. Average field area in crop rotation.

1.3 Agrochemistry

1.3.1 Fertilizers and their application

Most crops consist of 80-95% water and 5-20% dry matter. This ratio depends on the age, and more precisely, on the phase of plant growth and development. Dry matter contains: carbon — 45%, oxygen — 42%; hydrogen - 6.5; nitrogen 1.5-5; ash - 5-12%. The content of various elements depends significantly on the type of plants. Thus, grain and vegetative mass of legumes contain more nitrogen than cereals, and seeds always contain more nitrogen and phosphorus than straw.

Soil and climatic conditions, variety, fertilizers significantly affect their chemical composition.

Thus, winter wheat grain grown in Polissia contains less nitrogen than that grown in the Steppe or Forest Steppe. Potatoes with a high starch content can be obtained on sandy and light loamy soils.

According to the plants' need for nutrients, all agricultural crops can be conventionally divided into three main groups: crops with a high removal of nutrients (sugar and fodder beets, cabbage, potatoes, etc.); medium (wheat, sunflower); and low removal (oats, barley, varietal characteristics and weather conditions are important in this case. Intensive varieties need much more nutrients than ordinary varieties. In dry years, the removal of elements is always less than in years with favorable conditions for moisture.

Each plant has its own characteristics regarding the need for nutrients. Thus, winter wheat is in great need of nitrogen in early spring, in the phase of emergence into the tube and during earing. Phosphorus is needed by almost all plants at the beginning of the growing season of potash and boron - during flowering. These features must be taken into account when developing a crop fertilization system.

1.3.2 Physiological role of basic elements in plant nutrition

Depending on the amount of chemical elements needed by plants, they are conditionally divided into macro-, micro- and ultra-microelements. Macronutrients include nitrogen, phosphorus, potassium, calcium, and sulfur. To microelements belong copper, manganese, boron, zinc, etc., to ultramicroelements belong gold, silver, cesium, rubidium, strontium, etc. Each of them performs one or another function in metabolic processes and therefore cannot be replaced by another.

Nitrogen greatly affects growth processes, accelerating the growth of vegetative mass, due to which it is often called a growth element. An excess of nitrogen in the mineral nutrition of plants leads to excessive growth of vegetative organs, which reduces resistance against unfavorable growing conditions, negatively affects flowering, fertilization and the formation of reproductive organs. Potatoes, sugar beets, sunflower and some vegetable crops also react negatively to an excessive amount of nitrogen in mineral nutrition. An excess of nitrogen deteriorates the quality of the harvest of many agricultural crops.

When it is lacking, growth slows down, leaves become pale green, vegetative mass grows slowly, plants are smaller, metabolism is disturbed, photosynthesis is inhibited, and as a result, plant productivity decreases.

Nitrogen fertilizers are applied to prevent nitrogen deficiency. The best of them are ammonium nitrate and calurea.

Phosphorus is needed by plants for normal respiration, fermentation and photosynthesis.

It is important in the processes of metabolism of carbohydrates and nitrogenous substances. Phosphorus accelerates the transition from vegetative growth to generative development, promotes the formation of reproductive organs and ripening of seeds. Phosphorus nutrition has a positive effect on increasing drought resistance and winter resistance of plants, while phosphorus starvation inhibits the growth of vegetative organs and seed formation. Its signs are corrugation and curling of the leaves at the edges, the appearance of purple-reddish spots on the leaf plates, and the dying of the tissue.

Potassium increases the drought resistance and frost resistance of plants, has a positive effect on photosynthesis and the formation of organic substances (proteins, starch, fats), reduces the lodging of grain crops and increases the resistance of plants against fungal diseases. Signs of insufficient potassium nutrition in plants are yellowing, subsequent browning and dying of the leaves’ edges. This can be prevented by applying potash fertilizers. Root and tuber crops, sunflower, buckwheat, flax, tobacco, clover, alfalfa, vegetable crops, etc. respond well to them.

Agricultural crops, especially legumes, require a large amount of **calcium**. It positively affects the development of the root system, neutralizes organic acids, reduces the hydrophilicity of colloids and the level of hydration of protoplasm, contributes to the supply of boron, manganese, molybdenum and other trace elements to plants, activates the activity of beneficial microflora, etc.

In case of calcium deficiency, chlorosis is observed, the roots become slimy, the metabolism is disturbed, which reduces plant productivity. Calcium is especially important for soils with an acidic environment.

Magnesium, as a component of chlorophyll, takes part in photosynthesis.

Its deficiency on light soils causes "marble" chlorosis of leaves.

Manganese takes part in nitrogen nutrition, (influences the reduction of the content of proteins, carbohydrates), plant productivity, in the processes of photosynthesis and plant respiration. The plants' need for manganese is determined by its removal with the harvest, which is from 0.35 to 4.5 kg/ha.

Boron. In the case of a deficiency of this element, the growth points of plants die. Beets are affected by core rot, potatoes, scab, and linseed blight. Various crops with a harvest carry 30-270 g/ha of boron.

The application of phosphorus and lime increases the plants' need for boric fertilizers. This element in the plant is associated with carbohydrate, protein and nucleic exchange, in the plant it promotes fertilization, prevents the fall of the ovary and accelerates the development of reproductive organs. Exaggerated levels of boron are harmful for plants, as evidenced by the appearance of burns, browning, and significant shedding of the lower leaves.

Copper is a component of many enzymes, has a positive effect on photosynthesis, carbohydrate and protein metabolism in plants. Deficiency of copper is manifested by the characteristic whitening of the tips of the leaves and empty grain in cereals, dry top in fruit. Various crops yield from 10 to 170 g/ha of copper.

Flax, hemp, sugar beet and cereals respond the most to its application. Copper sulfate and pyrite slag are more often used as fertilizers.

Molybdenum takes part in the assimilation of atmospheric nitrogen. Molybdenum fertilizers are mainly used to fertilize leguminous crops. In modern agriculture, ammonium molybdate and molybdenized superphosphate are used.

1.3.3 Organic fertilizers

Organic fertilizers include dung, urine and liquid manure, bird dung, peat, peat composts, organic waste from cities and settlements, green manure, etc. They contain a significant amount of elements needed by plants: nitrogen, phosphorus, potassium and micro- and ultra-microelements: boron, manganese, copper, zinc, gold, silver, etc. Organic fertilizers are not only a source of nutrition for plants, but also an effective means of improving the water-physical, agrochemical and biological properties of the soil-(Table 2).

Thus, as a result of applying organic fertilizers, soils that are light in terms of mechanical composition become more cohesive, heavy soils become looser.

The main organic fertilizer is dung (Table 2). In the Polissia, it is applied in 3-4, in the Forest Steppe in 2-3, and in the Steppe - in 1-2 fields of crop rotation.

Dung should be applied under the main tillage and plowed immediately.

Table 2

Content of basic nutrients in organic fertilizers, %

(by M.M. Horodnyi, 2003)

Fertilizers	General nitrogen	Phosphorus	Potassium
Mixed dung	0,48	0,22	0,50

Liquid dung	0,40	0,20	0,45
Reed-sedge peat	1,97	0,37	0,12
Manure compost (manure 90%, earth 10%)	0,32	0,21	0,54
Cattle urine	0,60	0,01	0,50
Liquid manure	0,22	0,01	0,46
Sideral fertilizer: green mass of lupine	0,45	0,10	0,17

Dung is applied under winter wheat, corn, sugar beets, potatoes, cabbage, cucumbers, and other crops in crop rotation, preferably under black or busy fallow.

1.3.4 Mineral fertilizers, their characteristics

Depending on the content of the main nutrient, mineral fertilizers are divided into nitrogen, phosphorus and potassium.

Nitrogen fertilizers.

The most common ammonium nitrate contains 34-35% nitrogen. It is a fine-crystalline, powdery or granular substance that is mostly white in color. Easily soluble in water, quickly absorbed by plants. It should be remembered that the fertilizer dehydrates and clumps. It is used as the main, pre-sowing, drilling fertilizer and top dressing on most types of soil.

Urea is a highly concentrated fertilizer, containing 45-46% nitrogen.

It dissolves well in water, almost does not clump. It is one of the best nitrogen fertilizers. It is applied to the soil, as well as non-root (through the leaves) feeding of plants. It is important as a valuable feed additive in animal husbandry.

Ammonium sulfate contains 20-22% nitrogen - it is a crystalline, powdery white or grayish substance characterized by low hygroscopicity and good solubility in water. It does not clump, spreads well. It is more effective on the carbonate soils of the Steppe and Forest Steppe. In Polissia, the soil must be limed before its introduction.

Ammonia water is an aqueous solution of ammonia, the nitrogen content is 16-20.5%. It is necessary to introduce ammonia water into the soil to a depth of 12-15 cm with the help of cultivators-fertilizers, or herbicide-ammonia machine.

Phosphorous fertilizers.

The most common phosphorus fertilizer is superphosphate. It has a white color with a grayish tint.

Simple granular and double superphosphates containing 19.5 and 45-50% of the active substance are produced by the chemical industry. Both types dissolve in water and citric acid and are well absorbed by plants. Superphosphate is used for all agricultural crops as the main and pre-sowing fertilizer in the rows and in top dressing. It is especially effective to apply it in the steppe and in the forest-steppe on carbonate soils.

Phosphorite flour is a gray, sometimes brownish powder. It contains 10-38% phosphorus, does not dissolve in water. It has good physical properties and is available for plants. It is used on acidic soils as the main fertilizer. Phosphorite flour is not very effective in the south of Ukraine.

Bessemer slag is close to phosphorite flour in terms of properties, conditions of use and effectiveness.

Potassium fertilizers.

Potassium chloride is a white crystalline substance, contains 52-60% of the active substance, does not clump, and disperses well. It contains a relatively small amount of chlorine, which makes it possible to use it for potatoes, vegetable crops, grapes, tobacco, flax and other crops, the quality of which deteriorates under the influence of chlorine.

Potassium sulfate is a fine-crystalline salt that is easily dispersed, does not recover, and clumps together. This is a highly concentrated chlorine-free fertilizer. The potassium content is 45-60%.

Mixed potassium salts are also used, which are made by mixing finely ground sylvinite and kainite with potassium chloride.

Such a mixture contains 30-40% potassium.

They are applied to various crops, including sugar beets.

Complex fertilizers

Fertilizers containing two or more nutrients are called complex. These include ammophos, diamophos, nitrophos, various tocomixtures, etc. In production conditions, nitrophos with a ratio of nitrogen, phosphorus and potassium, %: 12:12:12 and 15-17:15-17:15-17 are preferred; nitroamophos-20:20:0, nitrophos 21:14:0, ammophos 12:5.0:0.

Complex fertilizers affect the yield of crops in the same way as the corresponding mixtures of simple fertilizers.

Liquid complex fertilizers (LCF): a relatively new type of fertilizers, which include nitrogen (10%) and phosphorus (34%). They can be supplemented, if necessary, with trace elements, biostimulants, herbicides.

It has been proven that the use of LCF for fertilizing agricultural crops has an advantage and is not inferior in effectiveness to solid mineral ones.

Mineral fertilizers are applied in different ways - under ploughing, in rows (during sowing), under cultivation (before sowing) and in top dressing (during vegetation). It has been proven that the most expedient method of applying fertilizers in many cases is the main application. Due to fertilizers, on average, you can get about 40-50% increase in yield.

Assessment questions

1. The importance of fertilizers in increasing soil fertility.
2. Types of organic fertilizers. Their meaning and use.
3. Green (green manure/cover crop), their use.
4. Name the green manure/cover crop, the technology of their cultivation for green manure.

5. Nitrogen fertilizers, their types, meaning.
6. Importance of phosphorus fertilizers, their types, features of use.
7. Potash fertilizers, their types, features of use.
8. Microfertilizers, their types, features of use.
9. Bacterial fertilizers, their significance.
10. Liming of acidic soils.
11. Plastering of saline soils.

Test tasks

1. Double superphosphate belongs to which group of phosphorus fertilizers:
1. Single-substituted phosphorus fertilizers.
2. Disubstituted phosphorus fertilizers.
3. Three substituted phosphorus fertilizers.

2. Specify the main methods of applying phosphorus fertilizers.
1. In the main tillage.
2. Spring feeding.
3. Sowing application.
4. Feeding during the growing season.

3. Organic fertilizers include:
1. Phosphorite flour.
2. Manure.
3. Potassium magnesia.
4. Sideral fertilizer.

4. Effective on sod-podzolic soils are:
1. Molybdenum.
2. Copper.
3. Borny.
4. Zinc.

5. On chernozem soils, the most effective microfertilizer is:

1. Magnesium.
2. Nutramin.
3. Copper.
4. Molybdenum.

6. On peat soils, the most effective fertilizers are:
1. Manganese.
2. Nutramin.
3. Copper.
3. Zinc.

7. Choose from the list the best cultures - ciders for the Polissia zone:
1. Oats.
2. Peas.
3. Lupine.
4. Mustard.

1.4 Land Melioration

Melioration (in Latin melioratio - improvement)

The term "melioration" means the improvement of the natural properties of individual components of the environment - climate, soils, vegetation, relief. Among the components of the environment, land reclamations that improve water and land resources are the most significant in a practical sense.

Land reclamation is a system of organizational, economic, technological and economic measures aimed at long-term fundamental improvement of unfavorable natural properties and conditions of land to obtain consistently high yields of agricultural crops and environmental protection.

At the expense of meliorative improvement of land, water, air, heat and nutrient regimes of the soil favorable for agricultural plants are created. The regimes of humidity, temperature and air circulation in the surface layer of the atmosphere are improving.

In Ukraine, there is no optimal combination of climatic conditions necessary for intensive agricultural production.

A significant territory of Ukraine is characterized by excessive soil moisture. These are mainly swamps and wetlands, concentrated mainly in the Polissia and Forest-Steppe zones. Their area is about 5.0 million hectares.

Waterlogged lands are areas of dry land with excessive wetting of the soil with a layer of peat less than 30 cm or without it.

A swamp is a land area characterized by excessive soil moisture and the presence of a layer of peat in an undrained state more than 30 cm thick and 20 cm in a drained state.

Swamps are classified into **upland, lowland, transitional.**

Upland swamps are mainly located on watersheds and sandy river terraces. Their sources of hydration are rainwater and spring water. There are upland bogs in the Volyn and Zhytomyr regions.

Lowland swamps are located in the terraced part of river floodplains on supraflood terraces.

The uneven moisture supply of the territory of Ukraine causes droughts to occur once every four years, which cover large areas (territories), causing significant losses to the agricultural sector of the economy. Damage to winter crops, seedlings and berry trees in winter, etc. is observed.

The need for water and land reclamation, their nature, and methods of implementation depend on the natural conditions of the soil and climate zones of Ukraine: Polissia, Forest Steppe, Steppe, Crimean Mountains and Carpathians. Polissia and Step are most in need of reclamation measures.

The area of the **Polissia** zone is 19% of the territory of Ukraine. Average annual precipitation is 500-700 mm, evaporation - 400-450 mm. The excess of moisture led to the development of gilding and swamp processes of soil formation, the formation of forest, meadow and swamp vegetation. About 70% of wetlands are located in Polissia, which are characterized by low natural fertility.

The forest-steppe occupies 34% of the area of Ukraine. Its southern border is determined by the replacement of deep chernozems with ordinary chernozems. Average annual precipitation ranges from 600 mm in the west and north to 450-500 mm in the south and east. Evaporation is between 550 to 750 mm. This is a zone of unstable or periodically insufficient moisture. The natural conditions here are favorable for growing winter wheat and sugar beets. Soil erosion should be attributed to the negative.

The steppe makes up about 40% of the territory of Ukraine. There are the largest number of warm sunny days, the longest period of active biological processes and the least moisture. The average annual rainfall decreases from 450 mm in the north to 350-300 mm in the Black Sea region. In dry years, their amount decreases to 206-135 mm, including during the growing season to 23-53 mm. Annual evaporation is 900-1000 mm. The most common crop is winter wheat, rice is successfully grown on irrigated lands. This is a zone of insufficient moisture. Droughts, black storms, droughts are often observed here, soil salinity occurs.

Depending on the soil and climatic conditions, directions of technological and economic and organizational measures are determined in relation to the purposeful transformation of these regions into zones of stable agriculture.

The main measures to improve natural conditions in the Polissia zone are the drainage of lands and their irrigation in the Steppe.

Types of land reclamation. According to its effect on the soil and plants, land reclamation is divided into the following types: **agro-land reclamation** (agro-technical land reclamation) - aims at land improvement - a significant improvement of the agronomic properties of the soil by deepening the arable layer with a shallow humus horizon and low natural fertility. To improve the water regime of the soil, special techniques are used with the cutting of intermittent furrows, rolling, slitting, holes, etc., which prevents water runoff and snow removal in winter.

Chemical reclamation is aimed at improving the agrochemical and agrophysical properties of the soil - by liming acidic and plastering saline soils and adding other materials - defecate, peat, compost, manure, siderates, sapropel and others that enrich the soil with organic matter. The dynamics of works on liming and plastering of soils are presented in the table.

Table 3

Liming and plastering of soils by year

Indicator	1990	1995	2000	2001	2002	2003	2004	2005
Soil liming was carried out, thousand ha	1407,9	286,6	23,9	26,7	21,5	23,5	40,9	41,7
Limestone flour and other limestone materials were introduce, thousand tons	6930,7	1597,4	169,7	191,1	143,8	132,0	222,8	243,1
Gipsum of soils was carried out, thousand ha	285,4	18,1	5,1	3,6	5,0	1,6	3,8	2,7
Gypsum and other gypsum-containing rocks were introduce, thousand ha	1275,9	79,2	27,0	14,3	25,0	5,4	16,5	12,1

Hydrotechnical melioration (hydromelioration) aims to improve the water regime of a certain area with the help of drainage or irrigation. For this, large-scale hydrotechnical works are being carried out to create irrigation and drainage systems, reservoirs. In the arid regions of the Steppe, estuaries are widely used to retain meltwater. The areas of drained and irrigated lands during the years of agricultural reform are shown in the table.

Table 4

Area of drained and irrigated land

Indicator	Drained lands							Irrigated lands						
	1990	1995	2000	2002	2003	2004	2005	1990	1995	2000	2002	2003	2004	2005
Farms of all categories	3220	3299	3299	3291	3294	3294	3307	2601	2585	2408	2262	2208	2195	2183
including in agricultural enterprises *	3004	2693	2084	1764	1478	1345	1160	2600	2558	2203	1902	1743	1577	1517
Those, which are with closed drainage	2181	2025	1657	1423	1191	1093	933	X	x	x	x	x	x	x

* Without farms

In the zone of insufficient natural moisture, various methods of irrigation (irrigation) are used, in the zone of excess moisture - draining melioration.

Cultural and technical land reclamation - measures to cultivate land, to bring it to intensive agricultural use by clearing forest clearings, destroying small forests, bushes and thickets, etc., and creating highly productive pastures, intensive hayfields, fertile arable land.

Forestry amelioration (forest amelioration) is carried out with the aim of improving the water regime of the soil and microclimate, protecting the soil from the development of erosion by creating forest strips along the borders of crop rotation fields, on steep slopes in gullies and ravines, around water bodies, to fix sand.

Agromelioration measures are one of the methods of regulating the water regime of the soil. They are especially effective on heavy mineral soils. Agromelioration measures have different directions and are divided into two main types:

- measures to remove excess water (narrow ploughing, selective harrowing, planting beds, formation of ridges, profiling);
- measures to accumulate moisture useful for agricultural plants in the soil (tilling, deepening of the arable layer, deep spudding, chiseling, slitting).

They are carried out as follows.

Narrow-row ploughing (row width 12-20 m) is performed every time the field is plowed with conventional multi-hull plows. On the drainage area, disconnecting furrows are laid, which serve as the smallest elements of the drainage network.

Selective harrowing is used in areas with a pronounced microrelief arrangement of a network of furrows in low places.

The arrangement of ridges (growing crops on ridges) aims to divert surface water, accelerate drying and warming of the soil. The formation of ridges is carried out before sowing or after sowing, depending on the type of crop, with tractor harrows. When growing beets and corn, ridges are arranged before sowing, placing them according to the direction of the slope of the terrain.

Cutting of ridges is carried out in spring or autumn with simultaneous application of fertilizers.

Excessive wetting of the soil can be prevented by seeding (sowing in beds). Beds with a width of 2.8-3.5 m are piled for corn and potatoes with a plow, for vegetable crops with a bed-former.

Profiling of the soil surface is carried out in very wet places with a flat micro-sag of the soil relief, forming convex profiles of the corrals. For a paddock width of 12 m, the required profile convexity is obtained with two ploughing, and for a width of 20 m - three ploughing.

Effective agromelioration measures for the accumulation and preservation of moisture in the soil include:

Packing - used on heavy clay and loamy soils that do not contain stones. During taming, mole holes are laid every 1.0-1.5 m to a depth of 35-40 cm simultaneously with ploughing or separately. During ploughing, packing is carried out by a cultivator attached to the second body of the tractor plow.

Packing as an independent operation is carried out mainly on sown and natural meadows. It is better to carry it out in conjunction with closed drainage. Closed potter's drains are laid before the ploughing across the direction of ploughing. They fall into collectors. A distinctive feature of mole drainage compared to mole removal is that it is carried out only in mole-resistant soils, has a large pipe diameter (8-12 cm) and is placed less frequently (4-8 cm).

Packing improves the water and air regimes of the soil, which contributes to the growth of crop yields.

Under conditions of dense placement and small depth of molehills, they provide a more uniform regime of soil moisture during the growing season, increase the water permeability of arable and subsoil soil horizons. At the same time, the soil reaches spring sowing faster. Molehills contribute to the increase in soil temperature, the activation of the vital activity of microorganisms, the decomposition of organic matter and the rapid transition of nutrients into forms available to plants. Thanks to this, conditions are created for the most favorable development of agricultural plants and the growth of their productivity by 25-30 cents.

Deepening of the top-soil is carried out during ploughing by means of gradual ploughing of the subsoil layer (up to 3-5 cm in one step) with simultaneous loosening. On the cultivated arable layer, plant roots penetrate the soil to a greater depth, which contributes to a better use of water and nutrients by agricultural crops. A strong structural arable layer better accumulates moisture and preserves it in the dry season. Research has established that a 30-40 cm thick layer of soil can absorb and retain (without excessive wetting) 30-50% of melt water.

Spudding the podzolic horizon and mixing it with the upper layer increases the porosity of the soil, which contributes to the rapid penetration of water into the soil.

The best period for deepening the arable soil layer is autumn. However, it is better to spend it on light soils in the spring.

It is better to regulate the water regime of temporarily overmoistened soils by combining agromelioration and hydromelioration measures. Depending on the location of the land, the method of surface runoff regulation is chosen, namely, at the water intake - by agrotechnical and forest improvement measures, on the slopes - by a system of terraces, at the foot of the slope - by mountain channels or reservoirs. In some cases, simultaneous use of the above-mentioned measures is possible.

Terraces on the slopes of the water intake are used to retain and absorb stormwater into the soil. They are arranged in stages along the length of the slope, depending on its steepness, with a width of 5-30 cm. The disadvantage of this method is too high operating costs for the maintenance of terraces and recesses and the difficulty in mechanizing these works.

Reservoirs for regulating surface runoff are placed, depending on local conditions, at the entrance of the thalweg to the plain, or in the form of a cascade along the length of the thalweg. The costs for the construction of the reservoir are justified on the condition that the drainage areas will be used for planting high-yielding crops and on large areas. Reservoirs on rivers can also be used for hydropower and transport purposes.

A significant disadvantage of reservoirs is the covering of large areas with water, the need to take additional measures against soil flooding in the upper part of the reservoirs and in order to improve the water and nutrient regimes of floodplains in the lower part.

1.4.1 Requirements of agricultural crops to the water-air regime of the soil

For normal growth and development, the plant needs heat, light, nutrients, water and air. All these factors are mutually irreplaceable. The optimal water regime of the soil, which is determined by the requirements of agricultural crops, is characterized by the following indicators: moisture and aeration of the soil, the regime of the depth of groundwater levels, the permissible period of flooding of the soil and crops.

Soil moisture. The upper limit of optimal soil moisture is determined by the degree of its aeration. It was established that when growing perennial grasses, the aeration of the active layer of the soil should be within 18-21%, cereals - 25-30, row crops - 30-35%. Therefore, the upper limit of optimal humidity or the lowest moisture capacity (nV) of the active soil layer for perennial grasses is about 79-82%. grain crops - 70-75 and row crops - 65-70% of the lowest moisture content.

The soil moisture at which the movement of soil moisture to the place of water consumption stops during evaporation is called **«capillary break moisture»**. It corresponds to the lower limit of optimal soil moisture for agricultural crops.

A decrease in humidity beyond the critical limit causes an increase absorption power of plants, a decrease in its transpiration, an increase in the concentration of cell juice, leads to a decrease in the productivity of photosynthesis of agricultural crops.

For row crops, the lower limit of optimal humidity of the active soil layer should be within 50-55% RH and 60-65% RH for perennial grasses.

Maintaining the moisture content of the active soil layer within the limits of the HB-VRK is the main task to be solved by hydromeliotrators.

Drainage rate. Creation of optimal humidity and soil aeration on drained lands in accordance with the **biological requirements** of plants is achieved by regulating groundwater levels, irrigation or their combination.

According to the definition of O.M. Kostyakov, the level of groundwater, which provides the most favorable water-air regime of the soil during the growing season of agricultural crops, is called the **rate of drainage.** It changes from its smallest value before sowing the crop to its largest at the end of the growing season. On well-decomposed and cultivated peatlands, groundwater should be maintained at a deeper level than on non-decomposed and light soils. In dry vegetation periods, the drainage rate is reduced by approximately 5 cm, and in wet periods - increased by 10 cm. In the non-vegetation period, the groundwater level should not rise above 50-60 cm.

With excessive precipitation in summer or autumn and stagnation of meltwater in the spring, fields are flooded, which can negatively affect the yield of agricultural crops. The permissible duration of inundation of meadows and pastures with flood waters depends on the botanical composition of the grass stand. According to these indicators, grasses can be divided into the following groups: 1) very sensitive to flooding for more than 5-8 days (alfalfa, meadow clover, red awnchaff, asparagus, darnel); 2) those that can withstand flooding for up to 12-15 days (meadow sedge, pink clover); 3) those that can withstand flooding for up to 18-25 days (black grass, brome), 4) those that can withstand long-term flooding for up to 30-40 days (canary, common beechmania).

Flooding of winter grain crops in the spring is not allowed.

In the summer-autumn period, the period of removal of water from the soil surface should not exceed 0.5 days for grain crops, 0.8 for row crops, and 1.5 days for perennial grasses; from a soil layer of 0-25 cm — 1.2, respectively; 1.5; 3.1 days; from the soil layer 0-50 cm — 2, 3 and 4 days.

When carrying out drainage reclamation, it is important to take into account not only the biological features of plants, but also the **requirements of agricultural production**. The main ones are: the elimination of the small contours of land, the creation of rectangular fields with an aspect ratio of 1:2 — 1:5, if possible, and on the borders of fields or in the middle of separate forest areas, ponds, the reduction of land allocated for hydrotechnical buildings; placement of roads, power lines, communications along crop rotation boundaries, along canals; the meliorative system should have a reliable source of additional moisture, ensure environmental protection.

1.4.2 Drainage and water-air regulation regime of drained lands

Drainage reclamation is a set of measures aimed at regulating the water-air regime of overwetted lands in order to create favorable conditions for the growth and development of agricultural crops. Therefore, it is important to establish the causes of excess moisture, sources of water supply and to determine measures or methods of drying. The following drainage methods are used: acceleration of surface runoff, lowering of the groundwater level, acceleration of runoff through the arable layer, protection of drained lands from the inflow of surface and underground water, acceleration of water filtration into the subsoil layer, protection of the territory from flooding or inundation by the waters of rivers and lakes, reservoir. Each of the listed methods of drainage is aimed at increasing the expendable elements of the water balance and reducing the profitable ones. Due to the fact that the causes of excess wetting of land are diverse, there is a need to carry out drainage of areas not by one, but by a combination of several methods of drainage.

Drainage methods determine a set of engineering and agrotechnical measures, with the help of which the task of draining a given territory is solved. Depending on the type of water supply, geological and soil conditions and economic use of drained lands, the following drainage methods are used: a network of open channels; closed systematic material drainage; rarefied buried drainage in combination with agromelioration measures; open drainage in combination with closed drainage (material or mole); selective closed drainage; sparse system of open thalweg channels; protective network of mountain channels and catch drains; land collapse; agromelioration measures without the installation of a permanent drainage network; vertical drainage. Due to the significant diversity of natural and economic lands to be drained, several methods of drying are used at one facility. The choice of one or another method of drainage involves not only the adoption of the main method of drainage, but also economic justification and requirements for the mechanization of production processes on reclaimed lands.

The choice of the type of drainage system depends on the methods of regulating the water regime of the soil. The following meliorative systems can be built on **drained lands**: **drainage systems**, which provide for the removal of excess water through drains and a system of open channels into a water receiver; **drying and humidifying plants**, where the internal flow is delayed with the help of regulator sluices, additional water is supplied and redistributed between different fields; **drainage and irrigation systems**, which provide for irrigation with sprinklers of various brands; **drying-moistening plants combined with the use of sprinkling**, which are technically the most perfect and are used as well as drying-irrigation plants regardless of the topography of the area and with the necessary set of crops in the crop rotation; **draining on embanked lands (polder)**, where drainage is carried out with the help of various drainage by means of mechanical pumping of water.

Reclamation systems with regulation of the water regime of the soil can be **reversible**, which ensure the accumulation of drainage water enriched with nutrients washed out of the soil in special reservoirs, so that when crops are not needed, the water is fed into the irrigation or irrigation network for reuse. Such systems are the most promising.

Two-way systems with subsoil moistening — sluicing, which occupied more than 1.2 million hectares in previous years, are very common in Ukraine. Such systems have significant advantages over systems with one-sided drainage and allow regulating the water-air regime of the active soil layer within optimal limits for agricultural crops. However, these systems also have disadvantages: unevenness of moistening along the fields, especially with an uneven surface; the difficulty of ensuring drainage standards for various crop rotations, the possible leaching of nutrients into groundwater and their subsequent pollution; unsatisfactory moistening of the surface layer of the soil;

significantly greater need of water for irrigation (more than three times) compared to sprinkling.

Theoretical developments and practical experience of land reclamation show that drainage and irrigation (with sprinkling) systems with a water return cycle should be built on most drained lands in the near future.

Drainage systems of two-way action include: a reclamation area, a water receiver, an open network of channels (fishing, mountain, collection collectors, main), hydrotechnical structures and a closed drainage network (drainage).

Water receiver - in most cases, these are large and small rivers, sometimes ponds and lakes, which have a source of water. The main purpose of the water receiver is to receive and drain water from the drained area in a timely manner. In cases of water backup from the side of the water receiver, it is pumped out by machine, for which pumping stations and dams are built in advance (Irpinska, Trubizka, Tyasminska, etc.).

The supply canal is laid on the lowest relief elements. In floodplains, this channel is rivers. Upland and grab channels are arranged for the removal of surface water and the interception of groundwater near the native shores. In addition, ,m can be used as channels for moistening the land and for unloading the supply canal during the period of flood waters.

Collecting channels are laid perpendicular to the highway across the floodplain at a distance of 1.5-2 km from each other, they are located in low places of the swamp and along the boundaries of land use or crop rotation fields. Collector channels are arranged along the floodplain and parallel to each other. The distance between them is about 200 m if they have drains on one side and no more than 1 m if on both sides.

Main, collection and collector channels are equipped with regulator sluices in the amount sufficient to regulate the level of groundwater. The reservoir is built in the upper reaches of the river of the main channel or in side beams. The useful yield of such reservoirs should be sufficient to cover the lack of moisture in dry growing seasons.

The regulatory network includes open channels or closed drainage (material or mole). Mole drainage is one of the important elements of the drainage system, which, in combination with sluicing, ensures regulation of the water-air regime of the soil.

The laying of mole drainage is fully mechanized and is carried out with the help of mole drainage machines. Drainage is carried out before installation preparatory work: clearing the area of bushes, stumps and clumps, leveling the spoil bank near the canals, filling in pits of various orders and furrows followed by leveling the entire area, especially these measures should be carried out where drainage lines pass. The quality and further work of the mole drainage largely depends on the performance of the above-mentioned works.

The best time to lay a mole drain on peatlands is the period when the groundwater is below the depth of the drains, and on mineral ones - when the soil moisture is 20-25% of dry mass.

On mineral wetlands with a heavy mechanical composition, soil tamping is used. Mole holes are laid at a depth of 0.4-0.5 m with a distance between them of up to 1 m. Mole holes are carried out simultaneously with ploughing the soil with the help of mole cutters attached to ordinary plows. Separately from ploughing the soil, weeding is carried out with the help of mounted weeding machines.

Mole drains can be combined with closed material drainage, laying it perpendicularly or at an angle to the material. The efficiency of the regulatory network with such a combination is significantly improved.

In swamps with stumps or buried wood, mole drainage is replaced by slotted drainage, using slotted drainage machines.

Agromelioration measures are the system of methods for removing excess water from the surface and from the arable layer of the soil, strengthening the internal soil runoff and creating additional reserves of productive moisture in the arable layer, improving the thermal regime and increasing the biological activity of the reclaimed soils. They are a mandatory addition to reclamation systems in conditions of drainage of lands of heavy mechanical composition with low water permeability. Agromelioration measures are divided into: 1) **draining**, which ensure the rapid removal of excess water from the soil surface and partially from the arable layer (surface planning, narrow-row ploughing, furrowing, soil profiling, combing, beding); 2) accumulative, which ensure an increase in water permeability and moisture capacity of the soil, removal of excess water through the subsoil layer (cropping, deep ploughing and deep spudding). A brief description of agromelioration measures is as follows: furrowing — the depth of the furrows is 20-35 cm, the distance between them is 12-20 m, it can be systematic or selective; narrow-row ploughing — the width of the folds is 10-24 m, across them on the slopes, exit furrows are arranged after 40-100 m; furrowing — creation of ridges along the slopes of the terrain with a height of 13-15 cm and a distance between them of 1.5-2.0 m; bedding - the width of the rows for vegetables is 0.7-1.4 m, corn is 2.8-3.5 m, and the height is 30-60 cm; profiling — provision of a two-slope profile of the soil surface with a width of 12-30 m, which is achieved by repeated (3-4 times) narrow-row ploughing; deepening of the arable layer — gradual ploughing of 3-5 cm of subsoil; deep spudding — by 60-100 cm (20-30 cm less than the minimum depth of laying material drains with a distance of 1-2 m between them).

Agromelioration measures make it possible to increase the distance between material drains by 1.5-2 times, which significantly reduces the cost of the drainage system.

Therefore, modern land reclamation has a complex character, its ultimate goal is to obtain maximum yields of cultivated crops, increase soil fertility and improve the ecological situation of the land reclamation and adjacent territories. This triune result is mandatory. Components of nature, natural and anthropogenic landscapes cannot be lost as a result of economic activity.

1.4.3 Methods and techniques of soil moistening

In the zone of natural moistening, wet years alternate with dry ones. In dry periods, agricultural crops on soils of light mechanical composition, heavy clay and loamy soils suffer from moisture deficiency. The greatest need for water is observed on dry dry lands of light mechanical composition (especially for vegetable crops and pastures). Mineral soils and small peatlands need additional moistening in dry years more than thick peatlands. Many years of practice have shown that drainage systems designed only for the removal of excess water often do not ensure a normal water-air regime of the soil.

Therefore, a remedial system of two-way action (drying-moistening) has been developed and is being implemented. It is the most effective and universal, because it allows you to regulate the water regime of the soil more fully in accordance with the requirements of agricultural crops in any weather: in wet periods, excess water is removed, and in dry periods, the necessary amount of moisture is supplied to the root layer of the soil. The Irpinsk, Trubizhsk and other reclamation systems were built and operate according to the principle of bilateral regulation.

The drying and humidifying system consists of two parts: drying (for removing excess water) and humidifying (for supplying water to humidifying devices).

Surface moistening is carried out on the surface of the soil either in a continuous layer (flooding of the strip) or in furrows. Strip flooding is used mainly for cereals and grasses in arid areas, except for broad-row crops.

The main method of surface moistening is furrow irrigation. Moistening is distinguished by small (depth 8-12 cm, width at the top 20-30 cm), medium-deep (12-17 and 30-40 cm) and deep blunt furrows (17-25 and 40-50 cm). Soil moistening occurs due to infiltration of water through the walls and bottom. The length of the furrow is inversely proportional to the water permeability of the soil: the greater the water permeability of the soil, the lower it is. The water that has accumulated in the transverse furrow is used to replenish the lower lying furrows.

During moistening, water enters through small furrows some time after they are filled. Wetting along the middle furrows is usually carried out without reset. The supply of water is stopped when it fills 2/3 of the total length of the furrow. Moistening deep dull furrows, water is stopped after they are filled. This method has significant advantages over continuous flooding: insignificant irrigation rates (less than 600-1000 m3/ha) and small losses of water for discharge and filtration.

The speed of water flow is not more than 0.3 m/sec. The minimum distance between furrows, which ensures normal moistening of the soil, depends on its water permeability: for light soils it is 45-60 cm, for medium - 60-75, for heavy - 75-90 cm. Water from channels is supplied by siphons or through pipes. To supply water to the furrows on the canals, supporting sluices and portable bridges are built.

The use of thin-walled irrigation pipelines equipped with water outlets gives good results with larger slopes and complex terrain. This makes it possible to significantly increase the efficiency of moistening and facilitates the work of irrigators.

Pipelines are placed either along the slope of the terrain or perpendicular to it. The distance between the pipelines is 200-400 m, the consumption of the irrigation jet is no more than 0.5-1.0 l/s. The productivity of the watering can is up to 5-6 hectares per shift.

Flexible pipelines made of kapron fabric, into which water is fed from reinforced concrete trays, were widely used for moistening with the help of grooves.

The disadvantage of moistening along the furrows is the unevenness of soil moistening along the length of the furrow. In addition, this method requires the use of heavy manual labor.

Estuaries are also used to moisten the soil surface. With the help of low dams or levees, meltwater from spring floods is retained. Areas with calm relief and small slopes are chosen for arranging estuaries. In practice, estuarine irrigation is used on drained lands: simple (one shaft is created); tiered with a deep flooding layer (0.4-2.0 m); tiered with a shallow layer of flooding (0.2-0.4).

Simple estuarine irrigation is arranged in conditions of a gentle slope with a small longitudinal slope, which is typical for most of the drained territory. For this purpose, earthen barriers or dams are built, located across the slope in the lowest part of the flooded area. Water outlets are installed in the shafts to discharge the water that remains on the surface of the site into the channels. The area of simple estuaries can be 100-200 hectares or more.

Arrangement of tiered estuaries is carried out on massifs stretched along the slope. For the purpose of uniform flooding, the area allocated for wetting by the estuary is divided into several sections along the length of the slope. The sites are separated by dams.

The water is released from drainage channels that surround the site. To release water from the canals, water outlets are arranged only from the downstream side of the canals.

Flood estuaries formed in depressions filled with meltwater in the spring deserve attention. In these areas, even in dry years, high harvests of herbs are harvested.

Disadvantages of estuarine irrigation include its unevenness, limited mechanization of work and the time of use of estuaries (only in spring).

Sprinkler irrigation is one of the promising methods of soil irrigation. It is used to regulate the water-air regime on both mineral and peat soils for crop rotations of all types.

The advantages of this method are:

– in full mechanization of the humidification process;

- efficiency and mobility;

- in the possibility of more frequent watering with small rates and areas with complex microrelief;

- in improving the microclimate;

- with the help of sprinkling, you can add fertilizers to the soil.

Three sprinkler systems are known: mobile (sprinkling-machines, pumping stations, distribution pipelines that move across the area), ***stationary*** (all parts of the system occupy a permanent position), ***semi-stationary***.

The most convenient are semi-stationary installations, the pump, engine and main pipeline of which maintain a constant position, and the sprinkler pipeline and aggregates move around the field depending on the needs of the farm.

Locking moistening (locking) consists in installing a system of sluices on drainage channels, which allow to stop or slow down the outflow of water through the channels and in this way regulate the level of groundwater.

Two types of locking are known: preventive and moisturizing.

With **preventive locking**, the sluices are closed during the decline of the spring flood, when water is still flowing through the canals, and the groundwater drops 50-70 cm from the soil surface. Preventive sluicing is effective only in the first half of summer. It can be used in cases where there is no water source nearby.

Moisture locking is carried out in the presence of a source that has the necessary amount of water to supply it to the network in dry periods of the year. The level of groundwater is regulated by infiltration of water from canals. This is possible only on well-permeable soils, on shallow peatlands (up to 0.8 m deep) and on mineral wetlands.

In case of wetting locking, water coming from the water receiver (reservoirs, lakes, ponds, rivers, etc.) maintains the groundwater level at the required depth. Water through the canal, fed into the water regulation network. However, this type, as a rule, does not provide uniform moisture over the entire area and requires a dense network of channels or drains.

To increase the effectiveness of locking mole drains are used. Humidification through mole drains is used in mole-resistant soils, poorly decomposed peat (the degree of decomposition is about 45%). A mole drainage is laid to a depth of at least 0.8 m, as well as in mineral, clay and loamy soils. Dusty, sandy and sandy soils are not suitable for molestation.

In peat soils, mole drains should be laid in the period when the groundwater lies below the laying of potter's drainage to a depth of 06-0.9 m. The distance between the drains is 5-15 m, the diameter of each drain in peat should be at least 12-15 cm, and the length should not exceed 200-250 m. The drains are placed perpendicular to the collector channels or at an angle of at least 80° to the direction of the water flow in channels In mineral soils, mole drains are laid every 3-5 m, to a depth of 0.6-0.8 m. The diameter of the mole drain in these soils ranges from 6 to 10 cm, the length of the drain can reach 200 m.

In dry periods of the year, when the moistening of agricultural crops is especially necessary, additional water is supplied to the collectors (usually from transport channels with closed locks). Water can also be supplied to the collectors under the pressure of the pumping station and sluicing of auxiliary collectors with drains in several strokes. In years of high humidity and periods when additional moistening of agricultural crops is not required, the valves in the discharge wells are opened and the drainage network works to drain the water. In dry periods, the valves in complex wells are located at the beginning of the sprinklers to moisten the soil, they are closed, and water flows from the sprinklers into the system by gravity. Reception wells are placed on high points of the terrain, therefore, a water pressure is created in all drainage pipes, which is almost equal to the maximum pressure above the drainage during the operation of the drainage system. This makes it possible to raise the groundwater level more evenly.

The ***drainage network*** is equipped with moistening devices - channels with expanded clay pipelines. Channels are laid perpendicular to the collectors after 300-600 m, their depth is 30-50 cm greater than the depth of the collectors. There are also combined systems of subsoil moistening. They include the methods above, with one being primary and the others secondary. The choice of additional methods (for example, preventive locking, moistening through mole and tube drains) depends on the natural features of the area, the nature of the land area.

A fairly widespread method of ***intrasoil*** drip ***irrigation***, in which water is supplied in relatively small doses (or after a day) directly into the root layer of the soil.

The method of in-soil drip irrigation, applied in vineyards, allows to ensure irrigation to a depth of 90 cm on a strip 80 cm wide. The rate of irrigation can vary from 0.9 to 9 l/h. Droppers serve as taps - cylinders with a length of 5 cm and a hole diameter of about 2 mm with a carved core. The number of drippers on the pipeline depends on the type of soil and the type of crops. Micro hoses made of plastic with an inner diameter of 0.5-2 mm can be used instead of droppers.

Advantages of drip irrigation:

– economical water consumption (60% less than during sprinkling);

- increasing the effectiveness of fertilizers;

– continuous moistening of the root layer of the soil;

- reducing the growth of weeds on the ground;

- reduction of the labor intensity of agricultural work.

The effectiveness of irrigation of agricultural fields depends on compliance with certain conditions of the term and amount of irrigation, that is, on the irrigation regime.

When establishing the optimal irrigation regime, the following factors are taken into account: water-physical properties of the soil (specific gravity, porosity, field moisture capacity, water yield, height of capillary rise), meteorological factors, biological - features of the cultivated crop and experimental data of scientific research institutes or experimental stations.

There are different methods of determining the optimal mode of moistening of agricultural crops: according to soil moisture, water consumption of agricultural crops and the given yield; bioclimatic method; method of single dry periods. According to research, it is the most acceptable method of taking into account soil moisture.

In order to determine the mode of hydration (norms, terms and number of irrigations), it is necessary to have data on the total amount of water that the plant needs to obtain a high yield; about the amount of precipitation and the amount of absorption from groundwater during the growing season; about the **irrigation rate** (that is, the amount of water needed by the plant during the season) and the **single irrigation rate** (that is, the amount of water supplied during a single watering); about the water supply in the soil.

The mode of humidification plays a significant role in determining and justifying the choice of sizes of drainage and humidification systems (pipelines, canals, reservoirs, etc.), the technique of humidification and the operation of hydromelioration systems.

The events are adjusted annually depending on weather forecasts.

Assessment questions

1. What is understanded by the term "melioration"?
2. What are the types of recreation?
3. Main tasks of agrotechnical recreation.
4. What are chemical recreation carried out for?
5. What are the tasks of hydrotechnical recreation?

6. Methods of draining overhydrate soils
7. Land irrigation methods
8. What is drying rate?
9. What are irrigation rate and irrigation rate?
10. Area of drained and irrigated lands in ukraine.

Test tasks

1. Melioration is a system of measures aimed at:
1. Short-term land improvement.
2. Long-term permanent improvement of lands.
3. Climate improvement.
4. Improvement of vegetation

2. Chemical recovery is:
1. Land draining.
2. Irrigation of lands.
3. Improvement of agrochemical properties of the soil.
4. Improvement of agrophysical properties of the soil.

3. Agrotechnical measures are applied to improve the water regime of the soil:
1. Deepening of the arrow layer.
2. Plastering.
3. Planning.
4. Chalking.

4. Drying rate is:
1. Irrigation rate.
2. Groundwater level.
3. Irrigation rate.
4. Moisture of the rupture of the capillary connection.

5. The irrigation rate is:
1. Amount of water needed by the plant during the season.

2. Water evaporated during the vegetation period.
3. The quantity of water supplied at a single irrigation.
4. Capillary rise of moisture.

6. The irrigation rate is:
1 water that evaporates during vegetation
2. Total quantity of water for crop formation.
3. The quantity of water needed by the plant during the season.
4. The quantity of water supplied at a single irrigation.

1.4 Basics of crop production

According to indicators of bioclimatic potential, Ukraine is able to fully satisfy its own needs in the production of food products and raw materials for various industries.

However, it has been observed in crop production for a long time reduction in the volume of production, which was caused, first of all, by a decrease in both the sown area and the yield of agricultural crops (Table 4).

Table 4

Production of grain and leguminous crops by year

Year	Area, thousand hectares	Productivity, c/ha	Gross collection, thousand ha
1990	14583	35,1	51009
2000	13646	19,4	24459
2001	15586	27,1	39706
2002	15448	27,3	38804
2003	12495	18,2	20234
2004	15433	28,3	41809
2005	15005	26,0	38016

2006	16464	24,3	33930

Acceleration of the agrarian reform was accompanied in 2000-2001 by the expansion of the area of grain and technical crops, potatoes, and vegetables. Already in 2001, the sown areas of grain crops in all categories of farms were expanded by more than 2.0 million hectares, including in agricultural enterprises on 0.8 million hectares, sugar beets - on 140 thousand hectares (14%). The specific weight of winter wheat, rye, corn, buckwheat, sugar beets, and potatoes increased in the structure of sown areas.

The measures taken made it possible to stop the decline in crop production in 2000.

In the subsequent growth of the production of plant products amounted to more than 13%, which is due to a much larger harvest of grain crops, which was collected in 2001, almost 40 million tons, and the growth of the production of sugar beets, vegetables, fodder crops, and other types of agricultural products. The only exception was 2003, when due to unfavorable winter conditions, the yield of grain crops decreased sharply and amounted to only 18.2 t/ha.

Since ancient times, our state has been considered a "granary" among European countries, a powerful producer of wheat, rye, barley, peas, buckwheat, and millet. In recent years, corn, sugar beets, sunflower, long-fibred flax, rapeseed, etc. should also be added to this list.

Further development of the field of crop production will be based on the implementation of scientific and technical progress on the basis of existing economic, energy, material and technical, ecological and social conditions. The main direction is to increase the yield and quality of grain at the lowest cost.

All efforts will be aimed at increasing the volume of grain production, which in the future will become a priority direction for the development of crop production. According to the calculations of Academician V.F. Saik, the gross harvest of grain in the future in Ukraine will amount to 60 million tons.

In the world, cereals occupy 35% of arable land. Their cultivation is possible in different soil and meteorological conditions. According to the FAO, the protein and energy needs of the planet's population are fully satisfied due to grain. (Table 5)

Table 5

Food origin, % (according to FAO data)

Products	Dry mass	Protein
Grain	70	54
Tubers and roots	9	5
Sugar	5	-
Beans	6	16
Vegetables	2	4
Fruits	1,2	0,8
Amount from plant production	93,2	79,8
Livestock and fish farming products	6,8	20,2

The importance of cereals will continue to grow due to the fact that a much larger part of the grain is used for animal husbandry than for food purposes.

Plant breeding as a branch of agricultural production and

science.

Plant growing is the main branch of agricultural production. It provides the population with food products, animal husbandry with fodder, industry with raw materials. The object of study is a green plant capable of converting a certain part of solar energy into the potential energy of organic matter in the process of photosynthesis. In the climatic conditions of Ukraine, the field of crop production operates seasonally: field crops vegetate and produce crops only in the period with positive temperatures. Plant breeding is important not only as a branch of agricultural production, but also as a theoretical and applied science.

Plant growing as a science studies genera, species, varieties and varieties of various agricultural crops, theoretical foundations and technical methods of obtaining consistently high yields with the least labor costs, financial and material and technical resources.

The main task of plant breeding is scientific substantiation and development of optimal technological methods with the aim of fully realizing the productivity potential of agricultural crops, adapting them to soil and climatic conditions on the basis of botanical and biological features of their growth and development.

Back in prehistoric times, humanity needed elementary scientific knowledge about the ability to grow plants. At that time, soil cultivation, application of organic fertilizers and ash, irrigation, mixed sowing of agricultural crops were put into practice.

The development of plant science in Ukraine begins in the 18th century. At that time, our state was part of the Russian Empire. Scientific centers were concentrated mainly in the cities of Russia, where outstanding scientists of the Russian Empire conducted their research. Thus, MV Lomonosov (1711-1765) is recognized as the founder of scientific agriculture. He was the first to substantiate the origin of the Black Earths, and became the initiator of the agricultural survey of the Russian Empire. He summarized the experience of growing agricultural crops acquired in various regions of the former Russia. A.T. Bolotov (1738-1833) was the first to develop and implement a seven-field crop rotation, in which four fields were occupied by perennial grasses. He proved the positive influence of perennial grasses on soil fertility, developed the classification of weeds and methods of combating them, improved methods of soil cultivation.

The outstanding scientist D. I. Mendeleev (1834-1907) initiated the organization of experiments on soil cultivation and fertilization of agricultural crops in different soil and climatic zones.

A classic of modern scientific biology and plant breeding with worldwide recognition by K.A. Timiryazev (1843-1920). experimentally and theoretically developed the doctrine of plant photosynthesis.

D. M. Pryanishnikov (1865-1948) - the author of a well-known textbook on agrochemistry - developed the theory of plant nutrition, methods of studying the content of individual nutrients in plants and soil.

M.I. Vavilov (1887-1943) - made a significant contribution to the biology, systematics and geography of cultivated plants. E. Vavilov - developed the modern scientific foundations of breeding, the doctrine of world centers of origin and evolution of cultivated plants. He and his followers created a world collection (over 300,000 specimens) of cultivated plants.

N.N. contributed to the development of crop production as a labor science. Kuleshova, A.I. Nosatovsky, M.A. Maisuryan.

The work of breeders P.Lukyanenko, F.G.Kyrychenka, and V.Ya.Yuriev contributed significantly to the development of crop production - the authors of intensive varieties of soft and hard wheat were created by V.S. Pustovoit; unsurpassed in oil content sunflower varieties. The famous Ukrainian breeder V.M.

The craft created the winter wheat variety Myronivska 808, which in the 70s occupied the largest cultivated areas in Europe.

Humanity faces a number of unsolved global problems, of which the problem of food production is especially relevant, both in terms of production volumes and in terms of their quality. Thus, there is an insufficient amount of protein and low calorie content in food products. The problem of hunger for part of humanity is due to the significant rate of increase in the population of our planet. If in 1650 it was 500 million, after 200 years it increased to 1 billion, then in 1999 - to 6 billion people and may increase to 8 billion by 2010. Therefore, it is necessary to find opportunities for the production of sufficient volumes of plant products. Annually, 110 billion tons of organic matter are obtained from soil and water, while the potential volume of its production is within 300-330 billion tons.

The solution to this problem is based on:

- using new types of plants. There are more than 350,000 species of plants in nature, of which only 20,000 species are cultivated. 640 species are important, of which only 90 species belong to field crops. The main share falls on 15 species, half of which are grain crops. In world agriculture, wheat, rice, corn, barley, sorghum, millet, oats, and rye occupy 70% of the entire sown area. Therefore, there is a need to introduce new high-yield crops into production. In Ukraine, such crops as triticale, Jerusalem artichoke, amaranth, and stevia have been studied and deserve a significant expansion of cultivated areas. Types of wild fodder crops are introduced. Dozens of types of essential oil crops, medicinal herbs are introduced into the culture;

- creation and introduction of new varieties. In recent years, the yield of grain crops in the world has doubled, and a third of the increase in yield was obtained due to the introduction of new varieties that are characterized by high productivity, resistance to pests and diseases, and high adaptability. On the basis of genetic engineering, wheat hybrids have been created and are being sown in the USA, France, Germany, rice hybrids in China and Japan, and rye hybrids in Germany. Due to hybrids, the yield increase is 15-20%;

- biological fixation of nitrogen by non-legume crops as one of the directions of genetic engineering. In a short time (10-20 years), significant results have been achieved in the study of nitrogen fixation in the rhizosphere of non-leguminous plants, which has received the name "associative nitrogen fixation". Microorganisms from 12 families that can coexist with the root system of wheat, corn, sorghum, rice, etc. have already been studied. Microorganisms feed on the carbohydrates of the root system and supply plants with nitrogen. Associative nitrogen fixation has significant ecological significance as a reserve of natural replenishment of available nitrogen in various ecosystems. In areas with a warm climate, 17-40% of the nitrogen requirement is still provided due to the activity of associative nitrogen fixers, in the temperate zone it is even less -10-20%.

The practical use of associative nitrogen fixation consists in the production of inoculants based on specific microorganisms, which will allow to increase the share of fixed biological nitrogen in crops of non-legume crops and thereby reduce the application of mineral nitrogen by 25% or more.

Associative nitrogen fixers can also produce physiologically active substances - auxins, gibberellins, cytokinin-like compounds, which help increase the mass of roots, increase their absorbing activity, affect reproductive organs, inhibit the activity of phytopathogenic microorganisms on plant roots;

- increasing the intensity and efficiency of photosynthesis. Increasing the productivity of photosynthesis in cereal crops of the temperate zone to the level of the most productive tropical and subtropical crops will contribute to increasing the yield of cereals to 150-200 t/ha. It is proved thatvarieties of cereal plants with leaves departing from the stem at an acute angle; semi-leafless and leafless varieties of peas, corn and sugar beet hybrids, plants of which have a higher waviness (corrugation) of the leaf surfacehave a high intensity of photosynthesis.

- using high-quality conditioned seeds. The productivity of plants largely depends on the quality of the seed, the way it is prepared for sowing. For example, seed encrustation makes it possible to create a film containing fungicides, insecticides, growth regulators, trace elements, moisture-retaining materials, and reduces the cost of pesticides, which is economically and ecologically appropriate;

- and the rational use of land.

The harmful extensive use of land in the past and now has led to an unstable state of agriculture, led to an increase in production costs, and an unprecedented increase in the ecological crisis.

Ukraine is one of the largest countries in Europe in terms of territory. The area of Ukraine is 60.4 million hectares, of which 42.4 million hectares (70.2%) are agricultural land, including 81% of arable land. In Vinnytsia, Ternopil, Kirovohrad, and Cherkasy oblasts, more than 90% of agricultural land has been plowed, while in other countries it is much less: in France and Germany, arable land is 48%, in Hungary - 37%, in England - 25%, in the USA - only 20% of agricultural land.

The high degree of ploughing of the land caused the development of significant erosion processes. Annual soil losses in Ukraine amount to about 600 million tons, including more than 20 million tons of humus. The biological activity of the soil has decreased, fresh water resources have decreased and become polluted, and the ecological crisis has acquired significant dimensions. Under such conditions, land use has reached a critical state. The farming systems that existed until recently do not correspond to changes in production relations, economic, ecological and energetic expediency. The emergence of new organizational structures in agricultural production, such as peasant, farmer, and private farms, as the most tested in agricultural practice in the world, with the beginning of the reform of the agricultural sector, calls for the introduction of new approaches to the prospects for the development of crop production.

Recently, a state program was adopted to remove at least 10 million hectares of land from cultivation and transfer it from arable land to natural fodder lands, including 6-8 million hectares for permanent lime treatment and about 2 million hectares for afforestation. The removal of land from cultivation will contribute to the improvement of ecological conditions, as the disturbed relationship between natural complexes - areas of forest, water, meadows, crops, etc. will be restored, which will contribute to the stabilization of balance in agricultural landscapes.

Expanding the area of natural fodder lands will create an opportunity to increase the share of cheap pasture fodder in the structure of fodder, provide more than half of the protein needs of cattle, and reduce the use of grain for feeding animals by 5-6 million tons. It has been proven that it is possible to reduce the arable area, to allocate 22 million hectares of the fertile and most flat part of the territory for intensive crop production, which will create an opportunity to concentrate organic and mineral fertilizers on a smaller area. In order to return organic matter to the soil, a significant part of the by-products must be used as fertilizer, and the sown areas of intermediate sideral crops must be expanded with green manure.

Consequently, there will be a need to use arable land more productively based on the intensification of agricultural crop cultivation technologies.

All field plants are divided into economic groups for ease of study and use:

- according to the **duration of life**, cultures are divided into one-year, two-year and perennial;

- according to light and heat **requirements** - into the plants ofmoderate and southern zone, or short-day plants arethermophilic, which mature faster in conditions of short daylight (10 hours) (corn, soybean, millet, sorghum) and those that require conditions of long daylight. On the contrary, they develop better in conditions of a long day, at moderate temperatures (wheat, oats, peas, flax, rapeseed. Field plants also differ among themselves by botanical, biological, and economic characteristics. However, some of them have a lot in common in terms of fertilization, peculiarities of cultivation, placement in crop rotation, care, harvesting. Plants with similar above-mentioned characteristics are grouped into economic groups. The most common is the grouping of crops according to the nature of the use of the main type of production (Table 6).

Table 6

Grouping of field crops

Group	Culture, number of generations
1	2
1. Cereals	Wheat, rye, triticale, barley, oats, corn, millet, sorghum, rice, buckwheat - 10
2. Legumes	Peas, fodder beans, beans, soybeans, lupine, heath-pea, lentils, chickpeas-8
	Continuation of table 6
1	2

3. Root crops	Sugar beets, fodder beets, fodder carrots, swede, turnips, kuuziku, chicory -7
4. Potatoes	Potato, Jerusalem artichoke, sweet potato -3
5. Oily	Sunflower, safflower, castor oil, poppy, peanut, sesame, perilla, lalemantia, rape, bitter-cress, ginger, mustard - 12
6. Essential oils	Coriander, cumin, fennel, peppermint, anise, lavender, clary sage, tobacco, hops – 9
7. Textile	Long-fibred flax, hemp, cotton, kenaf, jute -5
8. Gourds	Pumpkins, watermelons, melons, zucchini - 4
9. Fodder crops	Annual and perennial legumes, annual and perennial grasses, cabbage crops, new fodder crops.

2.2 Cereal crops

2.2.1 General characteristics

All grain crops belong to one large botanical family of cereals (Graminea) or leguminous plants – Roaceae L., therefore they have a lot in common in the structure of morphology. However, they differ greatly in terms of biological characteristics and requirements for environmental conditions.

According to biological features, economic purpose and based on production goals, all grain crops are divided into two groups: the first - wheat, rye, barley, triticale, oats - bread of the 1st group, or «real»; the second - corn, millet, sorghum, rice, corn - bread of the 11th group.

This distribution is due to some features in the structure of the inflorescence, flower, grain and features of its germination.

Typical cereals (plants of the first group) have inflorescences of ears or panicles (oats). The lower spikelet flowers are more developed compared to the upper ones, the grain has a longitudinal groove, sprouts several roots.

Millets (plants of the second group) have inflorescences of panicles or beginnings (corn); the upper ears are more developed than the lower ones, the grain does not have a longitudinal groove and germinates with one root.

Cereal crops of the first and second groups differ from each other in a number of biological features that determine the range of their distribution. Representatives of the first group are long-day plants, more cold-resistant and moisture-loving, grow quickly in the initial growing season. Millets - short-day plants, heat-loving, drought-resistant (except for rice), grow slowly at the beginning of the growing season.

Cereal crops have a lot in common in their structure.

The root system of grain crops is fibrous, the main part of it is located in the arable and subsoil layers. The roots of typical cereals penetrate the soil to a depth of up to 1.5 m, transparent roots - up to 2.5 m.

The root system is represented by two types of roots - radicle (primary) and nodal (secondary). Radicle roots are formed when the grain germinates. Secondary - appear from an underground stem node, which is called a tillering node. In winter cereal crops, the secondary root system develops better than in spring cereal crops. Maize and sorghum have a third type of roots - aerial or support, formed from the lower aerial stem node.

The **stem** is straw, which consists of 5–7 internodes separated by nodes. In corn and sorghum, the stem is filled with a core, the number of nodes and internodes reaches 18-25.

The **leaf** of grain crops is linear, consists of a leaf sheath, a leaf plate, a ligula and ears. Leaf sheaths with their lower part tightly cover the stem and, together with the ligula, located at the point of transition of the leaf sheath into the leaf plate, prevent the penetration of water and dust to the part of the stem covered by the leaf sheath. At the base of the leaf plate, ears develop, covering the stem. By their size and hairiness at an early age, cereal crops are easily distinguished from each other.

Ear, which is called inflorescences, is presented in wheat, rye, barley; **panicle** - rice, millet, oats, sorghum. In corn, male flowers are collected in inflorescences - panicles, female - spadix.

The base of the ear is a jointed spike rod, which is a continuation of the stem. On the projections of the rod on both sides, one or several spikelets sit. The panicle is also a continuation of the stem and is represented by a central axis with nodes and internodes. Lateral branches depart from the nodes, which can branch and form twigs of the first, second and subsequent orders. Spikelets sit at the ends of the twigs of the last order.

The **ear** consists of two spike scales, between which the flowers are located. Different crops have an unequal number of flowers in an ear: wheat, oats – 3–5, rye, corn, millet – 2, barley, rice, sorghum – 1. The flower is represented by two flower scales - the lower, outer one, in spiny varieties, a spine develops on it, and the upper, inner one; ovary with two feathery snout and three stamens (rice has six). At the base of the flower scales are two lodicules.

The **offspring** is a grain, the only seed of which grows together with the fertilization. In flaky cereal crops, the grain is covered with floral scales. It consists of the following parts: fruit coat, seed coat, aleurone layer, embryo, shield, endosperm.

In terms of chemical composition, and therefore in terms of quality, the grain of different crops differs greatly among themselves (Table 8).

Proteins include albumin, globulin, gluten and gliadin. With the exception of albumin, other forms of protein do not dissolve in water and are gluten. The ratio between gliadin and glutenin determines the quality of gluten. The most high-quality bread is obtained from flour in which the ratio of gliadin to glutenin is 3:1.

Wheat has a high gluten content, with the most favorable ratio of gliadin to glutenin, slightly less in rye and oats, and even less in barley, corn, rice, millet and sorghum. The content of protein in grain and its quality depend not only on the type and variety of crops, but also on growing conditions and fertilizers.

A significant part of the grain is represented by nitrogen-free extractive substances, which are 2/3 starch.

High fat content is found in oats, corn and millet. Fat is concentrated mainly in the embryo. The latter is released during the processing of grain into flour, which ensures its better preservation.

The increased content of fiber in oat, rice, millet and barley grains is due to the filminess of the grain. Ash is mainly contained in the shells of grains and flower scales. The food value of grain is determined by its chemical composition (Table 7).

Table 7

Chemical composition of grain, %

Culture	Raw protein	Nitrogen-free extractive substances	Fat	Ash	Cellulose	Water
Wheat	16,8	63,8	2,0	1,8	2,0	13,6
Rye	12,2	69,1	1,8	1,6	2,0	13,3
Barley	12,0	64,6	2,1	2,8	5,5	13,0
Oat	11,4	55,7	4,5	3,5	11,4	14,0
Corn	10,6	69,2	4,3	1,4	2,0	12,5
Fig	7,9	62,4	2,2	5,7	9,9	11,9
Millet	11,3	59,0	3,8	3,6	8,9	13,0
Sorghum	12,7	71,7	3,2	1,6	1,5	14,6

The amount of water in the grain, even after its full ripening, varies depending on the weather and storage conditions.

Cereal grains contain enzymes and vitamins.

2.2.2 Peculiarities of growth and development of grain crops

In the individual development of grains, two interdependent processes take place at the same time: growth and development.

Growth is a quantitative increase in plant mass, and development is a qualitative change characterized by a change in requirements for external conditions. Currently, two stages of development are more fully studied: the vernalization stage and the light stage.

The vernalization stage can take place only in growth cells and begins as soon as the seed embryo begins its growth. Certain conditions of temperature, moisture and oxygen are necessary for its passage.

In the absence of one of these factors, or if it is not fully provided, the vernalization stage does not occur.

The main factor for passing the vernalization stage is temperature. The optimal temperature for vernalization of different cultures is not the same. Winter crops are vernalized at a temperature of 0–5 °C, early spring crops - 5–10 °C, late spring crops - 15–20 °C. During the vernalization stage, vegetative organs are laid - stem and leaves.

To pass the light stage, a certain duration of lighting during the day is a mandatory condition. All typical cereals belong to long-day plants. To pass the light stage, they require long (14–16 hours) or continuous lighting. Breadfruits are short-day plants, they go through the light stage faster with a short (6–8-hour) day. The need for a certain length of the day in plants appears at the beginning of the growing season, after which they stop responding to the length of the day. During the light stage, generative organs are laid.

The vernalization and light stages continue until the phase of shooting.

Cereal crops go through a number of consecutive, closely related **growth phases** from seed germination to new formation (vegetation). The division into phases is based on the external morphological features characteristic of each of them. In the life cycle of grain crops, the following phases are distinguished: swelling and germination of seeds, seedlings, tillering, shooting, appearance of an inflorescence (earing, throwing out panicles), flowering and fertilization, formation, pouring and ripening of grain (milky, waxy and full ripeness).

Some agrotechnical methods are also associated with the growth phases: top dressing, harrowing of crops, treatment with herbicides and pesticides, irrigation, species and varietal weeding.

Swelling and germination of grain is associated with the beginning of absorption from the water table. When the humidity in the grain increases, physiological processes accompanied by changes in the chemical composition of the endosperm and corcle are enhanced. Under the influence of enzymes, such complex substances as starch, fats, and proteins are transformed into simpler, water-soluble compounds. The latter enter the developing corcle through the shield.

The intense growth of the corcle coincides with the absorption of a certain amount of moisture by the grain. In wheat and rye, it begins when the grain absorbs 50–55% of it, in oats – 55–60, in barley – 45–50, in corn – 35–40, in millet, sorghum, rice – 25–30% of air-dried masses.

The growth of the corcle occurs as a result of the growth of the radicle and the seedling. The radicle, which has increased in size, and a little later the sprout pierce the grain shell. The radicle begins to grow intensively deep into the soil, forms primary or corcle roots, and the seedling emerges on its surface. In cereal crops, the grain germinates with several germinal radicle, in the case of millets - with one.

In grain crops, during the period of grain germination, the roots grow faster than the seedlings. Seedlings reach the soil surface on the 8th–12th day after sowing. During this period, the roots penetrate the soil to a depth of 10–15 cm.

The minimum temperature for seed germination of cereal crops is 3–5 °C, transparent 6–8 °C. As the temperature rises to 20–25°, the germination process accelerates. However, a further increase in temperature, accelerating the process of swelling and germination of seeds, leads to drying of the soil. Optimal soil moisture for seed germination is 75–80% RH. The lower limit of soil moisture, at which seed germination and swellingare possible, is the wilting moisture of plants, which is 15.5–19% of the completely dry mass of the soil.

Sprouts. It is noted when the sprout of cereal crops is rolled into a tube of a leaf, covered from above with a protective cover - the coleoptile reaches the surface of the soil. At this time, coleoptile growth stops. The first true leaf appears, breaking the coleoptile. Unlike the coleoptile, which is usually colorless, white or pink, the first true leaf has a green color.

During the appearance of the first true leaf, the supply of plastic substances of the seed is almost completely consumed. A young plant begins to meet its need for nutrients by consuming elements of mineral nutrition from the soil and photosynthesis. During this period, the presence of nutrients in the soil in an accessible form is of particular importance. That is why post-sowing fertilization is very effective.

In young plants, as flexible substances accumulate, following leaves appear one by one after the first leaf - second, third, etc. The most favorable temperature during this period for real bread is 10–15 °C, for transparent bread – 15–20 °C. The duration of leaf appearance is 2–5 days. Cereal crops require a longer period for the next leaf to appear. With the appearance of the third leaf, the seedling phase ends and the root system grows. During this period, the roots penetrate the soil by 25–35 cm.

Tillering - the formation of lateral shoots from the tillering node. Its beginning coincides with the appearance of the third or fourth leaf.

The bale of tillering is the most important part of the plant. On it in the embryonic state are the main stem and buds, from which lateral shoots and secondary roots develop. Nutrients (mainly carbohydrates), which are of great importance for overwintering of winter plants, accumulate in the tillering node.

The formation of the tiller node begins early - with the appearance of the first leaf, when the buds of the embryo begin to rise to the top due to the growth of the root-like interstice. During the formation of three leaves, the root-like interstice stops its growth. The tiller node is formed from a bud above the root-like interstice and is located at a depth of 1.5–3.5 cm.

It is very important that the tiller node lies at the optimal depth. Inadequate planting can lead to the death of the entire plant, as the node of the tillering in this case falls into conditions of insufficient moisture, which leads to poor bushiness and weak development of nodal roots. Under such conditions, it is subject to freezing, blowing, damage by pests. The optimal depth of seed wrapping, sufficient illumination of the plants, moderate temperature, etc., contribute to the increase in the depth of the tillering node.

In winter cereal crops, tillering takes place in two periods - in autumn and in spring. As a rule, it ends in autumn. The duration of the autumn tillering period depends on the time of sowing and weather conditions. Under normal conditions, it takes 30–35 days, during which winter rye forms 5–8, winter barley 4–6, and winter wheat 2–4 shoots. If sowing is delayed, as well as during a drought, the winter crops do not have time to develop sufficiently before leaving for the winter, which reduces their winter hardiness. In the spring, the duration of the bushing period is shorter, in connection with which a smaller number of shoots is laid than in the fall.

Lateral shoots from the tillering node appear in pairs. Buds that give rise to shoots are located opposite each other at an angle of 180°. This creates an even arrangement of shoots in space. Depending on the conditions, up to 15-20 or more side shoots can form on one plant.

There is a **general bushiness** (the number of shoots on one plant) and **productive** (number of shoots with inflorescence). Productive bushiness is usually 2–3 times lower than the general one. High bushiness is not always a positive factor, because not all shoots give a harvest. High bushiness is especially undesirable in areas of insufficient moisture.

According to the degree of bushiness, typical cereals are arranged in the following order (from greater bushiness to less): winter rye, winter barley, winter wheat, spring barley, oats. Millets have a weaker bushiness than typical cereals.

During the period of tillering, secondary or nodal roots are formed, developing from the tillering node. Two secondary roots appear from each side shoot.

The period when the stem node rises above the soil surface by 3–4 cm and is easily felt in the axils of the leaves is considered in practice to be the phase of **shooting**. This coincides with the end of growth of the first, lowest internode of the stem.

Simultaneously with the growth of the first interstice, the second begins to lengthen, which soon significantly overtakes it in terms of length and growth rate. Then the third interstice lengthens, the growth rates of which are even higher. The following interstices also grow - the fourth and fifth. The length and growth rate of the higher interstice significantly exceeds the length and growth rate of the lower one. The longest is the last, upper interstice.

At first, the stem grows slowly and the height of the plant increases slightly. The most intensive growth is observed during the formation of the last interstice. With the end of flowering, the growth of the stem in height stops. The growth of the stem is greatly influenced by the availability of moisture, nutrients, temperature and light.

In the phase of shooting, which lasts 20–30 days in wheat, the plant forms up to 50–60% of dry matter from the amount accumulated during the entire vegetation period. That is why cereals in this period consume a large amount of water and nutrients from the soil.

An excess of moisture and nutrients in this period can lead to the development of vegetative mass with long and weak stems, which is the cause of plant drowning and insufficient harvest. Resistance to drowning is determined by the conditions during the formation of the first and second interstice. An excess of moisture and nitrogen nutrition, an insufficient amount of light (gloomy weather) lead to the formation of a weak stem.

In the phase of shooting, the formation of the germinal inflorescence ends. Flowering starts early, in the tillering phase. The time of the end of the formation of the inflorescence coincides with the end of tillering and the beginning of shooting. An insufficient amount of nitrogen during this period delays the development of the inflorescence and reduces its size. Therefore, early nitrogen feeding has a positive effect on the development of the inflorescence.

The **appearance of an inflorescence** is the moment it emerges from the vagina of the upper leaf. Earlier, this phase occurs in typical cereals, and then in millets. The timing of the appearance of inflorescences can change in one direction or another, depending on external conditions and characteristics of the variety. Increased temperature, sunny weather, optimal soil moisture contribute to the quick and friendly appearance of inflorescences. Inflorescences appear on the plant in 1–3 days, and in the entire field in 5–6 days. First, inflorescences appear on the main stem, and then on the side shoots. During this period, generative organs continue to form. High temperature and insufficient humidity lead to underdevelopment and sterility of flowers.

In most cereal crops, **flowering** occurs after the appearance of inflorescences. In barley and rice, it often occurs before the appearance of inflorescences, in rye - 7–10 days after earing. In most grain self-pollinated crops in good weather, along with self-pollination, cross-pollination is observed. Cross-pollinated plants include rye, corn and sorghum.

In spike cereals, flowers first bloom in the middle of the ear, and then the flowering spreads to the top. In paniculate cereals, the upper, then the middle, and finally the lower flowers on the panicle bloom first.

The flowering of one inflorescence continues for 3–5 days, and the entire field lasts for 6–8 days.

1–2 hours after pollination, the pollen germinates and penetrates the ovary. One of the male gametes fuses with the egg cell and forms an embryo, the other fuses with the central nucleus of the embryo sac and gives rise to the endosperm. Double fertilization occurs.

In the first days after fertilization, **an embryo develops**, which is already able to germinate on the 10th–12th day. Simultaneously with the formation of the embryo, the endosperm develops. From the walls of the ovary, a fruit membrane is formed, which grows with the seed membrane, which was formed from the walls of the seed bud.

By the end of formation, the grain has a green color, it accumulates up to 25–35% of dry matter. The water content in the grain is 65–75%. The lower leaves on the plant begin to turn yellow and die. In typical cereals, the duration of grain formation is 10–12 days, in millets -18–22 days, after which **milky stage** occurs. The growth of grain in length stops. It increases in width and thickness. There is an increased influx of plastic substances - there is a **grain formation**. During the period of milky stage, the weight of raw grain reaches its greatest value. When its humidity drops to 42–38%, and the accumulation of more than 90% of dry matter, the grain loses its green color, when it is crushed, a milky liquid is released. The lower leaves turn yellow and die. **Milky stage** of the grain is coming.

The longer the milk stage period, the more fully the grain is formed. Warm and humid weather favors pouring of grain. On the contrary, dry and warm weather, lack of moisture in the soil shorten the pouring period. Droughts can lead to premature termination of pouring, as a result of which the grain turns out to be thin. Under favorable conditions, milk stage in typical cereals lasts 8–10 days, in millets-12–20 days.

After the milk stage, the grain becomes **yellow ripeness**. The flow of flexible substances almost stops, the grain reaches its maximum size and weight, the humidity drops to 18–20%. Separation of the grain from the mother organism occurs. Harvesting in this phase provides the highest yield. In the phase of **yellow ripeness**, the grain acquires a natural color, it crumples in the hands like wax. The leaves and stem turn yellow, and only the upper internode retains its greenish color. Yellow ripeness lasts 8–10 days for typical cereals, 18–20 days for millets.

Full ripeness of the grain is characterized by yellowing of the entire plant and death of the leaves. The grain dries out, becomes hard, its moisture content decreases in typical cereals to 14–16%, in millets - to 18–22%. Violation of the correct supply of water and nutrients to the kernel causes the grain to be thin or insufficiently full, which is accompanied by a lack of harvest and a decrease in its quality. The earlier and more sharply unfavorable conditions for pouring grain appear, the more pronounced its fragility. The lack of harvest due to the thinness of the grain in real bread can be 25–50% or more, while the nature of the grain decreases. According to Professor A. I. Nosatovskyi, a decrease in the nature of wheat grain by 100 g leads to a reduction in grain yield by half.

One of the reasons for grain fragility is dry weather - strong easterly winds accompanied by high temperature (35 °C) and low relative humidity (up to 27% and below). Under the influence of droughts, plant transpiration increases, the root system does not have time to supply water to the above-ground mass of the plant. As a result, there is a "**shrinkage**" of cereal crops, which is manifested in the premature yellowing of ears of corn or the whole plant, the pouring of grain stops. A very low moisture content in the soil during the period of grain formation can lead to thinness.

The cause of grain weakness can also be fungal diseases - rust, fusarium, etc. Affected plants are characterized by less resistance to blight. If the leaves are severely damaged by rust, they die very early and assimilation stops.

Under the influence of fogs, dew, rains, accompanied by high air temperature, respiration processes are intensified, as a result of which the plastic substances that entered the grain are lost.

Often, freshly harvested seeds do not germinate. And only after some time it acquires the ability to germinate quickly and amicably. This is explained by the fact that in some cases the full ripeness of the grain does not correspond to the physiological ripening of the grain necessary for its germination. The period of time from the full ripeness of the seed to its acquisition of the ability to quickly and harmoniously germinate was called the period of **post-harvest ripening** of the grain. It tends to decrease from north to south because the high temperature and low relative humidity during grain ripening shorten the post-harvest ripening period.

The period of post-harvest ripening of seeds is caused by a number of reasons, including the low water and air permeability of grain shells. The impermeability of the membranes is caused by a very tight closure of the cells of the outer layers of the seed coat. The dense shell becomes impermeable to carbon dioxide, which is released during respiration and accumulates inside the seed, which inhibits the germination of the embryo. As the seed ripens, the impermeability of the shell increases.

You can bring the seeds out of dormancy by heating them in the sun for 2-3 days, under a canopy, or in a storeroom for 10-15 days. The period of post-harvest ripening in the seeds of grain crops is shortened with separate harvesting in the phase of yellow ripeness.

According to biological characteristics, typical cereals are divided into two groups: winter and spring. The main differences between winter and spring forms lie in the different requirements for environmental conditions necessary for passing the vernalization stage.

Winter crops are plants that have a long-term stage of vernalization (30-60 days), which occurs at low temperatures (0-5°C). They are sown in autumn, because during the spring sowing period, they do not have time to go through vernalization and do not go to fruiting (they tiller intensively, but do not form an inflorescence).

Spring crops have a short stage of vernalization (10-15 days), they pass it at higher temperatures (5-10°C and higher). They are sown in the spring, they form a crop in the year of sowing.

However, it is not possible to establish a big difference between these two groups of plants. There are semi-winter forms (two-handed), which are able to produce a crop both during autumn and spring sowing. All typical cereals have semi-winter forms. Winter crops have a number of advantages over summer crops. They ripen 10–12 days earlier than spring, the fields are cleared early, which makes it possible to use them for sowing post-harvest crops. Winter crops are more productive than spring crops. Thanks to autumn sowing, they use precipitation and a long warm period of autumn vegetation and have time to form a powerful root system and a good vegetative mass by winter.

However, the advantages of winter crops over spring ones are revealed only if they overwinter well and develop in favorable conditions in the spring. In this regard, the autumn-winter and early spring periods are decisive in the life of winter crops. For overwintering winter plants, **winter resistance** is of great importance - the ability of plants to withstand adverse conditions in the winter and spring period. **Frost resistance or cold resistance** is the ability of plants to resist the influence of low temperatures. Winter hardiness and frost resistance of winter crops depends both on the characteristics of the variety and on the conditions of autumn growth and development of plants. In autumn, plants have low winter hardiness. Then, with the cessation of growth processes, it increases, reaching a maximum at the beginning of winter. By spring, it decreases.

Winter crops, preparing for winter, go through **hardening**, which has two stages. At the first stage, plants **accumulate sugar in the nodes of the stems and vaginas of leaves**. This happens in autumn at low temperatures (8–10° during the day, 0–1° at night) and in sunny weather. Under such conditions, the sugar compounds entering the plant, with the slowing down of growth processes, are not spent entirely on the growth of the vegetative mass, but accumulate in the nodes of the shoots. At the second stage, with the onset of small frosts (from 2 to 5 °C), **tissue dehydration** occurs. As a result, the concentration of cell juice increases, the properties of protoplasm change, and the water-holding capacity of colloids increases. All this increases the resistance of plants against low temperatures.

By spring, reserves of carbohydrates for respiration are lost, vernalization stages end, and light and winter ones sharply reduce winter hardiness. Resistance to low temperatures in plants and as a result of winter thaws, even short-term, decreases. Alternating freezing and thawing negatively affect protoplasm due to constant transitions from dehydration to saturation with water.

Freezing of winter crops is observed in years with severe snowless winters. At low temperatures, ice forms in the intercellular spaces. Ice crystals, growing, draw water from the cell juice, the protoplasm of the cell is dehydrated. As a result, irreversible coagulation of its colloids occurs. After thawing, the protoplasm becomes impermeable to water and dies. In addition, ice crystals break cell walls. Direct sunlight, when water quickly evaporates, leads to the death of frozen plants.

With the early onset of spring and a gradual increase in temperature, even weakly weeded winter plants from autumn develop well and give a high yield.

Bulging is the death of winter plants due to the rupture of the root system and the exposure of the stem node as a result of alternating freezing and thawing of the soil. During freezing, the soil increases dramatically in volume, and when it thaws, it settles and exposes the root node. Bulging can also occur as a result of the formation of ice under the surface of the soil or ice crusts Underdeveloped plants with a shallow root node and a poorly developed root system are more susceptible to bulging, and when winter crops are sown on freshly plowed, non-saline soil.

To prevent bulging, it is not necessary to be late with sowing, to prepare the soil in a timely and high-quality way, to follow technological methods that contribute to the intensive growth and development of winter crops in the autumn period. In case of bulging, it is necessary to immediately roll winter crops with ring rollers (press the detached root system to the soil surface).

Most often, the death of winter crops from bulging is observed if winter crops are placed after late-harvested row predecessors: sugar beet, corn for grain.

Damping-out is the death of winter crops from exhaustion due to a lack of light and mineral nutrition. It happens when a thick layer of snow falls on unfrozen soil, as well as the formation of a suspended transparent crust, when winter plants breathe vigorously, using up the reserve substances of cells. First they consume carbohydrates, then proteins. Assimilation processes do not occur in these cases. Exhausted plants are susceptible to diseases (sclerocinia, fusarium, etc.) and die. Overgrown and thickened winter plants experience damping-out more often.

In order to prevent the death of winter crops from damping-out, it is necessary to observe the terms of sowing, the norms of sowing seeds, and not to allow the use of excess norms of nitrogen fertilizers. It is worth rolling the snow if it falls in a thick layer on unfrozen ground, which will accelerate its freezing. The crust is destroyed with rollers or fresh manure and mineral fertilizers are spread over the surface.

Damping-off is the death of winter plants as a result of violation of breathing conditions and increased consumption of sugars to support life in anaerobic conditions. It is observed as a result of the accumulation and stagnation of meltwater on clay waterproof soils. To prevent winter crops from damping-offit is necessary to apply measures to remove stagnant water and carry out soil drainage.

Blowing - damage and death of winter crops as a result of strong winds that expose the root system. Plants are blocked by particles of soil and break. Black storms cause especially great damage to winter crops. To protect winter crops from blowing, a system of anti-erosion measures is used. Timely sown, well-rooted and rooted crops are less damaged by blowing.

2 CEREAL CROPS

2.1 General characteristics of grain crops.

Cereal crops are the main group of agricultural crops. Depending on the use, botanical and morphological features and biological features, they are divided into grain bread, grain legumes and other grain crops.

Cereal crops include wheat, rye, barley, oats, triticale, corn, millet, sorghum, and rice. According to the features of use, this group also includes buckwheat. From the grains of these crops, the main food products are produced - bread, bakery and confectionery products, pasta, vermicelli, noodles, cereals and other products, the average annual consumption of which in different countries is from 80 to 150 kg per population unit. About half of the world's grain production is used for feed purposes. Straw and grain chaff have fodder value. Cereal crops are also used for green fodder and silage. Dextrin, starch, alcohol, beer, oil, glucose, etc. are produced from grain. Grain is well transported and stored, which makes it possible to create food reserves for a long period.

Grain and straw of many grain crops are used as raw materials for technical processing. Starch, alcohol, beer, dextrin, oil, glucose and other products are made from grain. Straw is used to make paper, cellulose, household items, adobe, mats and bedding for livestock..

Chemical composition. The chemical composition of grains changes under the influence of species and variety, soil fertility, meteorological conditions and cultivation technology.

Grain consists of water, organic and mineral substances. Among the organic substances in grain, there are the most non-nitrogenous extractive substances, represented by carbohydrates, among which starch predominates. Most of all starch is in rye, wheat (60–70%) and corn (75–78%).

The proteins of grain cereal crops contain essential amino acids (lysine, tryptophan, and others), which determine the food and fodder value of the grain. Grain contains both simple proteins (proteins) and complex proteins (nucleoproteins, lipoproteins). The presence of protein in grain depends on growing conditions. The protein content in the grain of crops grown in the south and east of the country increases. More protein is produced in dry weather, when nitrogen fertilizers are applied and when wheat is grown after black steam. The most protein is contained in wheat grains, especially durum (16%), the least - in rice grains (7.6%).

The quality of flour is characterized by the content and quality of gluten. *Gluten* is a clump of water-insoluble protein substances that remain after washing the dough from starch, fiber and other substances. In addition to proteins, gluten contains a small amount of fat, starch and ash elements. The highest quality gluten is in the grain of soft wheat, its content in the grain is more than 30%. Barley grain contains from 2 to 19%, rye from 3 to 26% of gluten. Its content is insignificant in the grain of other cereal crops, so their flour is not suitable for baking bread.

The content of *fat* in the grain is insignificant (2–6%) and it is mainly contained in the germs. The most fat is in the germs of corn - up to 40%, oats - up to 26%, millet - up to 20%, less in wheat, rye, barley - up to 14%.

Fiber is a high-molecular carbohydrate substance that forms the basis of cell walls, grain shells and flower squama (in membrane cereal crops). Unlike other organic substances, it is poorly digested.

Ash is contained in the shells of grains and in the flower scales of flaky cereal crops. It consists of oxides of phosphorus, potassium, sulfur and others.

Grain contains many *vitamins* (B1, B2, B3, A, PP, E, etc.) and enzymes (amylase, protease, lipase).

Grain cereal crops are conventionally divided into two groups: *typical cereals*, or cereal crops of the first group, and millets - cereal crops of the second group. Bread of the first group (wheat, rye, triticale, barley, oats) - cold-resistant plants, presented in winter and summer forms, are plants of long daylight, less demanding of heat, light and more demanding of moisture than bread of the second group. Cereal crops of the second group (corn, millet, sorghum, rice) are vigorous heat-loving plants, have a short daylight, demanding heat and light.

Morphological and biological features of cereal crops. Cereal crops, with the exception of buckwheat, belong to the leguminous (cereal) family and have much in common in structure.

The *root system* is fibrous, consists of primary and secondary roots, which in corn and sorghum penetrate to a depth of 2-2.5 m, in winter wheat, rye, triticale - up to 2 m, in other crops - up to 1-1.5 m The roots of rice penetrate the soil to a depth of 60 cm. Radicles are formed from the tissues of the seed embryo, secondary roots are formed from underground stem nodes, and the most from the stem node. The number of radicles in different types of bread is not the same. Thus, in wheat during germination, 3–5 roots are mostly formed, oats – 3, rye – 4, barley – 5–8, cereal crops of the second group – 1.

On sod-podzolic soils, the roots penetrate to a lesser depth than on chornozem soils. The distribution of roots in the soil layers changes with the age of the plants, but always more than half of their mass is concentrated in the 0–25 cm layer. Up to 70–85% of the mass of the root system is located in the 0–40 cm soil layer, and up to 90% on turf-podzolic soils % of the mass of the roots is placed in a layer of 0–30 cm. The optimal conditions for root growth are created when the soil temperature is lower than the air temperature, the soil density is 1.1–1.3 g/cm3, the soil moisture is 65–80% RH, capillary porosity - 50% of the total.

The most developed root system is in corn, rye and winter wheat. The root system of oats, rye and buckwheat is characterized by high physiological activity and is able to absorb nutrients from poorly soluble soil compounds. In spring wheat and barley, the root system is poorly developed with low digestibility, so it is necessary to add easily soluble compounds with fertilizers to the soil.

At the beginning of plant development, roots grow faster than shoots. In the phase of two or three leaves, the roots of oats penetrate to a depth of 80 cm, wheat - 45 cm, corn - 30 cm.

The *stem* of crop cereal grains is a cylindrical straw divided by stem nodes into interstice. It breaks the membranes of the grain and in whole-grain cereal crops a germ appears on the top, and in membrane of cereal crops - on the top of the grain. In cereal crops, the stems are able to bush, that is, to form lateral shoots from underground stem nodes. In corn and sorghum, the stem length can reach 2.5–5.0 m, in rye – up to 1.8 m, in other crops – 0.6–1.3 m. The stem in corn and sorghum is filled with a loose core, and in others cultures it 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 shooting) as a result of the activity of the apical meristem. At the same time, the rudiments of nodes, interstice, leaves, inflorescences are formed.

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

Intercalary growth of the stem is caused by the activity of the intercalary meristem, which is located above its nodes. It also forms nodular roots and sheath buds - no more than one leaf sheath. In cereal crops of the first group, vaginal buds are formed only near the underground nodes of the stem, in the second group - near the underground, surface and above-ground nodes.

Stem growth occurs sequentially from bottom to top. First, the first (lower) interstice, located above the upper node of the tiller, is elongated. While it grows, the length of the internode located above it remains almost unchanged. As the growth of the lower internode slows down, the growth of the next internode is activated, etc. The growth of each subsequent internode is longer, the length is greater, and the diameter is smaller than the previous one. The internode, which bears the inflorescence, has the longest length.

The underground interstice of the stem, except for the first in cereal crops of the second group and oats, and the second in cereal crops of the first group, under normal conditions and with shallow (3–5 cm) seed wrapping, do not lengthen.

Leaves consist of a leaf plate (50–90 cm long and up to 12 cm wide in corn and sorghum, in other cereal crops – 15–40 cm and 0.5–3 cm, respectively) and a leaf sheath and are formed at each node of the stem. The leaf sheath protects part of the stem from damage and forms a ring-like thickening above the stem node - a leaf node that helps to raise the stem when lying down.

Rosette and stem leaves are distinguished in cereal crops. Rosette leaves are connected to underground and surface nodes, stem leaves are connected to nodes of the above-ground part of the stem. The upper stem leaf is called a flag leaf.

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

The number of rosette leaves depends on the type of plant and the number of shoots. In cereal crops of the first group, 3–4 leaves are formed on the main shoot, 2–3 leaves on the lateral ones, so that a plant with three shoots can have 7–10 rosette leaves. Bread of the first group consists mostly of 4–6 stem leaves, 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 technology, etc.

Rosette and lower stem leaves ensure the creation of vegetative organs of plants, middle stem leaves - inflorescence elements, upper leaves, especially flag leaves, determine the level and quality of the harvest.

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

There are three types of inflorescences: *spica* (wheat, rye, triticale, barley), *panicle* (oats, millet, sorghum, rice, male inflorescence of corn), *spadix* (female inflorescence of corn). Common in the structure of all inflorescences is the presence of spikes. Spikes have two spike scales, between which flowers are placed.

An spica consists of an ear rod, on the protrusions of which ears of corn are placed. The base of the panicle is the axis that ends the stem. The axis is capable of branching, forming side branches (1–4 orders), spikelets are formed at the ends of the last order.

Each flower has two flower scales, an ovary, a column with a snout, three stamens with anther (rice has six), and two lodicules. In corn, the flowers are unisexual, in the panicle they are male with stamens, at the beginning they are female with a pistil. In other cereal crops, the flowers are androgynes. The fruit is a dry one-seeded grain, glabrous or membranous, covered with spikelets and flower scales. The grain consists of the embryo, endosperm and shells (fruit and seed). The fruit and seed coats make up 5–8% of the mass of the grain (up to 15% in membranous grains), the germ – 2–3% (in corn – 14%), and the endosperm – 76–82%.

2. Growth and development of grain cereal crops

Ontogeny (individual development) is a set of irreversible transformations that an organism undergoes in the process of vital activity from birth to natural death.

According to V. V. Skrypchinskyi (1977), ontogenesis is characterized as the actual life and reproduction of a new individual. Life itself begins from the moment of zygote formation and continues until natural death; reproduction of a new individual begins with the same zygote and ends with the formation of gametes.

Stages of the development include: *embryonic*, *juvenile* (youth), *generative* (maturity), *prussic* (old age); stages of reproduction of a new individual - *proembryo, cormus, sporangiumu, spores, gametes*. Own life and reproduction of a new individual in the first half of ontogenesis is a single process. With the onset of the generative stage, monocarpic shoots are formed, in which reproduction processes occur that go beyond their own life.

During the *prussic* stage (aging), the actual life of the plant continues, but the ability to reproduce is lost.

The full development cycle of grain cereal crops is completed within a year. In the ontogenesis of these cultures, phenological phases of growth and development and stages of organogenesis are distinguished. Phenological phases are characterized by external morphological changes that repeat in each generation, and the stages of organogenesis are qualitative organogenic processes that end with the appearance of new organs in the embryonic state.

Growth can be positive or negative. The main indicator of positive growth is an increase in the mass of dry matter, which is accompanied by the formation and increase in the size of the structural elements of the plant.

A sign of negative growth is a decrease in the dry weight of the plant due to the consumption of the products of photosynthesis, for example, for respiration during the winter dormancy of winter crops, when the seeds ripen after the end of pouring, etc. An example of negative growth is also seed germination: the size and raw weight of seedlings increase, but the dry weight decreases.

Thus, positive growth is characterized by the predominance of *anabolism* (synthesis) over *catabolism* (decay), negative growth is characterized by the predominance of catabolism over anabolism. The main sign of growth is an increase or decrease in the mass of dry matter of the plant.

Growth is inextricably linked with development. Growth is quantitative changes in the body, and development is its qualitative changes. Qualitative changes occur at the growth points of the plant, where hormones accumulate and cell differentiation takes place, as a result of which new structural elements appear. Growth is the process of forming the structure of organs, development is the formation of their functions. The function is performed only with a certain structure, any structure has a functional purpose. An organ capable of fully performing its function is considered developed.

The following phenological phases of cereal crops are distinguished: seed germination, sprouting, tillering, shooting (stalking), earing (ejection of a panicle), flowering, grain formation, grain maturation (milky, yellow, full grain ripeness). The beginning of any phase is noted at the time of its onset in at least 15% of plants, the full phase in at least 75%.

In most European countries, the so-called decimal code (Zadoks J.C., 1974) describing the phenological stages of the development of cereals was proposed to characterize the growth and development of plants, and based on it, the *BBCHscale* was developed for the unified coding of the phenological stages of the development of monocots and dicots (table. 3). The letters of the abbreviated name of the *BBCH* scale are the name of the departments of the code developers (B – Federal Biological Department of Agriculture and Forestry; B – Federal Department of Variety Testing; CH – Chemical Industry).

Table 3 - Stages of development of grain crops according to the scale of BBCH

Code	**Stages of cereal development**
1	**2**
	Macrostage 0: Germination
00	Dry grain
01	The beginning of water absorption
03	End of water absorption
05	The appearance of the tip of the radical
06	Radicle extensibles, root hairs and/or visible lateral roots
01	The appearance of the tip of the embryo vagina (coleoptile)
09	Sprouts: the coleoptile crosses the soil surface; the leaf reaches the tip of the coleoptile
	Macrostage 1: Development of leaves
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 appeared
12	The stage of the 2nd leaf. The second sheet is unfolded. The top of the third leaf appeared
13	The stage of the 3rd leaf. The third leaf is unfolded. The top of the fourth leaf appeared

1	2
1...…	Stages that last until...
19	9 or more leaves are unfolded
Macro stage 2: Tillering)	
20	There is no tillering
21	The first shoot of tillering appears: the beginning of tillering
22	The second shoot of the tillering appears
23	The third shoot of the tillering appears
2...…	Stages that last until...
29	End of tillering: maximum number of tillering shoots developed
Macrostage 3: Shooting (main shoot)	
30	The beginning of shooting: the main shoot and the shoots of the tillers are directed upwards, they begin to stretch out. The distance of the ear from the node of the tiller is at least 1 cm
31	1st node stage: The first node appears on the soil surface, the distance from the tiller node is at least 1 cm
32	2nd node stage: The second node appears, the distance from the 1st node is at least 2 cm
1) A leaf is considered unfolded when its ligule or the tip of the next leaf is visible. 2) Tumbling can occur from the 13th stage. In this case, go to stage 21. 3) Shooting can begin already before the end of rooting, in this case it is worth moving to the 30th stage.	
33	Stage 3 node: The third node appears, the distance from the 2nd node is at least 2 cm

34	4th node stage: The fourth node appears, the distance from the 3rd node is at least 2 cm
3....	Stages that last until...
37	The appearance of the last (flag) leaf
39	Stage of ligula (ligula): the ligula of the flag leaf is visible, the flag leaf is fully developed
1	**2**
Macrostage 4: Swelling of inflorescences (spikelets or panicles)	
41	The leaf vagina of the flag leaf lengthens
43	The inflorescence (ear or panicle) inside the stem is shifted upwards, the leaf sheath of the flag leaf begins to swell
45	The leaf vagina of the flag leaf is swollen
47	The leaf vagina of the flag leaf opens
49	Awns appear above the ligule of the flag leaf.
Macrostage 5: Appearance of inflorescences (spikelets or panicles)	
51	The beginning of the appearance of the inflorescence (earing): The upper part of the panicle or the ear is noticeable
52	Appearance of 20% of the inflorescence
53	The appearance of 30% of the inflorescence
54	Appearance of 40% of the inflorescence
55	The appearance of half of the inflorescence. The lower part is still in the leaf sheath
56	Appearance of 60% of the inflorescence
57	Appearance of 70% of the inflorescence
58	Appearance of 80% of the inflorescence
59	End of earing: The ear or panicle has fully emerged

Macro stage 6: Flowering	
61	The beginning of flowering. The first stamens appear
65	The middle of flowering. 50% of mature stamens
69	The end of flowering
Macrostage 7: Formation of grains (caryopses)	
71	The first grains have reached half their final size. The contents of the grains are watery
73	Early milk stage
75	Average milk stage. All grains have reached their final size. The content of grains is milky. The grains are still green
77	Late milk stage
1	**2**
	Macro stage 8: Ripening of grains
83	Early yellow ripeness
85	Soft yellow ripeness. The content of the grains is still soft, but dry
87	Hard yellow ripeness. A dent from a nail does not straighten
89	Early full maturity. The grain is hard, it can be splited with a thumb nail with considerable effort
Macrostage 9: Dying	
92	Late full maturity. The grain is hard, does not break with a thumb nail
93	The grain is weakly held in the ear during the day
97	The plant completely died. The straw breaks
99	Harvested grain

Germination begins when seeds are provided with a sufficient amount of moisture, heat and air oxygen. The process begins with the absorption of water by the seed (swelling). Wheat, rye, triticale, barley seeds absorb 48–60% of their own weight of water for complete swelling, corn, rice – 30–40%, millet, sorghum – 25–30%. The amount of water required for complete seed swelling is different in different cultures and depends on its biochemical composition. Different substances that make up the grain absorb different amounts of water: proteins - 180%, starch - up to 70%, fiber - about 30%, fats are not absorbed at all. In the process of swelling in the seed, the activity of enzymes increases hundreds of times, with the help of which proteins, fats, carbohydrates are transformed into water-soluble substances available to the embryo. At the third stage, the embryo absorbs these substances and seed germination begins.

Cereal crops of the first and second groups differ in the method of germination. In crop cereals of the first group, with the exception of oats, when the grain germinates, the internode between the nodes of the shield and the coleoptile (epicotyl) does not lengthen, so the node of the coleoptile and germ buds remain directly next to the grain. The removal of the embryonic stem with the growth point is carried out later, with the appearance of the second true leaf, as a result of the growth of the second internode - between the nodes of the coleoptile and the first leaf. Under natural conditions and at a normal seeding depth (6 cm), the point of growth of the embryonic stalk of cereal crops of the first group during germination remains in the soil at a depth of 1.5–3.0 cm.

In cereal crops of the second group and oats, the epicotyl elongates and carries the germinal bud together with the growth point and the coleoptile to the surface of the soil, sometimes completely removed from the soil.

*Sprouts.*When the grain germinates, the germinal rootlet are the first to start growing. Immediately behind them, a stem with leaves grows, which, under the cover of the coleoptile (a single-celled layer of white color, which performs a protective function, protecting the leaf from mechanical damage until it appears above the soil surface), break through the seed layer of the soil. In whole-grain cereal crops, the stem with leaves and the coleoptile appear from the embryo directly above the germinal roots; in membranous cereal crops, they first grow under the flower film and appear on the opposite side of the embryo at the top of the grain.

After appearing on the surface, the coleoptile stops its growth and, under the pressure of the leaves inside, breaks with a longitudinal crack. The first green leaf appears on the surface of the soil, which is evidence of the transition of plants into the seedling phase.

From a biological point of view, the sprout phase lasts until the leaves of the germ bud develop: in oats - two, in wheat and rye - three to four, corn - five to seven. At this time, the seedling feeds mainly on the organic substances of the seed (heterotrophic nutrition).

The minimum temperature for seed germination of cereal crops of the first group is +1...3°C, for the second +7...13°C (the minimum temperatures for sprouting are +2...3°C higher). The optimal temperature for seed germination of cereal crops of the first group is +18...23°C, the second +23...25°C, and the maximum is +30...33°C and +35...40°C, respectively.

The appearance of sprouts depends on the species (rye sprouts earlier), the energy of germination, the mechanical composition of the soil, the depth of seed germination, humidity and temperature of the soil. Seeds germinate well only with free access to air oxygen. If it is limited, for example, in overmoistened and very compacted soil, germination processes are suppressed.

Sprouts of grain crops have a characteristic color: wheat - green, rye - anthocyanin, barley - blue-smoky, oats and clear crops - pale green.

During the formation of 3–4 leaves, the embryonic roots branch out and penetrate the soil to a depth of 30–35 cm, the growth of the stem and leaves is temporarily suspended, differentiation of the embryonic stem into nodes and internodes occurs. During this period, there is a danger of damage to plants by root rot, especially if the seedlings fall into a situation of waterlogging, low soil temperature, and deep seed germination.

Tillering. For cereal crops, a characteristic biological process is the formation of lateral shoots and secondary roots on the underground stem node, which is formed closer to the soil surface. It is called a *tillering node*. A tiller node is a plant organ capable of forming and regenerating shoots equivalent to the mother's. Overwintering of winter plants depends entirely on the development of the tillering node and the accumulation of a sufficient amount of sugars in it. It is located in the soil at a depth of 1 to 4–5 cm, and most often – 2–3 cm.

With an excessive density of plants and their mutual shading, as well as with elevated soil temperature, underground interstice, especially the second, grow quickly 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. With the death of leaves and stems, the *tillering* nodeи are able to reproduce new shoots with leaves and a new root system.

In most cereal crops, tillering begins when the plants have three leaves - 13–18 days after germination in the first group of cereal crops, 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 node of the tiller for the branching of the main stem with the formation of side shoots. When a leaf of the first lateral shoot appears from the axil of the first leaf of the main shoot, the tillering phase begins. Under favorable conditions - with a sufficient area of nutrition for each plant, sufficient supply of nutrients and moisture, a moderate temperature at the tillering node, especially of the cereal crops of the first group - 5–10, and up to 15–20 lateral shoots and more can be formed on thinned sowing (under particularly favorable conditions – up to 100–200 shoots).

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

Among the lateral shoots that were formed in plants during tillering, there are fruit-bearing ones and those that do not form an inflorescence or form, but without grain. In this regard, a distinction is made between *productive tillering*, which is understood as the number of shoots on a plant with fruiting inflorescences, and *general* - the number of all shoots on a plant.

Productive bushiness in normally thickened crops of most cereal crops averages 1.5–3. It is higher in winter crops, in which tillering takes place over a longer period of time - in autumn and spring.

The tillering phase of cereal cereal crops ends at the III stage of organogenesis - when the plants transition to the light stage of development. The general and productive bushiness is determined by counting the number of plants, fruit-bearing and non-fruit-bearing shoots on plots of 1 or 0.5 m2 in several places along the diagonals of the field. Based on the calculations, the average coefficient of general and productive tillering is derived.

The intensity of tillering depends on growing conditions, species and varietal characteristics of grain crops. At optimal temperature (+10...15°C) and soil moisture, the tillering period is extended, and the number of shoots increases. Under normal conditions, winter crops form 3–6 shoots, spring crops - 2–3. The number of shoots is also influenced by the fertility of the soil, especially the introduction of nitrogen fertilizers before the beginning of the stemming phase.

The dynamics of the formation of tillering shoots and nodal roots in grain crops is not the same. In rye and oats, tillering and rooting occur simultaneously with the appearance of 3–4 leaves. In barley and wheat, tillering shoots appear before the beginning of rooting, tillering takes place during the period of the appearance of the 3rd leaf, and rooting - 4–5 leaves. In millet, tillering shoots are formed during the period of appearance of 5–6 leaves, in sorghum – 7–8 leaves. Nodal roots in these crops 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 laying of the future crop takes place - the formation of spikelets.

Bushing is one of the reserves of the strength of ontogenesis, a mechanism of increasing the competitiveness of plants due to an increase in the area of the leaf surface, the number of roots, and the reproduction ratio. With the onset of the tillering phase, the probability of plant survival increases. Tufting is characteristic of all cereal crops, but in cereal crops of the second group, unlike the first, lateral shoots are formed not only near the underground, but also near the nodes of the above-ground part of the stem, that is, the stem is bushy and branched, which increases the reproduction coefficient.

From an economic point of view, weeding plays both a positive (increasing plant productivity and yield) and a negative role: non-productive use of soil moisture and nutrients, uneven maturation of plants, increased costs for separate harvesting, seed heterogeneity, etc.

Bushing of plants can be controlled by adjusting the sowing rate, timing and methods of sowing, depth of seed wrapping, etc. Thus, the coefficient of bushiness of winter wheat decreases with an increase in the sowing rate, the depth of seed wrapping and with late sowing dates, and vice versa: a decrease in the rate, normal depth and early sowing increase bushiness.

For normal plant development, seeds should be sown to such a depth that the nodes of the stem, especially the upper one, above which the growth point is located, are in the soil. This guarantees normal tillering, the development of a powerful root system, and the preservation of the growth point. The optimal depth of wrapping the seeds of cereal crops of the first group under favorable conditions is 4–6 cm, while the upper node of the tiller is located 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 wrapping, temperature, light level, etc. Thus, in cereal crops of the first group, the upper node of the tiller lies deeper than in the cereal crops of the second group, and does not come out of the soil, while in cereal crops of the second group, with insufficient lighting or late rooting, the *tillering* nodes are brought out, sometimes to a considerable height. Winter wheat *tillering* nodes lie deeper at late sowing times and deep (more than 6 cm) seed wrapping than at early times and optimal sowing depth. With deep sowing, the internodes between the nodes are elongated, bushiness and the number of nodal roots are reduced. At the optimal sowing depth, the *tillering* nodes are usually brought together and have the appearance of thickening, in which individual nodes are difficult to distinguish.

The depth of the *tillering* nodes is regulated by the vagina and ligula. The sheath grows until the ligule appears above the coleoptile or sheath of the preceding leaf. Under the influence of light, the periscope cells of the tongue synthesize specific substances that reach the base of the vagina and inhibit its growth, as a result of which the *tillering* nodes to which the vagina is attached stops at a certain depth.

S*hooting*. The transition of plants to the phase of shooting begins with the growth of the stem in length. In cereal crops, even in the tillering phase, a stem with very short interstices, which have the appearance of densely placed transverse rings, can be found.

The growth of internodes begins with the lower one, which is located directly above the node of the tiller. After that, the second grows, then the third, and the following ones after it. Each interstice at the base has its own growth zone, which gave reason to call such growth *intercalary*.

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

The phase of shooting of plants in winter crops occurs in the spring, after the appearance of 2–3 new leaves. Simple elongation of leaf sheaths, which is often observed in thickened crops of winter crops in rainy autumn conditions, should not be taken as the stemming phase.

In agronomic practice, the booting phase is often determined by the appearance of a stem node above the soil surface at a height of 4–5 cm. This phase continues until the eighth stage of organogenesis.

Drought, heat stress, and frost during the period of shooting increase the number of dead shoots due to the limitation of plant resources. This period for plants is a period of intensive growth and development, 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 fertilization is carried out during this period, the synchronization of the plant's development is disrupted and they form many spikes that ripen late, which is also a problem during harvesting.

The size of the harvest also depends to a large extent on the size of the ear and its grain size. The ear begins to be established at the third stage of organogenesis, which coincides with the phases of tillering and stemming. During the tillering, 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 shooting and is characterized by the beginning of the formation and differentiation of flowers, the laying of stamens, pistils and integumentary organs of the flower. Its phenological sign is the appearance of the second stem node. At this stage of organogenesis, the potentially possible number of flowers in spikelets for the variety is finally determined. Foliar feeding will be effective and will ensure the establishment of a large spike, and the earlier it is carried out, the better the final result.

Shooting, the end of differentiation of the growth cone falls on the sixth and seventh stages of organogenesis, which coincides with the second half of the phase of shooting before earing. During this period, plants absorb the largest amount of nutrients, as a result of which the number of productive stems, spikelets and grains in the ear increases. At this time, a second dose of nitrogen fertilizers and foliar feeding is applied (the appearance of a flag leaf before flowering). Such feeding significantly increases productivity by increasing the viability of pollen and the formation of grains in the ear.

Thus, shooting is considered a critical period in the formation of plant productivity. The first critical period (*"double ring"* period) begins at the time when two constrictions are formed on the growth cone of the main shoot, which indicates the beginning of ear laying. In winter cereal crops, the "double ring" appears even before the beginning of winter dormancy, in the phase of the sixth leaf. The second, so-called "*big critical period*" begins with the appearance of the second above-ground node on the stem of the main shoot (the beginning of shooting) and continues until the appearance of a flag leaf. During this period, the stem and inflorescences are actively growing, the sensitivity of plants to the lack of moisture, nutrients, and lighting increases sharply. Under unfavorable conditions, spikelets die in wheat and rye at the bottom, and in barley at the top of the ear. With the appearance of a flag leaf, the sensitivity of cereal crops to growth regulators decreases.

Earing. During the growth of the last (upper) interstice, an inflorescence appears from the sheath of the upper leaf, which indicates the beginning of the earing phase or panicle shedding in cultures with panicle inflorescences. The intensity of growth processes depends on the supply of moisture and nutrients. Earing (ejection of the panicle) occurs at the VIIIth stage of organogenesis and lasts 5–7 days until the growth of the last internode stops.

The duration of the phase is greater, the greater the coefficient of tillering. High temperatures accelerate earing, low temperatures slow it down; under favorable conditions, the earing period is longer than under unfavorable ones.

Flowering in grain crops occurs during or shortly after earing. So, in barley, flowering takes place even before the ear is fully eared, when the spike has not left the vagina of the leaf, in wheat - after 2-3 days, in rye - after 8-10 days after earing. According to pollination features, rye, corn, and sorghum belong to cross-pollinated crops, and wheat, triticale, barley, millet, and rice belong to autogamous crops.

*Ripening.*After fertilization, a grain is formed from the ovary. Formation lasts 12–16 days, and at the end of the phase, 25–30% of dry matter accumulates in the grain. When the formation ends and the growth of the grain stops, the intensive supply of nutrients to it begins, that is, the ripening of the grain begins.

The *ripening* of the grain itself begins with the onset of milk-like ripeness, which indicates the beginning of ripening, that is, the accumulation of the products of photosynthesis, primarily starch. The products of photosynthesis reach the grain in the form of a solution, as a result of which its raw and dry weight increases.

During ripening, polymerization of organic compounds takes place, soluble substances become insoluble and are stored in reserve, displacing water from the cells of the endosperm, which leads to a decrease in grain moisture. This is the so-called metabolic (physiological) evaporation of moisture, which is carried out even at 100% ambient humidity.

At a humidity of 65–60%, the grain content takes on the form of a milky-white liquid. This state is called the *milky stage*of the grain, it lasts 10–12 days. At the end of the *milky stage*, the moisture content of the grain decreases to 45–40%, its content turns first into a dough-like mass, and then into a waxy mass - the phase of *yellow ripeness* begins. Depending on the conditions, it lasts 6–12 days. When the moisture content of grains is reduced to 35–30%, separate harvesting of bread crops can be started. The full ripeness of grains occurs when their humidity drops to 13–15% in the southern regions, and to 17–20% in the northern regions. The grain becomes hard, its volume decreases, it may fall off from the inflorescence.

The duration of the ripening period is directly correlated with yield: the longer the accumulation of plastic substances, the larger the grain and the greater the grain collection. High temperatures during this period lead to accelerated ripening, formation of thin grains. Temperatures that are too low also have a negative effect on yield, as they slow down the processes of assimilants draining into the grain, delaying the harvesting period. Heavy rains lead to the laying of crops, germination of grain, a decrease in the quality of grain (runoff of gluten), complications of harvesting. The delay in harvesting in conditions of elevated temperatures leads to a strong decrease in the moisture content of the grain, increased cracking and shedding of the grain.

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 state. According to F.M. Kuperman, twelve stages of organogenesis are distinguished in the ontogenesis of cereal crops (Table 1.3, 1.4).

The IV-X stages of organogenesis are the most responsible in the life of a plant. At these stages, the main elements of plant productivity are formed: the number of spikelets in an inflorescence, the number of grains in a spikelet, the number of productive inflorescences.

In the first-third stages of organogenesis, living conditions play a leading role in the formation of elements of plant productivity, in the fourth-tenth stages, the influence of the environment is largely limited by the genetic characteristics of the plant. Thus, under favorable conditions, during the IX-X stages of organogenesis, 3-5 grains can be formed in wheat ears, but there is no way to force the plant to form 20 grains in spikes, because this is not foreseen by the genetic program. At the XI-XII stages, new organs are not formed, the morphogenesis of the embryo and grain as a whole is completed.

The stages of organogenesis are taken into account when planning technological operations, which should provide favorable conditions for the formation of the rudiments of certain organs. An untimely technological operation not only does not achieve the goal, but can also cause harm. For example, watering or fertilizing plants during stage IV of organogenesis will not increase the number of spikelets beyond the number of spike duramen segments, but may cause excessive growth of vegetative organs and plant lodging.

Under unfavorable conditions at the IV stage of organogenesis, some of the lower members of the ear remain without spikes or bear underdeveloped spikes. At the V stage, it is not possible to increase the number of spikelets in the ear, or the number of branches in the panicle, because their formation was completed in the IV and III stages, respectively.

In foreign countries, when grading grain crops, not the stages of organogenesis are taken into account, but the detailed phases of plant growth and development. At the same time, each phase and its separate periods (subphases) are indicated by corresponding numbers (coded), the systematic series of which is called a *scale*. The most famous are the Ficus scale (Feekes) and the international scale of the breeders' association - *Eucarpia or EC*.

Cereal ear crops are sensitive to *lodging*. The normal growth and development of plants is disrupted due to the laying of crops, the size of the photosynthesizing surface decreases, the assimilation of nutrients and water slows down, which causes significant crop losses. The faster the crops are laid, the greater the shortage of grain. The level of losses also increases due to the deterioration of harvesting conditions during the harvest. There are two types of laying of cereal crops: stem and root.

Stem drowning is observed on thickened crops. Insufficient lighting of plants in such crops leads to the fact that the lower interstice are pulled out, little cellulose and hemicellulose is deposited in the cell walls. Such stems cannot withstand the weight of the plant and lie down during rains and winds. Rye and barley are most prone to drowning. Short-stemmed varieties are more resistant to drowning.

Root drowning is observed when the soil is excessively moistened. With frequent rains and strong winds, mainly tall varieties of crops with a strong stem (corn, sorghum) are planted.

With an increase in sowing rates, application of high doses of nitrogen fertilizers, laying increases. To prevent drowning, large amounts of nitrogen fertilizers are applied in individual doses during the growing season. Varieties prone to drowning and those with high tillering energy are sown at lower sowing rates.

To protect plants from drowning, biologically active substances are used that suppress stem growth - retardants. This is chlorocholine chloride (CCC, XXX), on the basis of which the following drugs are created: TUR, Retacel, Chlormequat, Arotex, and others, as well as Typhon (2-chloroethyl phosphonic acid), which is the active ingredient of campozan, etrel, flordimex, dihydrel, and other drugs. The action of the drugs is manifested in the inhibition of stretching of the cells of the subapical meristem, as a result of which the growth in length is inhibited, the differentiation of the growth cone is slowed down. This causes an increase in the duration of individual stages of organogenesis and an increase in the productivity of the spike due to an increase in its length, the number of spikes and grains in it. In plants sprayed with retardants, the height of the stems decreases by 15–30%, their thickness increases, and the plants become more resistant to drowning.

1.3 WINTER GRAIN CROPS

Cereal crops are divided into two biological groups: winter and spring.

Winter cereal crops(wheat, rye, triticale, barley) are such forms of cereal crops that fructescents only when seeds are sown in autumn, and the harvest is obtained after overwintering. During spring sowing, winter crops experience only tillering but not earing, because in order to complete development, they must go through the stage of vernalization (stimulation of flowering by cold) at low temperatures - 0...+30C (during the tillering phase +10...120C) for 35-60 days and autumn lighting. Acting on the growth cone, low temperatures contribute to qualitative biochemical changes in plants - the passage of the vernalization stage, which subsequently ensures the onset of generative phases. Therefore, they are sown in autumn 50-60 days before the onset of persistent frosts.

Spring crops (wheat, triticale, oats, barley, and all grain crops - millet, sorghum, soriz, corn, rice) are sown in the spring and harvested in the same year. For vernalization, they need higher temperatures (+5...200C) for 7-20 days under spring lighting.

In addition to winter and spring crops, there are also transitional forms - two-leaf crops (wheat, triticale, barley), which go through the stage of vernalization at a temperature of +3...150C. They are capable of sprouting and yielding a crop of grain during spring sowing and, having higher frost resistance than spring forms, during autumn sowing. A biological feature of two-leaf plants is that in the fall they complete their growing season later, compared to typical winter varieties, and in the spring they resume it earlier.

Winter ones, compared to spring ones, have a number of biological and organizational and economic advantages.

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

Winter ones, using the warm autumn period, have time to form a developed root system before winter and tiller up, undergo hardening. Hardened plants tolerate adverse overwintering conditions well, they start vegetation earlier in the spring, so it is better to use the early spring reserves of moisture, nutrients, and light. With the onset of persistent heat, they quickly build up vegetative mass, overtake weeds in growth and suppress them, and suffer less from spring droughts.

A better developed root system and earlier (by 10-15 days) ripening of winter crops contribute to reducing the negative impact of summer droughts. An integrating indicator of the biological advantages of winter grain crops is their higher yield, by 10-15 t/ha.

The *organizational and economic* advantages of winter crops are that sowing in the fall and harvesting them earlier in the summer reduce the intensity of sowing and harvesting. Early harvesting makes it possible to better prepare the soil for the following crops, so winter crops are valuable precursors for most agricultural crops. After harvesting winter crops, there is enough warm time to grow an additional crop of post-harvest crops for grain (buckwheat, millet) or green fodder on the same area.

1.3.1 Winter hardiness of winter crops

Biological features of winter crops limit their distribution. In regions where winter conditions are very harsh, winter crops may thin out or die.

The ability of plants to withstand a complex of adverse conditions in winter and early spring is called *winter hardiness*, and their ability to withstand low temperatures is called *frost resistance* (below 0°C) or *cold resistance* (above 00°C).

The resistance of winter crops to low temperatures is an important adaptive property developed in the process of evolution. In increasing the winter resistance of plants, the properties of protoplasm that determine its water-holding capacity play an important role. Excess or lack of water is one of the reasons for the death of winter crops. 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 biocolloids of protoplasm and plants die.

The resistance of winter crops to adverse conditions is influenced by the introduction of granulated, especially manganese, superphosphate at the rate of 10-12 kg of P_2O_5 per hectare, simultaneously with seed sowing. Fertilization at the beginning of the growing season with phosphorus and manganese contributes to the accumulation of plastic substances in the nodes of the shoots and increases the winter hardiness of plants.

The introduction of phosphorus-potassium fertilizers helps to increase the resistance of plants to adverse wintering conditions. Excessive nitrogen nutrition accelerates the growth of plants 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 transformation of cell contents from a relatively liquid state (sol) into a thickened, gelatinous state (gel) as a result of a decrease in free water that freezes easily and an increase of the content of bound, which is difficult to freeze and in the improvement of its structure and physical properties.

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

Carbohydrates synthesized during the day are not fully spent on the construction of green mass and respiration due to inhibition of growth processes in cool nights, so they accumulate (up to 30% or more of sugars in the nodes of the shoots and sheaths of the leaves in terms of dry matter). Carbohydrates play a protective role (they prevent coagulation and denaturation of proteins) and, in addition, are a reserve material that plants use in the spring to restore vegetation. After the first phase of hardening, plants can withstand a drop in temperature at the depth of the tiller node to -10...12oC.

The *second phase* of hardening (main) takes place at the end of autumn, with light frosts (0...–5oC) both in the light and in the dark. Some tissue dehydration occurs. There is an outflow of water from the cytoplasm into the intercellular spaces and the transformation of water-insoluble organic compounds in the solution in the cells. Thanks to this, the concentration of cell sap in the nodes of the stems and sheaths of the leaves increases, the properties of the cytoplasm of the cells change: the viscosity increases and the permeability decreases. Sugar delays the coagulation of colloids and lowers the freezing point of cell juice. Its osmotic pressure and water-holding capacity increase. Complex proteins change into simpler forms resistant to coagulation at low temperatures. Plants acquire resistance to frost and other adverse wintering conditions.

Rye undergoes the second hardening phase faster, winter wheat more slowly, and winter barley more slowly. After this phase, resistance to adverse winter conditions increases dramatically.

During the hardening process of winter crops, many soluble carbohydrates and free amino acids accumulate in the vegetative organs. Among them, oligosaccharides, proline, asparagine and glutamic acid have the highest specific gravity. During hardening, the largest amount of soluble carbohydrates and free amino acids accumulates in the nodes of the tillers. Frost- and winter-hardy varieties of winter wheat during hardening accumulate a larger amount of oligosaccharides and free amino acids compared to low-hardy ones. Oligosaccharides gradually turn into soluble sugars (sucrose, etc.), as a result of which the concentration of cell juice increases, which increases the resistance of plants to low temperatures.

Hardening of plants depends on meteorological conditions in autumn. Clear, sunny weather with warm days and cool nights promotes hardening, and, on the contrary, cloudy weather in autumn, with warm days and nights, delays the hardening of plants.

Well-tempered wheat tolerates temperature drops to -18...20oC, rye - to -22...23oC, triticale - to -20...22oC, winter barley - to -13...14oC.

The ability to harden changes during the staged development of plants. Successful hardening is possible only before the end of the vernalization stage. Hardening processes are reversed. If there are long thaws in winter and early spring and plants resume growth processes, their development is observed. After that, they are able to harden again, but there are no conditions for this and the plants are damaged by subsequent frosts.

Thus, the winter hardiness of winter crops should be considered as a result of the interaction of plants and the environment, as an adaptation to adverse overwintering conditions.

1.3.2 Causes of thinning and death of winter crops. Protection of plants from adverse overwintering conditions

The advantages of winter cereal crops can be most fully manifested in the presence of suitable conditions for their successful overwintering and spring-summer development. Therefore, the weather conditions of the winter and early spring periods play a decisive role in the life of winter crops.

The causes of damage and death of winter crops are different. In the conditions of Ukraine, winter crops in the steppe regions are most often liquefied or die from freezing, in the forest-steppe regions - from ice crusts, in the steppe regions - from washing out, getting wet, freezing.

The *freezing* of plants is observed when the temperatures at the depth of the tillering node drop to critical levels. Under the influence of long frosts, ice forms in plant cells and intercellular spaces, which leads to mechanical damage to cell membranes, and the cytoplasm dehydrates to such a level that irreversible processes of coagulation of its colloids occur, protein denatures.

Frozen plants emerging from the snow initially have a green color, and after thawing, they turn yellow and die.

The ability of plants to withstand low temperatures largely depends on the variety, stage condition and autumn hardening. In frost-resistant varieties, the hydrolysis of starch and sucrose proceeds energetically, which increases the concentration of cell juice.

The plant can also die from freezing as a result of insufficient depth of the tiller node. In winter-hardy varieties, the root node lies much deeper compared to less winter-hardy varieties. In addition, winter crops are at risk of freezing due to the formation of a hanging ice crust on the soil surface. The most dangerous is the rubbed crust covering the root node.

Snow retention is a reliable means of protecting plants from freezing. Snow has low thermal conductivity and protects winter crops well from excessively low temperatures. It has been proven that at a minimum air temperature of –32…33oC, the temperature at the depth of the tiller node without snow is –22…23oC, in fields with a snow cover of 15–17 cm it drops to –7…11oC, and with a snow thickness of 50 cm – only -2...3oC.

The measures that increase the frost resistance of plants include the selection of frost-resistant varieties, their sowing at the optimal time and at a depth that ensures that the root node is at least 2.5-3.0 cm from the soil surface. The depth of the tillering knot increases significantly when the seeds are treated with retardants before sowing. Phosphorous and potash fertilizers increase frost resistance.

Damping-out of crops can occur in the following cases:

1. if thickened, overgrown from autumn and weakly 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 is formed on winter crops, under which the temperature rises and plants recover vegetation under the influence of light.

3. when snow falls on unfrozen ground, when winter crops are not prepared for winter. They continue to grow, breathe intensively and quickly use up spare nutrients.

When washing out, wintercrops die from exhaustion due to insufficient lighting under the snow, which is necessary for assimilation. First, carbohydrates are used up, then proteins break down and, as a result, weakened plants are affected by snow mold and other fungal diseases and die.

To prevent damping-out when early snow falls on unfrozen soil, it is advisable to compact it with rollers. In this case, the soil quickly cools down and plant growth stops. Early and dense sowing, as well as excessive nitrogen nutrition of plants, should be avoided.

At the end of winter, to accelerate the melting of frozen snow, it is advisable to spudd it, spread peat, ash or other neutral dark materials on the surface of the snow. In addition, it is necessary to destroy hanging ice crusts, use varieties resistant to damping-out. It should also be taken into account that winter rye and barley are less resistant to damping-out than wheat and triticale.

Damping-off is observed on low-lying elements of the relief, on clayey soils with a heavy mechanical composition, where water is retained for a long time under the snow in early spring or after its melting. Under water, plants die after 10-15 days due to excessive consumption of sugars to support life in anaerobic conditions of respiration. As the temperature rises, the wetting process accelerates, weakly hardened plants get wet faster.

Protecting plants from waterlogging involves the installation of drainage ditches, vertical drainage, spudding of the soil, sowing water-resistant varieties, and, if necessary, pumping out water in places where water stagnates.

Protrusion is the displacement of tillering nodes onto the surface of the soil, which is accompanied by the breaking off of the root system. It occurs in autumn, winter or spring on heavy, structureless soils, as well as on soils that have not settled before the appearance of seedlings due to their settling and alternating freezing and thawing. Bulging is also caused by the formation of loose ice under the surface of the soil, when it increases in volume, and then when it thaws, it settles, exposing the tillering nodes of the plant. Protrusion is especially harmful when it is accompanied by severe frosts and dry windy weather in the spring and during dust storms. Strong winds blow and cover plants with soil particles.

Protection of plants from bulging is facilitated by timely tillage of the soil, its ramming before sowing, sowing of seeds at the optimal depth, treatment of seeds before sowing with retardants, which contributes to a deeper settlement of the tillering node and better development of the root system for better contact of the tiller nodes with the still moist soil, as a result of which new stem roots are formed faster and plant growth is restored.

The main means of protection against blowing, cutting and covering plants with soil, which are observed in the areas of the spread of wind erosion, are plowless flat-cut tillage, stubbling-in, notching and strip sowing.

Ice crusts. They can be transparent and cloudy, rubbed and hanging.

Grinded transparent ice crusts cause the most damage. They are formed when all the snow melts during thaws, and the water that forms freezes with the onset of frost. Depending on the depth of thawing of the soil, the ice either rubs tightly against the surface of the soil, or binds it to the depth of thawing and the 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 also deteriorates, the supply of plant tissues with oxygen decreases, and anaerobic processes increase.

Crusts that are on the surface of the frozen soil and do not capture the tillering nodeof the plant are much less harmful.

Hanging ice crusts appear when water freezes and forms on the surface of the soil after thawing. If the soil is melting, the water is absorbed and there is a free space between the soil and the ice crust. A hanging crust (especially cloudy) formed on frozen soil mostly does not harm plants, and sometimes even plays a protective role against severe frosts. Thus, at an air temperature of -250C, the temperature under a 4 cm thick ice crust rises to -140C.

However, with long-term storage of the hanging crust, the increase in solar insolation creates the so-called "greenhouse effect" as a result of which plants can come out of a state of rest and restore vegetation. With hanging ice crusts, plants die from washing out or getting wet when the soil is overmoistened.

Grinded ice crusts are destroyed by sprinkling them with dark materials (peat, ash, humus, etc.). Significantly reduces the formation of snow retention crusts. Hanging ice crusts are destroyed by rolling.

Ice crust formed after thawing on the surface of the snow, as a rule, does not harm winter crops.

Snow mold is caused by the parasitic fungus *Fusarium nivale* and is manifested in the fact that on winter crops (most often on winter rye), which have come out from under the snow, the plants are covered with a whitish or pink coating. Snow mold is often accompanied by damping-out and develops on plants that are dead or dying as a result of damping-out or adverse events. However, mold also affects plants that are alive but weakened during wintering.

In addition to snow mold, a disease caused by the fungus *Sclerotina graminearum* often develops on winter crops after overwintering. At the same time, first white, and then dark brown dense lumps - sclerotia - appear on the plants. In the fight against snow mold, the introduction of fusarium-resistant varieties is of crucial importance. Disinfection of seeds before sowing with Granozan gives good results.

Taking into account the ability of winter wheat to continue tillering in the spring, it is possible to correctly determine the areas of dead crops only 2 weeks after the start of the spring vegetation of plants.

1.3.3 Winter wheat *(Triticum)*

Wheat is one of the oldest and most widespread crops. It was known for 6.5 thousand years BC. on the territory of modern Iraq, 6 thousand years BC. it was grown in Egypt and 3 thousand years BC. - in China. Wheat has been grown in Ukraine since ancient times.Archaeological research has established that already in the fourth millennium BC. wheat was grown in the territory of modern Khmelnytskyi region.

Winter wheat is the most important grain crop in Ukraine. In terms of cultivated areas, it occupies the first place and is the main food crop. Winter wheat is grown mainly in countries with a mild climate. In countries with a harsh climate, vigorous forms are common. In Ukraine, winter wheat is sown on an area of 6.5-7.5 million hectares (the world area is 240 million hectares), rye is grown on 400-450 thousand hectares.

Wheat cereal crop is characterized by high nutrition and taste qualities, and in terms of digestibility, bread made from the flour of other grain crops prevails. 100 g of wheat bread contains 245-255 kcal, which indicates its high nutritional value and energy intensity. The value of wheat bread is determined by the chemical composition of the grain. Wheat grain contains from 11 to 20% protein, 63-74% starch, about 2%

fat, up to 2% ash minerals and many vitamins (B1, B2, PP, E, provitamins A, D). In addition to baking, wheat flour is used for the production of pasta and confectionery products. Grain is processed into alcohol, starch, dextrin, etc.

However, high-quality bread and bakery products are obtained only from the flour of strong wheat, which belongs to the type of soft wheat. According to the state standard, the grain of durum wheat belongs to the first and second classes, which contain, respectively, 36, 32 and at least 28% of raw gluten of the first group and has a nature of at least 755 g/l, glass visibility - not less than 60%, and the baking strength of flour 280 or more alveograph units.

Winter wheat is an important fodder crop. Wheat bran is a valuable concentrated feed for all types of farm animals. Straw and chaff have significant fodder value. Straw in chopped and steamed form or enriched with fodder molasses is used as roughage for cattle. 100 kg of straw contains 20-22 fodder units and 0.5-1 kg of digestible protein. Winter wheat in its pure form or mixed with vetch is grown for green fodder, which is used in early spring, following rye.

The agrotechnical significance of winter wheat is that it is a good precursor for other crop rotations.

Biological features, varieties. In ontogeny, wheat goes through 12 stages of organogenesis and the following phenological phases: seed germination, sprouting, tillering, tuberization (stalking), earing, flowering, formation and filling of grains, milky stage, yellow and full ripeness. Seed germination, seedling phase and partial tillering occur in autumn, during the I and II stages of organogenesis, the last phenophases and stages of organogenesis - in the spring and summer of the following year. Vegetation lasts 40-50 days in autumn, 90-110 days in spring and summer. The weight of 1000 grains is 35-50 g.

Under favorable conditions, seedlings appear 7-9 days after sowing. After 13-15 days, when 3-4 leaves form 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. At this time, the root system is deepened by 50-70 cm.

With the arrival of average daily temperatures of +4...5?C in spring, wheat resumes vegetation and continues to grow for another 25-30 days. After that, the shooting (stalking) begins. It lasts 25-30 days and is replaced by the earing phase, and after another 4-5 days, flowering and stem growth stop. Wheat is a autogamous crop, so pollination can also occur in fallen crops, but the number of grains in an ear, the weight of 1000 grains, and the yield decrease by 20-40% or more. After fertilization, a grain is formed, which after 12-17 days reaches its final length and enters the phase of early milkystage, and then milky stage, pasty, yellow and full ripeness. The milky stage of maturity lasts 7-14 days, the yellow ripeness phase lasts 7-9 days. In the middle of the yellow ripeness, when the moisture content of the grain is 33-35%, the flow of plastic substances into the grains stops and you can start separate harvesting.

Wheat is a cold-resistant crop. Its seeds begin to germinate at a temperature of +1...2?C. To obtain friendly seedlings, the temperature during sowing should be +14...16?C. The sum of active temperatures of 130–1400C is required to obtain ladders. At a temperature of +25?C and above, weakened seedlings with thin roots are formed, which are strongly affected by diseases. Well-hardened plants can withstand a drop in temperature in the zone of the stem node to -17...18°C in winter, and highly frost-resistant varieties - to -19...20°C. Sufficient snow cover protects plants even when the temperature drops to -35...40°C. A layer of snow of 10 cm or more completely protects plants from freezing even when the temperature drops to -30°C. In the presence of a snow cover with a layer of 2 cm, winter wheat can withstand a drop in temperature to -22...25°C.

Winter wheat is demanding on moisture. During germination, seeds absorb 50-55% of water from their own weight. It consumes 300-450 units of water to form a unit mass of dry matter. The transpiration coefficient (TC) decreases with sufficient use of phosphorus-potassium fertilizers, which promote the development of the root system, and retail application of nitrogen fertilizers. During the growing season, the soil moisture should be within 65-75% of RH and not decrease to the level of moisture that breaks the capillaries and, even more so, to the moisture level of permanent wilting of plants. If there is less than 10 mm of plant-available moisture in the 10-centimeter top layer of soil, seedlings appear late and are thinned. A high grain yield is obtained with spring reserves of moisture in the 0-100 cm soil layer of about 200 mm, and in the earing phase at least 80-120 mm.

A lack of moisture in the soil during seed germination and emergence of seedlings causes great damage to crops. At the same time, the stairs are usually thinned out and appear singly. Deficiency of moisture during tillering (II–III stages) reduces bushiness, and during earing and flowering (VIII, IX stages) reduces grain size, when pouring grain (X stage) reduces the weight of 1000 grains.

Winter wheat is light demanding. If there is insufficient lighting, the root knot is formed close to the soil surface, the plants do not harden well and therefore have low winter hardiness. Insufficient lighting in the spring is the cause of pulling out the lower internodes and laying down of plants. If there is insufficient lighting during the pouring and ripening of the grain, its quality deteriorates, in particular, the content of protein and gluten decreases.

Requirements for nourishment components. 30-40 kg of nitrogen, 9-13 kg of phosphorus and 20-30 kg of potassium are required for the formation of 1 ton of grain with the appropriate amount of straw, depending on the variety and growing conditions. Phosphorus and potassium added to wheat seeding contribute to the better development of the root system and the accumulation of sugars in plants, which increases their winter resistance. Nitrogen is more valuable for plants in spring and summer. It enhances plant growth, promotes the formation of grains with a higher protein content. The intensity of absorption of nutrients from the soil changes during the growing season. The most nitrogen is absorbed during tillering, and potassium and phosphorus are absorbed during the phase of shooting and earing.

Soil requirements. Wheat grows well on fertile soils with a high content of humus (at least 2%) and nutrients easily available to plants. The valuation of the land must exceed 55 points. The best for it are black earth, chestnut, gray and dark gray soils, medium loam in mechanical composition, with a neutral reaction (pH 6.5–7.5) and a bulk density of 1.1–1.25 g/cm3. When the volumetric mass of the soil increases to 1.35–1.4 g/cm3, the growth of roots is suppressed, and when it exceeds 1.6 g/cm3, the roots do not penetrate into deeper horizons.

Wheat does not grow well on saline and acidic soils with heavy mechanical composition, prone to flooding and in areas where water stagnates.

Varieties of wheat are divided: according to the type of development - winter, spring, according to baking qualities (soft wheat) - strong, valuable, good fillers, satisfactory fillers, weak; according to the level of productivity - intensive, ordinary; according to the duration of the vegetation period - early ripening, mid-early, mid-ripening, mid-late, late-ripening; according to resistance to high and low temperatures, lack of moisture, to lying down, diseases, etc. - stable, unstable.

Strong, or improvers, are varieties whose grain contains at least 14% protein. The flour, thanks to its high-quality gluten, forms a dough that can withstand intensive kneading, long-term fermentation and provides a large volume of bread.

Flour of strong varieties has the ability to improve the baking qualities of flour of weak wheat. Thus, to obtain bread with good volume and porosity, it is necessary to add 20-50% of strong flour to weak wheat flour.

Valuable varieties have high baking qualities, but they are not able to improve the quality of flour of weak varieties.

Fillers are varieties with average baking qualities. Their flour is used independently for baking bread, and is also added (30-35%) to flour of strong varieties in order to dilute it, because the very high content of gluten in flour of strong varieties negatively affects the quality of bread. It is impractical to bake bread from pure flour of improver varieties.

Different varieties are offered for different soil and climatic zones of Ukraine, taking into account their biological and economic features: drought resistance, winter resistance, baking qualities of grain, etc.

Almost 64% of strong varieties are intended for cultivation in the

Steppe and Forest-Steppe, 55% of valuable varieties - in the Forest-Steppe and Polissia.

Breeders have created many wheat varieties of intensive type with high baking and pasta qualities. The yield potential of current varieties reaches 12.0 t/ha and more.

In recent years, highly productive varieties of strong and valuable wheat have been added to the Register of Plant Varieties of Ukraine for the steppe zone: Columbia, Podolyanka, Kuyalnyk, Povaga, Smuglyanka, Pereyaslavka, Remeslivna, Poshana, Dryada 1, Kiriya, Vesnyanka, Dobirna, Dar Luhanshchyna, Zernogradka 11, Luhanchanka, Stanichna, Spivanka, Tronka, Lyona, Pobeda 50, Zira and Khersonska 99.

Strong wheat varieties are recommended for the Forest Steppe: Columbia, Podolyanka, Kuyalnik, Povaga, Smuglyanka, Pereyaslavka, Remeslivna, Vesnyanka, Dobirna, Vasylyna, Dimetra, Dykanka, Yermak, Levada, Tronka, Lyona, Pobeda 50. Valuable wheat varieties: Vesta, Elegia, Kopilivchanka, Zira, National, Capital, Favorite, Owner.

For the Polissia zone, new varieties of strong wheat are recommended: Podolyanka, Columbia, Povaga, Smuglyanka, Remeslivna, Vesnyanka, Dobirna, Vasylyna, Dimetra, Yermak; varieties of valuable wheat: Vesta, Lars, Elegia, Kopylivchanka, Pereyaslavka, National, Stolichna, Favorite, Volodarka.

In order to rationally use productivity factors in each farm, it is advisable to grow 2-3 zoned varieties that differ from each other in biological features and economic characteristics.

Cultivation technology.*Predecessors*. In different zones, the best predecessors for wheat, as well as for other winter crops, are crops that clear the field early, do not deplete the soil of nutrients and moisture, leave fields clean of weeds, and do not have common pests and diseases. Pure vapors, which are economically beneficial only in arid steppe areas of Ukraine, best meet these requirements. In all zones, wheat is sown after busy pairs, perennial leguminous grasses (clover, alfalfa), early-harvesting legumes (peas and ultra-early varieties of soybeans), corn for green fodder and early silage. In the Forest Steppe and Polissia, it is also grown after perennial leguminous grasses and early potatoes, buckwheat, in Polissia - after lupine for green fodder and silage, long-leaved flax, and on sandy soils - after sideral lupine pairs.

It can be sown after oats, as it is not affected by root rot and leaves better-quality harvest residues compared to other grain crops. The yield of winter wheat in repeated sowings is noticeably reduced when placed after barley and corn of the Ministry of Internal Affairs of late harvest periods.

Wheat is picky about its predecessors and reduces productivity by 15-20% when replanted, and by 30-35% or more when it is sown for the third year in a row. With unchanged cultivation, yields decrease even with the introduction of an additional amount of fertilizers. The main reason for the decrease in yield is the progressive spread of diseases, pests and weeds.

Wheat and other winter cereals should not be grown after Sudan grass, sorghum, corn for grain, sunflower, which are harvested late, besides, they dry the soil to a considerable depth.

Soil preparation. When preparing the soil for winter wheat, like other winter grain crops, the sowing layer should be brought to a fine-grained state to ensure maximum accumulation and preservation of soil moisture, to create favorable conditions for high-quality sowing, seed germination and plant development at the beginning of the growing season. The sowing layer should consist mainly of aggregates up to 10 mm in size, and the number of lumps 3-10 cm in size in it should not exceed 10% of the mass of the sowing layer.

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

The areas set aside for black steam, after harvesting the predecessor, are husked to a depth of 6-8 cm with disk-shaped paring plough (LDH-20, LDH-15A, LDH-10A, LDH-5A), and after the germination of weeds, a second shallow ploughing is carried out with plow paring plough (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 sprout after the second shallow ploughing, ploughing is carried out with plows with front plows (PTK–9–35, PNL–8–40, PLP–6–30, PLN–5–35, PL–5–35, PLN–4– 35, PLN–3–35) or the soil is unconsolidated with a flat cutter (PG–3–100) to a depth of 27-30 cm. Deep tillage under black steam improves the structure of the arable layer, enhances the activity of beneficial microorganisms, and contributes to the destruction of weeds, pests and diseases, penetration of precipitation into deeper layers of moisture, development of the root system. After the crops, which vacate the field late, shallow ploughing is carried out with disk-shaped paring plough in two directions to a depth of 6-8 cm, followed by deep ploughing.

In the spring, the cultivation of black steam begins with closing the moisture with heavy harrows (BZSS–1.0, BZTS–1.0) in 1–2 tracks. During the spring and summer, the soil is cultivated at various depths, which would ensure maximum moisture storage and the destruction of weeds. 5-7 days after closing the moisture, 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 appear with a gradual decrease in depth by 1-2 cm. In fields littered with rhizome 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, treating black steam with herbicides. Cultivation is impractical in dry weather and on weed-free fields. Pre-sowing cultivation is carried out to the depth of seed wrapping.

Under the conditions of sufficient moisture, after crops that are harvested early, the skimming and ploughing with plows with front plows in a unit with ring rollersare carried out, and on unweeded fields - tillage without harrowing is carried out. The depth of ploughing is 20-22 cm, after perennial grasses and corn - 25-27 cm, on sod-podzolic soils - 16-18 cm. If corn is harvested no earlier than 20 days before sowing wheat, surface tillage is carried out.

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

Considerable attention should be paid to pre-sowing soil cultivation. It should be carried out carefully adjusted to the depth of cultivation with KPS-4, USMK-5.4 type cultivators with harrows or combined units RVK-7.2, RVK-5.4, VIP-5.6. Uneven cultivation of the seed layer is the cause of uneven depth of seed wrapping, which, in turn, leads to a decrease in its field germination, non-simultaneous emergence of seedlings, uneven development of plants. Pre-sowing treatment is carried out to the depth of seed wrapping.

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

If the content of humus in the arable layer of the soil is less than 2%, the application of organic fertilizers is mandatory. Organic fertilizers at the rate of 20–25 ha in the Steppe, 25–30 t/ha in the Forest Steppe, and 30–35 t/ha in Polissia are applied under the main tillage or previous crop.

Mineral and organic fertilizers should be used under wheat. It is mandatory to apply the latter on those soils, the humus content of which does not exceed 2.2%. In this case, more water-resistant aggregates are formed and the effectiveness of mineral fertilizers increases.

Applying organic fertilizers is also mandatory when growing wheat after stubbly predecessor, as it improves the phytosanitary condition of the soil and enhances the activity of beneficial microflora.

The system of using mineral fertilizers involves basic, row fertilization and top dressing. Potash and 80–90% of phosphorous fertilizers from their total amount for the entire growing season are used as fertilizers. Fertilizers are applied under the deepest tillage of the soil. The remaining phosphorus fertilizers (P10–15) are applied to the rows during sowing, using granulated superphosphate or complex granulated fertilizer for this purpose.

Nitrogen fertilizers are applied in several terms. On poor soils, a part of ammonia-nitrogen fertilizers (up to 30 kg per year) should be applied under pre-sowing cultivation or mainly as fertilizers together with phosphorus and potassium. This accelerates the development and increases the winter resistance of plants on poor soils. An excessive amount of nitrogen in the autumn period reduces the winter hardiness of plants, so the main part of nitrogen fertilizers is applied in the form of top dressings in the spring and summer growing season.

Fertilization with nitrogen fertilizers is recommended to be carried out in three periods: at II–III, IV and VII–IX stages of organogenesis. When carrying out early spring (*regenerative*) fertilization, the main condition should be the maximum use of extremely scarce moisture in the upper layer of the soil. For this, it is extremely important to take advantage of the state of frozen ground, which can be very limited in time. Where it will be difficult to carry out this measure, it is worth applying urea forms of nitrogen on a low layer of snow, since the washing away of dissolved fertilizers is unlikely due to the high hygroscopicity of the arable layer of the soil. If possible, it is worth using the night time. In the absence of snow, it is advisable to apply ammonium nitrate without waiting for the frozen soil. First of all, *early spring fertilizing* should be carried out on thinned and underdeveloped crops, on which the dose of nitrogen fertilizers in fertilizing before the restoration of vegetation should be approximately 70-90 kg/ha, on crops in satisfactory condition - 50-60 kg/ha, in good - 20-30 kg/ha. Fertilization should be carried out before the beginning of the recovery of vegetation of winter crops. For early spring feeding, it is recommended to use ammonium nitrate, the effectiveness of which is 15-20% higher than that of urea.

The main dose of nitrogen in top dressing (productive) should be used at the beginning of shooting (IV stage of organogenesis). The introduction of nitrogen during this period of plant development contributes to better survival of the productive stem, an increase in the number of spikes in the ear, and an increase in the drought resistance of winter wheat plants. This top dressing is the main one on all areas occupied by winter crops in the forest-steppe and steppe zones of Ukraine. At the same time, nitrogen doses are adjusted taking into account the previously applied ones. Yes, if 50-60 kg/ha of d.r. was introduced during the restoration of vegetation. of nitrogen, then 40-50 kg/ha should be added at the IV stage, and 60-70 kg/ha should be added for the introduction of 20-30 kg/ha in the first period at the IV stage.

In order to form a full-fledged protein-gluten complex of grain, it is necessary that plants are supplied with nitrogen not only at the beginning of the growing season, but also during the pouring and ripening period, for which late feeding of plants is used in the earing phase - pouring of grain with application of at least 30-60 kg /ha of nitrogen. The foliar application of urea solution (30-45 kg/ha) by spraying crops significantly improves grain quality. The concentration of the solution (in terms of active substance) in the earing phase should not exceed 15%, and at the beginning of the milky grain maturity – 20%. In hot, dry weather, smaller doses of nitrogen are used in crops with moderate vegetative mass and in the late phases of plant development, larger doses are used in wet weather, with developed above-ground mass of plants and in the early phases of their development.

In areas where strong wheat is grown, there is sometimes a need to carry out additional, so-called high-quality, feeding with a solution of urea or to improve grain quality. Spraying is carried out during grain pouring at the rate of 30-45 kg of nitrogen per 1 ha.

Another effective way to obtain high-quality products is the use of *microfertilizers*. The use of microfertilizers in chelated form in foliar fertilization increases the protein content in grain by 0.9-1.4%, gluten in flour by 2.5-4.8%. It has been established that microelements are most effective for plants in the form of metal complexes (chelates) (Nutrivant, Ecolist, Reacom, Crystalon, Omex, Puccioni, Nanomix, Quantum, etc.). They contain both macro (NPK) and trace elements (boron, zinc, manganese, molybdenum, copper, etc.). Elements directly increase the activity of enzymatic systems in the plant organism, stimulate biochemical processes, improve the photosynthetic activity of plants, which contributes to the full realization of their productivity potential.

A predominance of nitrogen is necessary for the formation of high productivity of winter wheat grain at high rates of fertilizer application.

The need to introduce increased nitrogen rates is due to high removal of nitrogen from the soil (3-4 kg/h), which is 3-4 times greater than the removal of phosphorus and 2-3 times - potassium. The recommended ratio of N:P:K power cells is 1.5:1:1.

Sowing. The basis of the high efficiency of the intensive technology is the sowing of high-quality seeds. It must be conditioned, meet the requirements of Ukrainian State Standard 2240-93 and have a purity of not less than 98%, germination not less than 92%, growth strength not less than 80%, weight of 1000 seeds more than 40 g. Seeds are disinfected from diseases or encrusted using PVA film-forming agents (polyvinyl alcohol), sodium salt of carboxymethylcellulose, liquid complex fertilizers, PVA with one of the systemic preparations.

Today, more than 20 mordants are allowed to be used in Ukraine. Each of them has its own spectrum of action on harmful organisms, its different mechanism and character. Therefore, when choosing poisons, you should pay attention to which pathogens they are used against:

- systemic preparations effective against types of smuts: Baytan Universal, 19.5% (2 kg/t); Vincite, 5% k.s. (2 l/t); Vitavax 200 FF, 34% w.s.c. (2.5–3.0 l/t); Derosal 50% k.s. (1.5 l/t); Dividend Star, 036 t.k.s. (1 l/t); Premium 25, 2.5% t.c.s. (1.5 l/t); Raxil 6% d.c. (0.4 l/t); Real 200 k.e. (0.2 l/t), etc.;

- the following preparations are widely used against fungi of the *Rysagint* genus: Baytan Universal (2 kg/t), Maxim 025 (2 l/t), Vincyt (2 l/t), Vitavax 200 FF (2.5–3 l/t) and others;

- against root rots - Baytan Universal, 19.5% z.p. (2 kg/t); Vitavax 200 FF, 34% w.s.c. (2.5–3 l/t); Maxim 025, 2.5% d.c.s. (2 l/t) and others.

Sowing. Optimum sowing times are those in which plant sprouts do not pass to the III-IV stages of organogenesis and at the same time have time to reach such a state before the end of the autumn vegetation that, after the resumption of the spring vegetation, the growth cone differentiation process will quickly begin and proceed to the enhanced, synchronous formation of the rudimentary spica, using winter-spring moisture reserves in the soil at these stages of organogenesis.

Wheat is sown in such a way that by winter 3-5 shoots will form on the plants. Optimum sowing times in Polissia – September 5-15, in the Forest-Steppe – September 10-20, in the Steppe – September 15-20, in the Autonomous Republic of Crimea – September 20 – October 10.

Sowing times depend on soil fertility. On poor soils, it is necessary to sow earlier, on fertile ones - later, so that the plants do not overgrow by winter. Optimal sowing times on fertilized fields are shifted 10-15 days later, compared to sowing on a less fertilized background.

Sowing begins with late-ripening, medium-ripening varieties and ends with early-ripening ones. When sowing winter wheat after different predecessors, you should follow the rule: start sowing after the worst predecessors (corn for silage, cereal grasses) and finish after the best ones (legumes, occupied fallows). 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 end of the optimal sowing period; in the spring, it is better to occupy these areas with spring wheat, spring barley, peas, corn, soybeans, buckwheat, millet and other grain crops, depending on the market conditions, spring vegetation and the actual weather conditions.

The main method of wheat sowing is conventional row seeding with a row width of 12.5 to 19 cm with seed drills, and in arid areas, where wind erosion is possible, with stubbly ешддфпу after surface or flat-cut tillage.

Special attention should be paid to regulation of sowing rates and seed wrapping depth. Excessive thickening in some rows and thinning in others reduces crop yield. The optimal sowing rate in Polissia is 5.0-5.5 million, in the Forest Steppe - 4.5, in the Steppe - 4.0-4.5 million similar seeds per 1 ha. Sowing rates are increased when growing low-growing, precocious, weak-bush, lodging-resistant varieties with erectoid leaves, after worse predecessors, on poor soils with good moisture supply, with late sowing. In the opposite cases, the sowing rates are reduced by 0.3-0.5 million, or by 10-12%.

The rate of sowing is directly related to the timing of sowing.

When sowing early, the plants grow well at lower sowing rates. In late periods, the seed sowing rate should be increased by 10-15%.

Calculations of sowing rates should be based on the need to obtain seedling density within 400 pcs./m2 for varieties with a low tillering coefficient, and for intensively tillering varieties - 350-380 pcs./m2. If there is a gap in indicators between laboratory and field similarity and germination energy by 10% or more, the sowing rate is increased by 8-10%.

The depth of seed wrapping on structural soils of medium mechanical composition with sufficient supply of moisture should be equal to the depth of the tiller node (about 3 cm, taking into account soil subsidence). When the top layer of the soil dries out, the depth is increased to 5-6 cm, and in arid regions - to 8 cm. On heavy soils and in conditions of waterlogging, the depth of wrapping is reduced to 2-3 cm.

Crop care. Properly organized care is a significant reserve for increasing productivity. The main task of care is to keep at least 500-600 pcs./m2 of productive stalks at the time of harvesting, which will guarantee the highest possible yield. For this purpose, crops are protected from pests, diseases and weeds, plants are fed, and retardants are used. In order to correctly predict and develop these measures, before sowing, it is necessary to examine the soil for the presence of pathogens and pests, weeds and moisture content in it. If the pest in the soil exceeds the economic threshold of harmfulness, sowing should be carried out with the introduction of insecticides into the soil: 5% Bazudin (50 kg/ha), 5% Volaton (50-75 kg/ha), Phosphamide (100 kg/ha).

If the productive moisture in the soil layer 0–10 cm is less than 10 mm, then after sowing, the crops are rolled with ring-spur rollers, which contributes to the harmonious emergence of sprouts. The soil crust is destroyed by harrowing with toothed or rotary harrows before or after cereal-shoots. With the help of harrowing, weeds that are in the "white thread" phase during the cultivation period are also destroyed.

During the period of cereal-sprouts and tillering of early crops of winter crops under certain weather conditions, there may be a threat of damage to crops by leafhoppers, grain aphids and flies, gnawing scoops, and grain weevils. In this period, marginal or selective spraying of winter crops with one of the following insecticides is necessary: Bi-58 new, 40% of the active ingredient (1.5 l/ha); Volaton 500 , 50% k.e. (0.8-2.0 l/ha); Decis, 2.5% c.e. (0.2-0.25 l/ha); Karate, 5% k.e. (0.15-0.2 l/ha); Sumi-alpha, 5% k.e. (0.3 l/ha); Kinmix, 5% k.e. (0.2-0.3 l/ha). In the same phase, during a 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% (0.5 l/ha); Fundazol, 50% z.p. (0.5-0.6 kg/ha); Impact, 25% s.c. (0.5 kg/ha); Tilt, 25% k.e. (0.5 l/ha).

The autumn use of herbicides on winter wheat crops is economically and biologically justified. During this period, it is recommended to apply herbicides Peak 75 WG v.d.g. and Derby 175 SC, c.s. Preparations can be applied from the beginning of tillering at a minimum temperature of +5...80C.

In the autumn period, it is not recommended to use herbicides that contain phenoxyacetic acid or its salts, due to their negative effect on the reproductive organs of plants - ear deformation, partial or complete.

In autumn, it is necessary to take care of the protection of crops from mouse-like rodents. Use grain baits infected with bacterioendicide at a dose of 2 g per hole or Storm wax briquettes 0.005% at a rate of 0.7-1.5 kg/ha.

Winter hardiness is monitored in winter. This makes it possible to plan preventive measures in advance to eliminate the causes of plant death, to predict reseeding and reseeding. Completely dead and thinned by 50% or more unrooted crops are replanted, when there are on average no more than 700 live shoots of all orders per 1 m2 during plant growth. Crops on which no more than 25% 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 thinning of the crop and the looseness of the plants. In order not to reduce the volume of grain production, it is advisable to sow thinned crops with barley varieties that have the same early maturity as wheat. Barley sowing rates are changed depending on the degree of liquefaction of wheat.

In adverse overwintering conditions with frequent thaws in wellbushinned crops, the leaf apparatus is sometimes damaged and such crops are mistakenly considered dead. In this case, the degree of viability of the tiller node must be determined by the staining method. In the presence of a viable node of tillering in the spring period, in conditions of probable early recovery of vegetation, top dressing with nitrogen fertilizers at a dose of 30-45 kg/ha per year should be carried out as early as possible in order to strengthen growth processes, tillering and prevent significant plant loss.

The introduction of nitrogen during the first feeding in the conditions of the early recovery of vegetation on well-rooted crops causes additional tillering and the formation of regrowthи, which ultimately becomes the main reason for the irrational use of fertilizers by pods and a decrease in yield by 3-4 t/ha, and in the conditions of lying crops, due to their excessive density, it leads to the flow of grain on the stump and a decrease in yield to 7-10 t/ha.

The fourth stage of organogenesis is a critical period in the development of winter wheat with respect to moisture and nutrients, and especially nitrogen. It is at this stage that the segments of the growth cone differentiate into spike papillule. Timely application of nitrogen fertilizers at moderate temperatures creates conditions for the most effective differentiation of them, which ensures a higher grain yield in the future. In addition, nitrogen nutrition ensures survival and, accordingly, reduces shedding in the further development of spike-bearing synchronous shoots of the second-fourth order.

The dose of nitrogen application at this stage is at least 40-50% of the total amount. In order to prevent additional weeding and the formation of unproductive stems, which usually leads to a decrease in crop productivity, the terms of the second top dressing are regulated depending on the agro background and fertilizers applied during the first top dressing. On *low* agrofons, such feeding is started in the first days of the diagnostically established term, *medium* - on the 4th-6th day, and *high* - on the 8th-10th day of the fourth stage of organogenesis. When determining the term of feeding, it should also be taken into account that the ammonium form of mineral nitrogen during foliar feeding in conditions of positive temperatures (+5°C) on the third day interacts with the carbohydrate complex of the plant.

The improvement of grain quality with a decrease in moisture reserves is maintained approximately until the moisture reserves in the meter layer are (in the spring and during the phase of shooting) 70-80 mm. With a further decrease in moisture reserves, the protein content remains unchanged, even a trend towards its decrease is noted. Therefore, in the conditions of a likely sharp rise in temperatures after the recovery of winter vegetation, an important measure for the care of crops should be harrowing, which is carried out when the soil is physically ripe. The period of harrowing of winter crops is limited in time, therefore, this agricultural measure should be carried out in 1.5-2 days, preventing the soil from drying out. It should be carried out using different types of harrows, taking into account the degree of plant development and the condition of the field. So, medium harrows can be used on well-developed crops, and light harrows with passive installation of working bodies can be used on poorly developed crops. Harrowing can not only destroy the soil crust, harrow the upper layers of the soil, increase air access to plant roots and thereby intensify microbiological processes in the soil, but also destroy weeds, free plants from shoots and leaves that died during the winter period; improve the illumination of growth cones and promote the formation of a normally developed spica. Spring harrowing is especially important for overgrown crops. A delay in spring harrowing in such a case can lead to the elongation of the growth cone without its differentiation into spica papillule. Such shoots then die, sharply reducing productivity.

It is not possible to harrow weakly harrow crops, especially on light soils, as well as crops on which there is bulging of plants. Very dense crops should be harrowed in two tracks. Thinning such crops prevents early lodging. If the crops are fertilized with the help of disc seeders, then additional spudding is not carried out.

In spring, under favorable conditions (humidity - 95-100% and average daily air temperature above +150C), powdery mildew, septoriosis, and root rot develop on winter wheat crops. To limit the development of these diseases, effective spraying of vegetative plants in the budding phase is the beginning of the shooting of one of the fungicides: Alto Super 330

EC, k.e. (0.4-0.5 l/ha), Falcon k.e. (0.6 l/ha), Derosal, 50% k.s. (0.5 l/ha); Impact, 25% hp (0.5 kg/ha); Fundazol, 50% z.p. (0.3-0.6 kg/ha); Topsyn M, 70% (1.0 kg/ha).

Application of a relatively high dose of nitrogen fertilizers in the early spring period on diluted and weakened crops of winter wheat with significant reserves of weed seeds in the soil can provoke intensive germination of the latter already in the early spring period, and they will be the main competitors of plants for moisture, nutrients and light, which will require intensive protection against segetal vegetation. The main weeding of winter grain crops was formed in the autumn period - up to 75% of the total amount.

Herbicides are used to protect crops from weeds during the budding phase of plants. The choice of herbicide depends, first of all, on the types of weeds in each specific field, but preference should be given to drugs with a relatively broad spectrum of action and those that work effectively at relatively low air temperatures. This is, first of all, Agritox, 50% (1.0-1.5 l/ha); Granstar, 75% of alcohol (20-25 g/ha); Grodil, 75% v.g. (20 g/ha); Grodil Ultra, v.g. (0.15-0.2 kg/ha); 2.4–D, 50% of (0.5-1.7 l/ha); Dialen Super, 46.4% r.c. (0.8-1.4 l/ha); Cowboy, 40% of annual income (120-190 ml/ha); Krose, 16.4% of annual (100-150 ml/ha); Satis, 18% of the salary (100-150 g/ha) and others.

Against cereal weeds on winter wheat crops, the herbicide Puma Super, 7.5% m.e. is used. (1.0 kg/ha), against pink thistle and tenacious nightshade - Grodil Ultra, v.g. (0.15-0.2 kg/ha). A fairly effective mixture of herbicides: Grodil Super + Puma Super.

Well-developed crops with a sufficient density of tillering shoots (more than 1,000 pcs./m2), sown after steam and leguminous predecessors, should be treated with *retardants* at the III-IV stages of organogenesis. This will not only protect crops from lodging, but also improve the efficiency of plant use of moisture and nutrients. As a result of treatment with retardants, which redistribute nutrients in plants, to a greater extent, to the growth of the ear and its elements, the grain size and fullness of the grain improves, the grain-straw ratio shifts towards the formation of a larger amount of grain. The following drugs are allowed for crop treatment: Chlormequat chloride 460 at a dose of 1.5-2.0 l/ha, Stabilan – 1.0-2.0 l/ha, Terpal – 1.0-2.5 l/ha.

During the earing phase, wheat crops are harmed by the caterpillars of the cereal leafworm, leech larvae, and the harmful shell bug. To protect crops from these pests, it is necessary to spray with one of the insecticides: Bi-58 new, 40% c.e. (1.5 l/ha); Volaton 500, 50% k.e. (1 l/ha); Decis, 25% c.e. (0.25 l/ha); Karate, 5% k.e. (0.15 l/ha); Sumition, 50% of (0.6-1.0 l/ha) and others.

In the earing phase - the beginning of flowering in wet and warm weather, oidium, brown rust, septoriosis of leaves and ears, and fusariosis of ears develop. To protect winter wheat crops from these diseases, it is necessary to spray in the earing phase with one of the fungicides: Alto Super 330 EC k.e. (0.4-0.5 l/ha); Bumper, 25% c.e. (0.5 l/ha); Impact, 25% k.e. (0.5 l/ha); Tilt, 25% k.e. (0.5 l/ha); Falcon, k.e. (0.6 l/ha); Folikur BT, 22.5% c.e. (1.0 l/ha); Topsyn M, 70% (1.0 kg/ha).

During the formation and ripening of grain, significant losses of the crop are possible due to its damage by grain aphids, grain thrips and bread beetles. A bug-harmful turtle significantly damages crops. Therefore, at this time, it is necessary to spray the crops with one of the insecticides: Aktellik, 50% k.e. (4.0 l/ha), Bi-58 new, 40% k.e. (1.5 l/ha), Volaton 500, 50% k.e. (1.6-2.0 l/ha); Decis, 25% c.e. (0.25 l/ha); Zolan, 35% k.e. (1.5-2.0 l/ha); Karate, 5% k.e. (0.15-0.2 l/ha); Sumi-alpha, 50% of the (0.2-0.25 l/ha); Sumition, 50% of (0.6-1.0 l/ha) and others.

Depending on the condition of crops, weather conditions, weediness and other factors, *harvesting* is carried out by direct combining or separately. Low-growing varieties, as well as non-bearing, weed-free crops, in rainy weather and humidity of the main grain mass of 17-18%, are harvested by direct combining; fallen, weedy, with non-simultaneous ripening and prone to shedding - in a separate way. Harvesting of wheat in windrows begins with the onset of the phase of waxy ripeness, when the moisture content of the grain in the ear drops to 30-32%. The height of the cut during separate harvesting should be at least 20-22 cm. Threshing of wheat in windrows is started when the moisture content of the grain is within 14-16%. Seed crops begin to be harvested at a grain moisture content of no more than 16-18%.

1.3.4 Winter rye

(Seca1e)

The first mention of rye comes from the Roman writer Pliny (1st century BC). In the III and IV centuries. rye was already sown in the Kerch Peninsula region, from where it spread to other regions. Brief information about the cultivation of rye can be found in the annals of Nestor (1056-1115).

Two types of rye grow in Ukraine: cultivated or sowing rye (S. cereale) and wild rye (S. silvestre). Oats and rye are believed to have been weeds in wheat crops before their introduction.

Rye has been known in Europe since the Bronze Age. In the basins of the Dnieper and Dniester rivers, it was grown already in the first half of the 1st millennium AD. Later, rye spread from here to the north, east and west of the continent. Nowadays, it is cultivated in the temperate zone 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-chornozem zone, in the Carpathians, to a lesser extent in the forest-steppe and steppe, and in the Carpathians - on small areas, rye is also grown.

Rye grain contains 8-19% complete proteins, easily digestible carbohydrates - 67-80%, fats - 2%. It contains vitamins B, D, E, fiber, carotene, mineral salts. The composition of the grain includes unsaturated fatty acids capable of dissolving cholesterol. Rye flour is used to bake bread, which has good taste and in many respects is not inferior to, and sometimes surpasses, wheat flour. However, gluten has a looser consistency, less viscosity, elasticity and extensibility, due to which rye bread is not as loose and porous as wheat bread. Eating rye bread prevents heart diseases: rye flour contains linoleic and other fatty acids necessary for heart activity.

The value of rye as a fodder crop is determined by the fact that it forms an early highly digestible green fodder, and rye bran contains up to 16% protein, 3.5-4.0% fat and up to 60% carbohydrates. Winter rye is sown on green fodder, early silage and hay are made from it. A perennial fodder rye that produces green mass for several years has been bred.

Winter rye has increased cold resistance, grows intensively in the spring and produces better in those regions where winter wheat freezes for certain years.

In medical veterinary practice, rye flour in the form of gruel and porridge is prescribed as a mild laxative for constipation. Decoction of rye bran can be used internally for diseases of the respiratory tract (bronchitis, tracheitis, bronchopneumonia) as an expectorant, and externally - in the form of poultices for pointing.

The main crops of rye are concentrated in Europe, partly in the countries of Asia, North and South America. The cultivated area in the world is 12 million hectares. About 75% of world rye production is concentrated in Russia, Poland, Belarus, Germany and Ukraine.

On the territory of Ukraine, winter rye has long been considered a valuable food and fodder crop. Over the past 80 years, its crops have decreased from 4,517,000 hectares to 300,000 hectares, productivity has increased from 10.1 to 22.7 t/ha, production has decreased from 4.5 million tons to 0.68 million tons. Recently, both in Germany and in Ukraine, there is a noticeable trend towards the growth of the acreage under rye. Most rye is grown in Polissia and in the northern part of the Forest Steppe. The average yield of rye is lower than that of wheat (about 2.4 t/ha). In advanced farms, 4.5-6.0 t/ha are harvested.

Biological features, varieties. Out of 13 types of rye, only one is cultivated. It is an annual herbaceous plant of long daylight. Rye has a lot in common with other cereal crops of the first group in structure. Its root system is well developed and better than that of other cereal crops, it absorbs nutrients from poorly soluble soil compounds. The tillering node in rye is formed closer to the soil surface than in wheat (1.7-2 cm), more often it forms 2-3 tillering nodes. The depth of the upper node of the tiller depends less on the depth of sowing. The height of rye plants is 90-200 cm, it is prone to lodging. Rye ripens worse than wheat, it ripens in windrows, it crumbles more when standing. Therefore, it is better to collect it at the end of the yellow ripeness - at the beginning of full ripeness in a short time.

Temperature requirements. Rye seeds germinate at a temperature of +1...20C, and sprouts appear at a temperature of +4...50C. As the temperature rises to +250C, the sprouts appear the fastest. At a temperature above +300C, germination stops. Winter rye begins spring growth the fastest among grain crops, already at a temperature of +2...30C. During the growing season, the optimal temperature is +18...200C. The frost resistance of rye is higher than that of winter wheat. Rye can withstand up to -20...220C at the depth of the tillering node.

In the spring, plants develop better in moderately warm weather. High temperatures, intense lighting and dry air during this period reduce tillering and accelerate the shooting. Rye is sensitive to high temperatures during flowering. Dry, hot, as well as rainy and windy weather during flowering causes incomplete pollination of flowers and cross grain. In conditions of high temperatures (above $+30^0$C) during the plumpness, a thin grain is formed.

The sum of the effective temperatures required for full grain ripening is $1700\text{-}2100^0$C.

Rye is less demanding on *moisture* than winter wheat. The transpiration coefficient is 340-420. It easily withstands spring droughts. The greatest damage is caused by soil drought in the phase of shooting, when generative organs are formed. After flowering, rye is not very demanding on the presence of soil moisture, however, on light sandy soils, even a slight drought has a negative effect on grain filling.

Soil requirements. Rye is less demanding on growing conditions than wheat. For the formation of 1 ton of grain, about 30 kg of nitrogen, 12-15 kg of phosphorus, and 20-25 kg of potassium are removed from the soil. Rye absorbs phosphorus from poorly soluble soil compounds better than other crops. In terms of assimilation of potassium from the soil, it is somewhat inferior only to oats. Rye has a well-developed root system with high digestibility. Therefore, it grows well on podzolic sandy and loamy soils, which are not suitable for wheat, but the best for it are fertile structural chornozems, dark gray podzolized soils of light and medium mechanical composition. Rye grows poorly on heavy, clayey, swampy soils. Rye tolerates high acidity (pH<5.5) and slight soil salinity well. Optimal soil acidity is pH 5.5–6.5.

The following varieties of winter rye are zoned in Ukraine: Hasto, Kharkivske 98, Verkhnyausne 94, Veleten, Dozor, Intensivne 99, Klych, Matador, Polikrosne, Pervistok F1, Matador, Picasso; hybrids - Askari, Festus, Fugato, Amato, Agronom.

Features of the intensive technology of growing rye. Rye is sown earlier than wheat, so it is important to place it after crops that clear the field early and allow timely tillage. The best for rye are the same *predecessors* as for wheat. But rye reacts less to predecessors than wheat. Among grain crops, rye is considered the most resistant to growing in a monoculture. In Polissia, it is grown after vetch-oat mixtures, peas, early potatoes, flax, lupine, perennial grasses, and corn. In forest-steppe areas, it is more appropriate to sow rye after annual and perennial grasses, peas, corn for silage, early potatoes, in steppe areas - after corn for silage, legumes, vetch mixtures. All over the territory of Ukraine, rye is grown in a layer of perennial grasses, after buckwheat and barley. On poor sandy soils, where other crops do not grow well, lupine and rye are often grown alternately.

The main cultivation of the soil for rye differs little from the cultivation of the soil for wheat and is aimed at moisture storage, protection from weeds, accumulation of nutrients. In Polish areas, where the soil has 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 there is wind blowing of sand (plot), it is necessary to apply surface or flat-cut tillage, leaving on the surface of the soil stubble of the previous crop.

Winter rye is more sensitive than other grain crops 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 plowed soil. After the predecessors, who vacate the field early, the main cultivation for rye is carried out according to the semi-steam method. During the dry summer-autumn period, it is advisable to use surface tillage instead of ploughing when sowing rye after peas, flax, and potatoes on weed-free fields.

In regions with sufficient moisture reserves, where the gap between harvesting the predecessor and sowing rye is more than 5-6 weeks, it is advisable to sow intermediate crops (cabbage) after harvesting.

Lupine for green fertilizer is prioritized in the phase of gray beans to a depth of 23–25 cm in an aggregate with heavy rollers no later than 3–4 weeks before the optimal sowing time for winter rye.

Rye responds well to *fertilizers*. According to generalized data, with a yield of 6.0 t/ha, winter rye takes 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, it is necessary to apply up to 30-40 t/ha of manure, and on gray forest soils - up to 20-25 t/ha. This amount of organic fertilizers on podzolic soils provides an increase in grain yield by 6-8 t/ha, on chornozem soils - 4-6, and in arid areas - 2-3 t/ha. In areas with sufficient moisture, it is advisable to sow lupine on green manure after harvest.

Rye is less resistant to lodging than wheat and is characterized by increased activity of the root system. These features are taken into account when calculating fertilizer doses. Phosphorus-potassium fertilizers (40-90 kg/ha per year), and on podzolic soils nitrogen (30-40 kg/ha per year), as well as when growing wheat, are applied under the main tillage. This contributes to the better development of the root system, especially in the autumn period. Phosphorus and potash fertilizers are immobile, they even move slowly in the soil, and when they are applied under pre-sowing cultivation, they will be concentrated in the upper layer of the soil. At the same time, the root system is also formed and grows closer to the soil surface.

50 kg/ha of granulated superphosphate (P10) or nitrofoska are applied to the rows during sowing.

Prevention of lodging is an important task of the modern intensive technology of growing winter rye. During dormancy, 20-50% of the harvest is lost, mechanized harvesting is complicated or impossible, and grain quality is sharply reduced. Therefore, nitrogen fertilizers should be applied 2-3 times - this prevents a high concentration of nitrogen in the soil, which causes lodging, and provides the best nutrition for plants in the corresponding phases of development. On poor sandy soils, it is advisable to apply part of N_{30} nitrogen under the main cultivation, and the rest - in spring top dressing. At the beginning of the spring growing season, depending on the density of the plants, their development, moisture and nitrogen reserves in the soil, apply $N_{30–50}$ during the first feeding. In the phase of shooting, a second feeding is carried out at the rate of $N_{30–60}$, and in the phase of earing – a third time, $N_{20–40}$. The later the sowing is carried out, the higher the rate is set for the first top dressing. 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 the productive plant stand, in the shooting phase it increases grain size, and in the heading phase it increases the weight of 1000 grains and the protein content of the grain.

In order to prevent lodging, it is necessary to follow the recommended ratio of power elements. The one-sided advantage of nitrogen, which is often observed in practice, leads to lodging, severe damage by diseases and a decrease in grain yield.

Winter rye is more demanding than wheat in providing microelements. To get 3-4 t/ha of grain, their application is mandatory. Rye reacts especially well to the application of trace elements on soils with a low content of them. Fertilizers are applied on sod-podzolic, sod-clay, peat and gray forest soils. Copper microfertilizers should be applied on the same soils, which are light in terms of mechanical composition. Zinc is applied to sod-carbonate, chornozem and sod-podzolic soils with a high phosphorus content and well-calcified. Dose of boron 0.4-0.5 kg/ha, copper - 0.2-0.2 kg/ha; zinc - 0.15-0.20 kg/ha.

Sowing. Conditioned seeds are used for sowing, which have a purity of at least 97%, germination of 87% and more, growth strength of more than 80%. Preparation of seeds for sowing is the same as for wheat.

Optimal terms for sowing rye are more extended. It grows less in the spring, so it is worth promoting the weeding in the fall. In order to ensure a high yield of winter rye, before the end of the autumn vegetation, the plants must be well-rooted and accumulate a sufficient amount of sugars and nutrients, which ensure their good overwintering. To ensure such development, the sum of average daily temperatures (above +5°C) of 500-550°C is necessary before the end of autumn vegetation, and the duration of the autumn vegetation period is 60-70 days. In the conditions of Polissia, the optimal sowing dates are August 25–September 15. First, they are sown on poor soils and after worse predecessors, and on fertile soils and after good predecessors in the second half of the optimal terms.

Compared to winter wheat, the sowing time of rye is shifted by about five days earlier. If wheat is allowed to be sown in October, then winter rye must be sown by the end of September.

Sowing rates depend on the recommended plant density, soil-climatic and weather conditions, sowing time, variety characteristics, etc. On poor soils, when sowing is delayed, they are increased. It is recommended to sow 2.5-3.5 million/ha on fertile soils, 3.5-4.0 on medium-fertility soils, and increase the sowing rate to 4.0-5.0 million/ha on poor soils. The approximate sowing rate of rye in Polissia is 5.5-6.0 million, in Lisostep - 5.0-5.5 million similar grains per 1 ha, or 150-180 kg/ha.

The rate of hybrid seed sowing is 1.5-1.8 million/ha during early sowing (September 15-early October), 1.8-2.4 million/ha in the optimal period (beginning of October) and 2.5- 3.0 million in late sowing (end of October - November).

Rye is sown in the usual row method with a row width of 15-19 cm, leaving a technological track.

Rye reacts negatively to an increase in the depth of seed sowing. This is due to the fact that it has relatively small grains, and therefore lower germination energy. Plants germinating from deep-earned seed must first form a cotyledonary knee that raises the tiller node closer to the surface. The energy reserves of the grain endosperm are spent on the growth of the cotyledon, so the seedlings appear later, are weakened, develop slowly, are less winter hardy, the plants are weakly bushy and have an increased tendency to go dormant.

When the seeds are wrapped at the depth of the tillering node, seedlings appear earlier, the secondary root system is formed at the same depth as the primary one, thanks to which the plants are better supplied with nutrients and moisture. Such plants grow well and are more productive.

Crop care. Measures of autumn, winter and spring care for crops and approaches to their selection are the same as when growing wheat. As a tall crop, winter rye is more prone to lodging than wheat. To prevent rye lodging, apply Campozan (3-4 l/ha) or a mixture of Turu (3 l/ha) with Campozan (2 l/ha). The optimal timing of spraying is the beginning of stemming. Crop treatment with Camposan cannot be combined with spraying with herbicides.

Gathering. The optimum time for harvesting rye is shorter than that of wheat, because when it is fully ripe, it crumbles more and is capable of seed germination. This feature is often ignored in production and allows significant crop losses. Therefore, it is necessary to collect rye separately, at the end of yellow ripeness at a moisture content of 20-25%, because it ripens worse in windrows, and by direct harvesting - in the first days of full ripeness at a moisture content of 15-18%. It is better to mow fallen crops across or at an angle to the direction of lying.

1.3.5 Winter triticale *(Triticale)*

Triticale is an artificially created culture by crossing wheat (soft and hard) with rye. Depending on the wheat used (soft or hard), triticale has hexaploid or octaploid forms.

The protein content of triticale grain is 1.5-2%

higher than that of wheat, and 3-4% higher than that of rye. The gluten content is the same as in wheat and higher (25-38%), but due to the rye genome, its quality (elasticity, extensibility) is lower. In terms of protein nutrition, triticale grain exceeds wheat grain by 9.5%, and barley and corn by almost 40%.

Biological features, varieties. In terms of most morphological features and biological properties, triticale occupies an intermediate place between wheat and rye with some differences.

Temperature requirements. Seeds germinate at a temperature of +1...30C. In terms of frost resistance, triticale occupies an intermediate place between rye and wheat, tolerates a decrease in temperature at the depth of the tiller node to -18...20^{0}C. In terms of winter resistance, it is close to winter wheat. Plants are more resistant to ice crusts, thaws, grow faster and better than wheat in the spring.

Moisture requirements. Triticale has a well-developed root system, so its drought resistance is much higher than that of winter wheat. Triticale is able to provide better seedlings with insufficient moisture reserves during sowing. However, triticale needs more water than rye. The transpiration coefficient is 450-550. Prolonged rainfall can cause crops lodging. Rainy weather during earing and flowering contributes to the damage of plants by septoriosis. Triticale does not tolerate drought well during the period of intensive growth of vegetative mass.

Soil requirements. Triticale is more demanding on the soil than rye and less demanding compared to wheat. Its highest productivity is on soils with medium and high quality. It grows well on sandy, sandy and loamy soils. The potential yield on fertile soils is higher than that of rye and lower than that of wheat. The optimal reaction of the soil solution is neutral or slightly acidic (pH 5.5-7.0).

Varieties of winter triticale are divided into three groups according to their use: *grain* - used in the bakery, confectionery, fermentation and compound feed industries; *grain-based* - for green mass, fodder, compound feed; *harvest* - for green fodder, hay, grazing.

Common grain and fodder varieties in Ukraine: ADM 11, Amphidiploid 52, Polisky 7, Charodiy, Slavetne, Uragan, Souvenir, Kyivske early, Region, Harne, Blagodatny, Buyana, Ladne, Amphidiploid 256; hybrid - SV Talentro.

Features of cultivation technology. *Predecessors*. Different varieties of triticale differ significantly in their requirements for growing conditions (some of them are close to rye, others to wheat). The highest yields of triticale are grown after clean and occupied pairs, layer and layer turnover of perennial grasses, legumes, early potatoes, rapeseed, that is, after predecessors that are better for winter wheat in the respective regions.

The worst predecessors include grain crops and corn for silage. After worse predecessors, triticale exceeds winter wheat in terms of yield and is partially inferior to winter rye.

Tillage. Preparing the soil for growing triticale is almost no different from preparing it for other grain winter crops. Ploughing, flat cutting and surface cultivation are used. Pre-sowing tillage is similar to other winter grain crops. Before sowing, cultivation is carried out to the depth of seed wrapping with simultaneous harrowing with heavy harrows. Triticale is very demanding on the quality of the compacted seed bed.

Fertilization. In terms of nutrients, triticale occupies an intermediate place between wheat and rye. Fertilizer doses are determined by soil fertility, planned yield, and moisture conditions. 20–25 t/ha of manure and phosphorus–potassium fertilizers (P45–75K45–75) are added to the main fertilizer. Phosphorous (P10) or complete mineral fertilizer is added to the rows during sowing. Nitrogen fertilizers N30–60 are used for early spring fertilization. On irrigated soils, the dose of fertilizers is increased by 1.2-1.5 times.

Sowing. The reaction of triticale varieties to the timing of sowing is not the same. The yield of many varieties depends more on the timing of sowing than that of wheat. It is recommended to sow triticale in the middle of the optimal wheat sowing period. For sowing, seeds with purity of not less than 98%, germination not less than 90% for grain varieties and 85% for fodder varieties are used.

The seeds must be carefully sorted. A large fraction is used for sowing. Small triticale seeds have a low growth force and therefore their field germination is much lower than the laboratory one. In order to prevent the development of powdery mildew, Alternaria, and hornworms, to protect young plants from root rot, the seeds should be treated by the encrusting method with fungicidal poisons, and in the presence of soil pests, with the addition of an insecticide. Before seed treatment, the seeds should be warmed against the sun for 3-4 days, periodically shoveling. 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 triticale seeds are wrinkled and have a well-developed fringe.

Triticale should be sown at the same time as wheat in the respective zones. By the end of vegetation in autumn, each plant should have 2-4 shoots. In the Polissia zone, the best time for sowing is the second decade of September, in the Forest Steppe - from September 5 to 25. In the conditions of the Western Forest-Steppe, the optimal sowing dates are September 10-25, and permissible - until October 5.

The main method of sowing is the usual row sowing. When determining the sowing depth, it should be taken into account that as the depth increases in triticale more than in wheat, seed germination decreases. With sufficient soil moisture, the sowing depth should be about 4 cm on light soils and 5-6 cm in bad weather. The seed bed should be compacted.

When setting the sowing 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 Polissia are 5.5-6.0, in the Forest Steppe - 5-5.5, in the Steppe - 4-5 million laboratory-like seeds per 1 ha. Norms should be differentiated depending on the biological characteristics of the variety, seed size, moisture, weediness of the field, soil fertility.

Crop care. In the spring, triticale grows quickly, so spring care should be carried out early. Technological care processes are the same as for other cultures. N_{30} nitrogen fertilizers are applied during early spring top dressing, and $N_{30–40}$ during emergence.

The need for the use of herbicides in triticale is less than in wheat, but if weeding is significant, the crops are treated with the same herbicides as winter wheat crops. As signs of powdery mildew, rust, septoriosis, and root rot appear, the crops are sprayed with a fungicide solution, and in case of mass infestation by pests (they are the same as on wheat and rye), with an insecticide solution. The preparations and their doses are the same as for wheat, but it should be taken into account that the leaves and stems of triticale are covered with a wax coating, so surfactants must be added to the solution. If the laying of crops is predicted, then at the beginning of stemming, the crops should be treated with a mixture of Camposan M (0.75-1 kg/ha) and Tur or Tsikocel (2 kg/ha).

Harvesting. Triticale is resistant to shedding, but the fragility of the spike increases during standstill, so harvesting is carried out with grain harvesters by direct harvesting at the beginning of full grain maturity. It is also possible to collect separately, but this requires additional costs. If necessary, straw is removed from the field, or chopped and spread over the field.

1.3.6 Winter barley

(Hordeum)

Barley in Ukraine, as well as in other countries of the SNM and Western Europe, has always been a leading fodder crop. Currently, winter barley is sown annually in our country on an area of 300,000 hectares. This is due to the fact that its grain is best balanced in terms of amino acid composition and is close to standard final feed in terms of feed quality. Grain contains 12% protein, more than 75% carbohydrates, 2.1% fat. 1 kg of grain contains 1.2 calories. and 100 g of digestible protein. The protein complex includes more than 20 amino acids, 8 of which are essential. Barley protein is more complete than that of other cultures, but contains little lysine - 2.5-3.2%.

Barley is better digested by animals than oats. When dairy cows are fed with barley, they give milk, from which excellent butter is made. Barley is a good fodder for fattening pigs.

Winter barley is a younger crop than spring barley by approximately 2,000 years. About 10% of the world's 80 million ha of barley is grown in winter crops. In Ukraine, 90% of its cultivated areas are located in the southern region - Crimea, Odesa, Mykolaiv and Kherson regions. Winter barley overwinters well and provides high yields even in the conditions of Western Ukraine.

Biological features, varieties. According to the degree of wintering, barley is divided into three types. *Winter* - grown only in winter crops. When sowing in the spring, they do not ear, or ear with a long delay, which excludes their cultivation for grain. Plants hibernate in the budding phase. For the transition to the next phases of growth and development, they need low temperatures (+2...40C) and long daylight hours.

*Winter-spring crops*are grown mainly in winter crops. Requirements for the temperature regime in the early stages of organogenesis are close to winter forms. When sown in the spring, they ripen at the same time as spring barley, but produce less productivity. The most common varieties are Taina, Osnova, Taman, Rosava.

Spring is grown in spring culture, sowing them in early spring. Autumn crops are prone to wilting and freezing.

Winter barley is the most precocious cereal crop. Compared to wheat and rye, its frost and winter resistance is lower. This is explained by the fact that there are no typical winter forms of seed barley. The vernalization stage of barley lasts 30-40 days (it has time to pass during autumn, winter, winter and early spring sowing).

Individual development of winter barley has the same phases of growth and development and stages of organogenesis as other grain winter crops, but their duration is shorter. Therefore, the duration of the growing season will be shorter, accordingly, it will ripen earlier than winter wheat by 9-10 days, and spring barley by 12-14 days.

Temperature requirements. Winter barley is the least frost-resistant among winter crops. Plants are damaged even at a temperature of +10...12°C. Resistance to low temperatures and other adverse wintering conditions sharply decreases during the early sowing period. The minimum temperature for seed germination is +1...3°C.

Winter barley, with slowly rising temperatures, grows well in spring. It has a higher tillering ratio than the ardent one. Rapid warming in the spring causes a rapid shooting, which prevents the formation of the necessary density of the productive stem.

The optimal air temperature during the growing season is +20...25°C. Plants are characterized by resistance to high air temperatures. As a precocious crop, barley is less affected by heat than other winter crops.

Moisture requirements. Winter barley makes good use of winter moisture reserves thanks to the early shooting. For germination, seeds absorb 48–50% of water from their own weight. The transpiration coefficient is somewhat lower than that of other cereals, and is 300-450. Precipitation during the earing period - the pouring of grain contributes to the formation of high productivity of plants.

Soil requirements. Winter barley is less demanding on soil fertility than spring barley. Barley has the same soil requirements as wheat, but it is more demanding on calcium content in the soil. It grows best on chornozems with a neutral or slightly alkaline reaction of the soil solution (pH 6.5-7.5).

The most suitable for cultivation using intensive technology are the high-yielding varieties Avans, Kozyr, Secret, Ogonkovskiy, Metelitsa, Mykhailo, Luxor, Luran, Dobrynya 3, Dniester, Voskhod, resistant to lodging.

Among the varieties of winter barley there are winter-springvarieties that produce crops both in autumn and in spring sowing - Taina, Rosava, Pallidum.

Winter barley varieties Dniester, Dobrynya 3, Mykhailo, Seim are characterized by field resistance to hard smut; Cinderella, Aborigine, Toiler, Worthy - to flying smut; Dniester, Winter - to black smut; Cinderella - to yellow blight; Askold, Seim, Cinderella - to powdery mildew; Dobrynya - to cancellated punctation; Seim - to dark brown punctation; Borysfen - for rhynchosporiasis; Laborer - to septoriosis.

Cultivation technology.*Predecessors.* 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, in the western regions - after corn, potatoes, and legumes. The best precursor for barley in the south of Ukraine is pure steam. You can sow after winter and spring wheat, oats. The worst precursor is rye.

Fertilization. Barley is demanding on the content of readily available nutrients in the soil and responds well to fertilizers. About 23-30 kg of nitrogen, 9-11 kg of phosphorus, and 17-23 kg of potassium are consumed from the soil for the formation of 1 ton of grain and the corresponding amount of straw.

Under winter barley in the southern regions, after the best predecessors, $N_{40}P_{40}K_{40}$ is applied, after the worst ones - $N_{60}P_{60}K_{60}$, in the forest-steppe, on chornozems of podsolized and dark gray forest soils - $N_{30–45}P_{40–50}K_{40–50}$, on light gray ones - $N_{45–60}P_{45–60}K_{45–60}$, in in the western regions on sod-podzolic soils – $N_{60–90}P_{40–60}K_{40–60}$. Phosphorus-potassium fertilizers are applied under the main tillage and in the rows during sowing, nitrogen fertilizers are applied in separate doses: after the worst predecessors, N_{30} for pre-sowing cultivation, the last amount in early spring top dressing, after the best - the full rate in spring top dressing.

Tillage. The main cultivation of the soil depends on the predecessor and natural conditions. It is advisable to combine several operations, performing them in one unit. This eliminates the excessive use of heavy machinery, which greatly destroys the soil structure.

After qualitatively harvested row crops, surface treatment is applied. In the fields where there was corn, the field is disked and then plowed to a depth of 20-22 cm.

Among the measures of pre-sowing soil cultivation, cultivation using aggregates with needle harrows in passive mode deserves attention. Especially on areas with a large amount of post-harvest residues in the surface layer of the soil. Under such conditions, needle harrows are the only tools 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 that it is carried out later. In other parameters, it does not differ from preparation for other winter grain crops. Winter barley reacts negatively to soil ramming, waterlogging and lack of oxygen.

Sowing. Winter barley is the most sensitive among winter crops to the sowing time. With early sowing, barley overgrows in autumn. In warm autumn conditions, until the end of the autumn vegetation, it can shoot, which significantly reduces its winter resistance and leads to freezing. Late sowing results in poorly developed crops that develop in worse hydrothermal conditions.

The optimal time for sowing barley comes in the second half or at the end of sowing winter wheat. It should be sown at such a time that no more than 4-5 shoots form on each plant. Approximate sowing dates in Transcarpathia – September 20-25, Lviv region – the first decade of October, in Chernivtsi region – the end of September–beginning of October, in the Steppe zone – the third decade of September, in the Crimea – October 1-15.

When winter barley is sown too early, the plants are severely damaged by Hessian and Swedish flies, and intensively affected in the spring by snow mold, rust diseases, and oidium.

The method of sowing is ordinary drill sowing or close sowing. When setting the sowing rate, a differentiated approach must be followed. On fertile and well-prepared soils with a sufficient amount of moisture, when appropriate agrotechnical measures (variety, fertilizers, growth regulators) ensure high bushiness of the plant, the sowing rate can be set at the level of 3.0 million/ha. The best results are obtained when sowing 3.5 million/ha of similar seeds/ha. And only when sowing is delayed and growing conditions deteriorate, the sowing rate must be increased to 4.0 million/ha (400 seeds/m2), which ensures the formation of 600-700 productive stems per 1m2 and the maximum yield.

In fields with a low agricultural culture, it is recommended to use traditionally recommended high sowing rates (4.5-5.0 million/ha of similar seeds, or 450-500 seeds/m2).

Sowing rates and plant density largely shape the microclimate of agrocenosis and significantly affect the development of diseases. In conditions of thickened crops of winter barley, favorable conditions are created for the development of causative agents of root rot, powdery mildew, and brown rust; thinned crops - contribute to intensive damage to plants by septoriosis.

Deep and uneven seed wrapping is the main reason for the decrease in field germination and the formation of low-yielding crops of winter barley. In the Polissia and Forest-Steppe zone of Western Ukraine, which is characterized by sufficient soil moisture, the optimal sowing depth is 3-4 cm.

The depth of seed wrapping is of great importance for obtaining friendly and aligned seedlings. Deep wrapping of seeds contributes to the damage of seed sprouts by pathogens of mold, root rot, powdery mildew.

Seeds need heat, moisture and oxygen to germinate. Barley, due to the filmy nature of the grain, requires better moisture conditions. With deep sowing of the seed, its supply of moisture increases, but access to oxygen worsens. Winter barley is sown relatively later, at lower average daily temperatures, therefore, with deep wrapping, the duration of the sowing-seedling period increases.

Barley is very affected by smut, so the seeds must be treated with Raksil (0.5 kg/t) or Vitavax at the rate of 2-3 kg/t by encrusting before sowing.

Against oidium, brown and yellow rust, septoriosis, helminthosporiosis and rhynchosporiosis, it is recommended to treat the seeds with the drug Tilt Turbo 575 k.e.

Crop care. Against snow mold on winter barley, autumn top dressing of crops with ammonium nitrate at the rate of 0.7-0.8 t/ha at a temperature of +2...40C is recommended.

In the sprout phase - the beginning of tillering on well-developed crops of the early sowing period and in warm weather at the beginning of mass settlement by aphids, grain flies, leafhoppers, edge or continuous spraying is carried out with one of the insecticides: Karate Zeon 050 CS mk. s. (0.15-0.2 l/ha), Fury (0.07 l/ha), Kinmix (0.2 l/ha), Engio (0.18 l/ha), Nurel D 55 % k. (0.75-1.0 l/ha).

During the tillering phase in autumn and winter, against voles and other mouse-like rodents (3-5 or more colonies per 1 ha), 2-3 g of Rodenfos grain lures and Storm briquettes (0.7-1.5 kg/ha) are laid out in vein holes. or Bacterodenticide (2-4 kg/ha).

During the spring survey of winter barley crops, especially in years with unfavorable wintering conditions, attention should be paid to the fact that when the above-ground mass of plants is damaged or killed, the tiller node often remains alive. Such crops have the property of quickly restoring vegetative mass, bushing well, and then forming a satisfactory yield. In the spring, they are harrowed and fed with nitrogen fertilizers.

Herbicides, fungicides and insecticides are used during the growing season, just as on wheat crops. To prevent lodging, retardants (Rikotsel, Tsikotsel, etc.) are used at the beginning of stemming.

Harvesting. Winter barley, like rye, is more difficult to harvest than spring barley or winter wheat. Harvesting is complicated by drooping and fragility of the ear, a tendency to lodging, and a short optimal threshing period. It is advisable to collect barley by the separate flow method, especially crops with a large amount of dressing, in the phase of waxy ripeness and by direct harvesting at the beginning of full ripeness at a grain moisture content of no more than 16-18%. The visual signs for the beginning of threshing are as follows: the drooping and brittleness of the ear is still insignificant, the spikelets have reached and break only during threshing. The delay in harvesting is associated with large crop losses, because the fragility of the ear increases during rest, the ear droops (bends to the ground) and during mowing with a harvester, it is not threshed, but falls to the ground.

After winter barley, it is recommended to sow lupins on sideral fertilizer. The yield of green mass of lupine of summer crops is 300-400 t/ha. Its prioritization is an important measure of biologicalization of technologies for growing other crop rotation crops and restoration of soil fertility.

1.4 EARLY SPRING GRAIN CROPS

Cereal crops, which withstand spring frosts relatively well, are sown first at the beginning of spring field work, called early spring crops. They ripen earlier than other spring crops. They include spring wheat, barley, rye (spelt), oats.

Spring wheat is less productive than its winter forms (because of this, winter forms of wheat and rye are more common in Ukraine). Other grain crops are significantly inferior to winter wheat, triticale and rye in terms of winter hardiness and cannot withstand harsh conditions in most of the territory of Ukraine. That is why spring forms prevail here in production, in particular wheat, barley and oats. Plants are moisture-loving and cold-resistant, they are physiologically active at temperatures above +5oC. Theirgrowth and development at the beginning of the growing season is fast.

1.4.1 Spring Barley *(Hordeum)*

Barley belongs to the most ancient cultures. Along with wheat, it was known even in the Stone Age. It was grown in Egypt in 5000 BC. e., and in Greece, Italy, China - from prehistoric times. On the territory of Ukraine - from the III millennium BC. e. Nowadays, barley is grown in a wide area - from the Arctic to the subtropics.

Barley is a fodder, food and technical crop. According to FAO data, 42-48% of the gross harvest of barley grain is used for industrial processing, 16% - for feed purposes, 15% - for food and 6-8% - for beer production.

The grain contains up to 76% carbohydrates, about 12% protein, 7-

11% pentosans, 1.7-2% sucrose, 3.8-5.5% fiber, 1.6-2.1% fat, 2-3% ash, as well as enzymes, vitamins (carotene; groups B, D, E). Barley protein 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 low-quality gluten, flour is not suitable for baking bread. If necessary, it is used as an admixture to wheat or rye flour, when baking higher quality bread. Barley grain is also used to make coffee substitutes and malt extracts.

Barley is mostly used for grain and fodder purposes. In terms of nutrition, 1 kg of barley grain corresponds to 1.2 feed units, which includes 100 g of digestible protein. The chemical composition of the grain is characterized by high feed qualities and is used as a highly nutritious energy and dietary concentrated feed for all types and age groups of farm animals and poultry, and especially for fattening pigs. The fodder properties of barley are much better than those of wheat. If 20% of lysine is not enough in barley protein for physiologically complete feeding of animals, then in wheat protein - 43%.

Barley straw and capes are valuable roughage. In the south, barley is used for green fodder and hay mixed with legumes (peas).

Two-row barley grain is the best raw material for brewing. Brewing grain should be large, leveled with a low protein content (9-12.5%) and a high starch content (63-65%). Brewing waste (beer grits) is used for animal feed.

Spring barley is a precocious plastic crop with a wide variety of forms. It withstands air drought better than other spring cereals, providing good and stable harvests. Grows mainly in the same regions as wheat. The western region is more suitable for the production of malting barley. Modern advances in genetics and breeding made it possible to advance barley culture to the north. Previously, barley was grown mainly for food in the form of groats and flour, but now it is mainly used for animal feed and in brewing. A few years ago, scientists discovered such substances as triglyceride and tocotrienol in barley protein, which can significantly reduce the level of cholesterol in the blood. Adding a small amount of these substances to poultry feed (25 parts per 1 million parts of all feed) reduces the cholesterol content in its blood by 40%.

Barley occupies an important place in world crop production. Its cultivated area is about 80 million hectares or 10.4% of the area occupied by grain crops. The gross harvest reaches 160 million tons with an average yield of 2.43 tons/ha.

Barley in the group of forage crops takes the second place in terms of the area of sowing. By continent, its crops are distributed 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 ha. Among the countries, the first place belongs to Russia (15%), second place to Ukraine (8.2%), third place to Canada (7.9%). In Ukraine, the sowing of spring barley is 4.0–4.5 million hectares. The average yield is about 2.5 t/ha.

The highest yields were obtained in European countries: in Belgium – 5.65, Switzerland – 6.4, France – 5.4, the Netherlands – 5.9, Great Britain – 5.4, Ireland – 6.0, Germany – 5.1, Hungary – 2.6, Austria – 5.4 t/ha.

Biological features, varieties. The genus barley unites 30 species, of which only one is cultivated - seed barley. This is the most precocious grain crop (the vegetation period lasts 60–120 days).

After sowing, seedlings appear in 6-9 days. 12-15 days after sprouting, tillering begins, and after 30-40 days - stemming. The energy of tillering is higher than that of wheat and oats. In crops, productive bushiness is usually 2–3. High bushiness is not desirable for malting barley. In barley, tillering is unlimited in stages, and shoot formation under intensive moisture can continue when the first shoots have reached full maturity. As a result, in rainy weather, a mature stem grows with shoots of late tillering.

Earing occurs 45-65 days after germination. It takes 30-45 days from threshing to wax maturity, 20-25 days for pouring and ripening of grain.

A typical self-pollinating plant of long daylight. In conditions of severe drought, fertilization occurs before tillering or the latter may not occur at all.

Temperature requirements. Barley seeds begin to germinate at a temperature of +1...3°C, the optimal temperature for this is +18...20°C.

Seedlings withstand frosts up to -7...8 °C, but during flowering and ripening, a slight decrease in temperature below 00C leads to the sterility of flowers and the formation of frost-resistant grains. During the earing period, the optimal temperature for barley is +20...22°C, during ripening +23...24°C. Barley tolerates high temperatures (heat) better than other cereal crops of the first group, withstanding up to +38...40°C. At such a temperature, the stomata of barley are not destroyed within 25-35 hours, while in spring wheat - after 10-15 hours, and in oats - after 5 hours, their paralysis occurs.

High temperatures and drought during tillering reduce productive bushiness of barley, during earing and ripening - grain fullness, nature, weight of 1000 grains.

Relation 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 the plants do not tolerate spring droughts well. Therefore, late sowing can cause unfriendly appearance of seedlings and slow down the development of plants at the later stages of organogenesis. Deficiency of moisture during tillering reduces projective bushiness, causes significant asynchrony of shoot development. Drought from earing to ripening leads to the formation of thin grain.

Soil requirements. Barley is a rather flexible crop and grows on different soils. The most suitable for it are cultivated structural soils with a pH of 6.0-7.5. It cannot withstand waterlogging, it grows worse than rye and oats on sandy soils. Its root system is relatively poorly developed, has an average assimilation capacity, therefore it responds well to the application of fertilizers and their aftereffects.

Humus, dark gray and gray forest soils are the best soils for *brewing barley*. High yields of barley with good brewing qualities are obtained on sod-podzolic soils. Less suitable are turf-podzolic sandy and sandy loam soils in Polissia, as well as turf-podzolic surface-glazed soils with increased acidity in Precarpathia.

When growing for brewery purposes, it is advisable to give preference to such domestic varieties as: Askold, Obolon, Hetman, Chudovy, Vakula, Charivnyi, Vidyorii, Zherelo, Nosivskyi 21, Aspect, Augit, Vykyl, Vivat, Soncedar, Soborniy, Helios, Yucatan, Etiket , Kozak, Kazkovy, as well as foreign ones: Tolar, Jersey, Quench, Europrestige and Josephine. Valuable varieties include Pivdenny, Vakula, Adapt, Palidum 107, which are characterized by high heat and drought resistance.

For the cultivation of barley for fodder and the production of groats, preference should be given to varieties characterized by high protein content, high productivity and ecological plasticity. Among them, the most adapted varieties are: Stalker, Adapt, Ilot, Donetsk 14, Sanctrum, Partner, Sovira, Vodogray, Zdobutok, Perseus, Priazovsky 9, Sozonivskyi, Inclusive, Avgiy, Hadar, Psyol, Vzirets, Gosya, Nezabudka, Zdobutok, Lofant .

Requirements for malting barley grain (USS 3769/98). In recent years, the use of spring barley grain for the production of beer has increased dramatically. In this regard, breeders, scientists and field technologists face the task of creating varieties and developing technologies for growing grain of this crop, which would meet the modern requirements of breweries for the production of domestic beer with a quality at the level of world counterparts, that is, competitive both domestically and internationally and on world markets.

The brewing barley harvesting zone includes the Vinnytsia, Volyn, Zhytomyr, Ivano-Frankivsk, Kyiv, Lviv, Rivne, Sumy, Ternopil, Khmelnytskyi, Cherkasy, Chernihiv and Chernivtsi regions.

Barley grains for brewing are evaluated according to the following characteristics: external (color, smell, shape, infestation by pests, etc.), physical (nature, weight of 1000 grains, size, alignment, presence of impurities), physiological (ability to germinate, water sensitivity), chemical (moisture , extractability, protein and starch content, filminess), technological (water absorption capacity during soaking, germination intensity, i.e. the ability of grain to germinate at the same time on the fifth day).

Barley of the Nutans variety, i.e. two-row, with a higher percentage of grain alignment, is used for beer production. It must be pure-bred, biologically ripe, have a normal color (yellow or light yellow) and smell, extractability - 79-82%, protein content - 9.0-11%, filminess - no more than 9%, starch - 79-82 %. Low film density (less than 7-9%) and high germination energy are also important - at least 95% on the 4th day of germination. According to the requirements of DSTU 3769–98 for malting barley, grain moisture, depending on the cultivation zone, should be 14-15%, the content of garbage and grain impurities should not exceed 1-2%; coarseness (the rest of the grain left on the sieve 2.5 x 2.0 mm) – not less than 50%. Infestation with collared pests is not allowed.

The needs of the brewing industry stimulate the creation of new high-yielding varieties of barley, which are more resistant to lodging and damage by common diseases: powdery mildew, striped helminths, dwarf rust, dark brown spotting, and flying soot.

Cultivation technology.*Placement in crop rotation, predecessors.* Due to the underdeveloped root system, short growing season, increased requirements for the soil structure, barley is the most demanding among grain crops to its predecessor. It is not very competitive with weeds, so it should be sown after clean and fertilized predecessors. When growing for food and fodder purposes, it is better to place after perennial legumes and annual grasses, legumes and rapeseed, for breweries - after fertilized row crops: corn, potatoes, melons, sugar beets (in the zone of sufficient moisture). Barley is one of the best cover crops for sowing perennial grasses due to its relatively short stature and early precocity.

Sugar beets and potatoes will be good predecessors for malting barley if they have formed a high yield, having used the main part of the organic and mineral fertilizers applied to them. On soils with a humus content of 3.5% or more, the remains of ghee, due to the high nitrogen content, can contribute to an increase in the protein content. Rape is also not a good precursor, as the by-products leave a significant amount of nitrogen in the soil. Cereal spike crops are not suitable for malting barley. Legume crops reduce brewing quality due to high nitrogen residues in the soil.

It is not recommended to place barley after ear crops to avoid severe damage by root rots and other diseases, and after sunflowers, which dry the soil and litter the soil with carrion.

The optimal level of saturation of crop rotation with spring cereals in the country's forest-steppe is up to 30%, of which 10% is barley.

Tillage. When growing barley after crops that vacate the field early, it is better to use semi-steam and improved tillage of the soil. With semi-steam cultivation, after harvesting the predecessor, the field is immediately husked with LDH-15A, LDH-10A, BDT-7, BDT-3 disc tools in two tracks.

After 12-14 days, when weed seedlings appear, plow with plows with front plows to a depth of 20 cm. Later, as weeds sprout, the field is harrowed and, if necessary, cultivated, keeping it clean of weeds until winter.

If the predecessor was overgrown with perennial weeds, after its harvesting, the field is disked in two directions, after the germination of weeds, processing is carried out with PL–5–25, PPL–10–25 plowshares or flat-cutting tools OPG–3.5, KPE– 3.8, KTS–10, KPSh–9. When the weeds sprout, the field is plowed for frost.

When growing barley after potatoes, fodder and sugar beets, for which deep ploughing is done, after their harvesting, plowless cultivation can be carried out with plow huskers, chisel cultivators or flat cutters.

After corn, the field is disked in two directions with disk harrows and then plowed to a depth of 23-25 cm. In the zone of insufficient moisture, cultivation is carried out with flat cuts-deep looseners. On heavy flooded soils, in conditions of irrigation, cultivation with milling cultivators and deep looseners KFG-3.6 gives good results.

On heavy soils, on slopes, in areas where water stagnation is possible in the spring, in the pre-winter period, crevices 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 cultivation in the autumn period, since its transfer to the spring leads to a delay in sowing and, as a result, a lack of harvest. But if the main tillage has not been carried out since autumn, in the spring it is necessary to carry out surface tillage with disk tools, without allowing a significant break with pre-sowing tillage with combined units or tools, which include loops and rollers for the purpose of high-quality leveling of the surface and ramming of the soil. Under such conditions, these works should be performed as soon as possible to avoid a significant delay in sowing.

Pre-sowing tillage is differentiated depending on the soil and climatic conditions and the degree of cultivation of the soil. On overmoistened soils with a heavy mechanical composition and in the conditions of a cool, prolonged spring, it consists in spudding the soil by 5-6 cm and bringing it, as it ripens, to the sowing condition. On light soils and under arid conditions, pre-sowing cultivation is aimed at preserving moisture, which is achieved by minimizing it with the use of combined units, which include spudding, leveling working bodies and rollers and ensure uniformity of soil cultivation in depth, which significantly increases field uniformity. synchronicity of plant development at the initial stages of organogenesis and increases productivity.

For pre-sowing cultivation, instead of steam cultivators, in which the depth is poorly regulated, it is advisable to use combined units of the RVK type, combined soil tillage units of the APB type, AG of the "Europak" system, foot harrows and attachments of sequentially connected harrows.

Fertilization. Barley is very sensitive to fertilization, quickly reacts with an increase in biomass, an increase in bushiness. It is quite demanding on nutrients, especially it needs a large amount of readily available nutrients during the initial period of growth and development. A high level of nutrition leads to early emergence of crops.

It is not recommended to apply manure directly under the barley. Irregularity of its introduction, clogging with weeds causes variegation of the stem, curtain laying, uneven ripening, and therefore, deterioration of the sowing and brewing qualities of the grain. Barley makes good use of the after-effects of organic fertilizers. Therefore, they should be applied under the predecessor, and only mineral fertilizers should be applied directly under the barley.

According to the summarized results of the research of the scientific institutions of the Forest Steppe and Polissia on fertile soils (chornozem, dark gray, etc.), N45–60P45–60K45–60 should be applied to spring barley after the best predecessors. On poorer soils (turf-podzolic, light-gray, etc.), the dose of fertilizers is increased to N60–90P60–90K60–90. High-yielding, fertilizer-sensitive and lodging-resistant varieties provide maximum yields with increased dosage up to N90–120P90K90. It is better to apply phosphorus-potassium fertilizers under the cultivation of fennel. It is advisable to apply nitrogen in small amounts: a part of the dose (20%) together with a full dose of phosphorus and potassium fertilizers before sowing, and the second part - for pre-sowing cultivation and in the form of top dressing at the IV stage of organogenesis. It is advisable to add 50–75 kg of granulated superphosphate to the rows during sowing.

Full fertilization is more effective on podzolic, gray podzolized soils, podzolized chornozems, on ordinary, typical chornozems - phosphoric and phosphoric-potassium, on chestnut soils - nitrogen-phosphoric.

When growing malting barley, as well as when sowing perennial legumes, the dose of nitrogen fertilizers is reduced by 25-30%. It should not exceed N30–45 after fertilized row crops, and N60 after other predecessors.

In case of a lack of fertilizers, effective use of nutrients is ensured by local application of complex fertilizers in doses of 10-18 kg/ha of NPK, which provide the highest return on the yield of fertilizers, and the coefficients of the use of nutrients, compared to the main application, are doubled.

Due to the lack of trace elements in the soil, they are introduced during the preparation of seeds for sowing or sprayed during the growing season.

Ploughing by-products of predecessors is also effective, which ensures an increase in spring barley yield 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 return and ecological safety as etching. According to scientists, in the case of sowing with non-poisoned 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-former and one of the fungicidal drugs is widely used - Benlat (2-3 kg), Vitavax 200 FF (2.5-3 l), Raksil (1.5 kg) at the rate of 20 liters of aqueous solution per 1 ton of seeds. It is desirable to add growth regulators (such as Fumar-10 mg/t) to the composition of the tank mixture, which increases the productivity of spring barley by 5-10%.

With long-term use of the same poisons, pathogens acquire resistance to them. Therefore, they should be alternated. Under conditions of moisture deficiency and high temperatures, the best results are shown by the poisons Vitavax 200 FF, Raksyl, Sumi-8 FLO. It should be noted that liquid forms of drugs are less stable during storage and require stricter regulations regarding expiration dates.

All systemic poisons protect plants from powdery mildew diseases. Vincyt 050, Vita-Classic, Vitavax 200 FF, Kinto Duo, Fundazol are more effective against fusarium-helmintosporium root rots; against cercosporellosis - Fundazol, Raxil Ultra, Granivit, Korriolis; against septoriosis - Vincyt, Derosal, Kinto Duo, Kolchuga, Corriolis, Lamardor, Sumi 8-FLO; against seed mold - Viking, Vincyt Forte, Sulfocarbation-K, Maxim 035, Kinto Duo, TMTD, Vitavax 200 FF.

It should be taken into account that some poisons (Raxyl Ultra, Vincyt 050, Sumi-8 FLO) have retardant properties, so they should be used only with high-quality grain and sow seeds to a depth of no more than 2-3 cm.

To increase the resistance of plants against viral diseases and other harmful factors, at the same time as poisoning, seeds are treated with trace elements (compounds are selected taking into account the results of agrochemical analysis of the soil) and plant growth biostimulators (Emistim S, v.r., 10 cm3 in 10 l of water per 1 ton of seeds , Agrostimulin, v.s.r., 5-10 ml/t, Vermistim, r., 8-10 l/t, etc.).

Sowing. Spring barley is a cold-resistant crop, so it should be sown early, as soon as the soil conditions allow. The criterion for starting sowing is the maturity of the soil, when its high-quality crumbling during cultivation is achieved. Barley needs a relatively low temperature for seed germination, withstands frost and responds better to early sowing times than other grain crops. On light soils, sowing should be done earlier than on heavy ones.

In conditions of insufficient moisture in over-thickened crops, barley plants ripen prematurely, reduce the yield and form thin and small grains, and in dry years such crops even die. The yield of barley decreases sharply when the crops are thinned. On fertile soils, where plants are well bushed, the rate of spring barley sowing is set at the level of 3-4 million similar grains per hectare, and on less fertile soils, where plants have less intensive bushing, it is increased to 4.5-5 million/ha. Intensification of crops more than 6.0 million/ha under all conditions is impractical and does not increase productivity. When growing barley with perennial herbs (clover), the sowing rate is reduced by 15-20%.

Under favorable conditions, the optimal seed wrapping depth is 4-5 cm. When the top layer of soil dries out and sowing is delayed, the depth is increased by 1-2 cm.

In the forest-steppe, the most common methods of sowing are conventional row sowing with a row spacing of 15 cm and narrow row sowing with a row spacing of 7.5 cm. In the conditions of the zone of unstable moisture, the conventional row sowing method promotes more efficient use of solar radiation, as well as nutrients, moisture and ensures a higher yield.

Care of crops includes a whole complex of works, which includes harrowing, post-sowing rolling, protection against weeds, diseases and pests, and for seed crops - species and varietal weeding.

To improve germination conditions and the appearance of friendly seedlings, immediately after sowing or at the same time, the area is rolled with ring-spur, ring-tooth rollers in a unit with light harrows. On overmoistened, heavy, sloping soils capable of flooding, as well as during a cold, protracted spring, rolling crops is impractical.

When the crust is formed, crops are harrowed diagonally across the rows. Depending on the mechanical composition of the soil, the density of the crust, light or medium harrows or rotary hoes are used. It is not recommended to harrow crops after the emergence of seedlings, 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 from weeds, pests and diseases. Treatment of crops with herbicides and insecticides is carried out only in the presence of harmful organisms in quantities above the economic thresholds of harmfulness, and fungicides are used only on the basis of the results of disease development forecasts and agrobiological control of the condition of crops.

The choice of herbicides depends on the species composition of weeds. The following herbicides can be used when spring grain crops are weeded, mainly by annual dicotyledonous weeds: 2,4D 500, v.r. (0.9-1.7 l/ha), 2M–4X 750, v.k. (0.9-1.5 l/ha), Dikopur MCPA, v.r. (0.7-1.0 l/ha), Agritox, v.r. (1.0-1.5 l/ha), Luvaram, v.r.k. (1.2-2.0 l/ha). Spraying of crops should be carried out in the phase of tillering of plants before shooting.

For the spread in crops of weeds resistant to 2,4-D, crops of barley are treated with herbicides 18WP, z.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 PAR Trend 90), Bromotrile 22.5, k.e. (1.0–1.5 l/ha), Grodil Ultra, v.g. (0.1–0.15 kg/ha), Dialen, v.r. (1.9-2.5 l/ha), Lotus, k.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 drugs. Lontrel 300, v.r. (0.16-0.66 l/ha) or Lontrim, v.c. (1.5-2.0 l/ha). The choice and dosage of the herbicide depends on the phase of development of the culture and the main types of weeds, soil quality, and weather conditions.

In the sprout phase - the 3rd leaf (I-II stages of organogenesis), it is necessary to protect the crops from pests if their number exceeds the EPSH: leeches - 10-30 beetles per m2, striped bread scale - 30-50 specimens. per m2, Swedish flies 40-50 copies. for 100 net swings. Crops are marginally or continuously sprayed with one of the recommended insecticides: Bi-58 new, k.e. (1.5 l/ha); Antizuk Profit, z.p. (0.045-0.05 kg/ha), Decis f–Lux, k.e. (0.2-0.25 l/ha); Karate Zeon 050 ES, k.e. (0.15–0.20 l/ha); Svyatogor, k.e. (1.0-1.5 l/ha); Fastak, k.e. (0.1-0.15 l/ha); Fury, V.E. (0.07 l/ha) and others.

In the phase of tillering - shooting (III-VII stages of organogenesis), it is necessary to protect crops from leeches (120-150 or more larvae per 1 m2). They carry out selective spraying of crops in the centers of the pest with one of the drugs: Accent, k.e. (1.5 l/ha); Bi-58 new, k.e. (1.5 l/ha); Decis Profi, 25, v.g. (0.04 kg/ha); Zolon 35, k.e. (1.5-2.0 l/ha); Karate Zeon 050 ES, k.e. (0.15-0.20 l/ha); Nurel-D, k.e. (0.75-1.1 l/ha); Svyatogor, k.e. (1.0-1.5 l/ha); Fury, V.E. (0.07 l/ha); Shaman, k.e. (0.75 l/ha).

Diseases of leaves and stems of ears of corn (powdery mildew, types of rust, helminthosporiosis, spotting, etc.) can be controlled during the growing season.

In the phase of shooting - flowering (IV-IX stages of organogenesis) there may be a need to protect crops from leaf spotting, powdery mildew, rust, septoriosis of leaves and ears, fusarium of ears. Crops are sprayed with one of the recommended preparations: Alto Super 330 EC, k.e. (0.4 l/ha); Abacus, m.e. (1.25-1.75 l/ha); Byleton 25, z.p. (0.5-1.0 kg/ha); Bumper Super 490, k.e. (0.8-1.2 l/ha), Derosal, k.s. (0.5 l/ha); Impact 25 SC, k.s. (0.5 l/ha); Rex Duo, k.e. (0.5 l/ha); Topsin M, z.p. (1.0 l/ha); Fundazol, z.p. (0.5-0.6 kg/ha); Tilt 250 ES, k.e. (0.5 l/ha); Folikur BT, k.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 EPSH: cereal aphids - 20-30 copies/ear, grain beetles - 5-8 copies/m2; cereal thrips - 40-50 copies/ear, harmful bread bugs 8-10 copies/m2. Spraying of edge strips or continuous spraying is carried out with one of the recommended insecticides: Aktara 25, v.g. (0.1–0.14 kg/ha), Bi-58 new, k.e. (1.5 l/ha); Decis Profi 25, v.g. (0.04 kg/ha); Karate Zeon 050 ES, m.k.s. (0.15–0.20 l/ha); Fastak, 10% k.e. (0.1-0.15 l/ha); Bulldog, k.e. (0.25 l/ha); Mospilan, r.p. (0.050-0.075 l/ha) and others.

In the phase of yellow ripeness and full ripeness of the grain (XII stage of organogenesis), it is very important to prevent deterioration of grain quality due to damage by bread bugs, bread beetles, Fusarium wilt and other ear diseases.

On a high agro background, especially in years with excessive precipitation, the danger of barley crops lying down increases. In such cases, it is advisable to use one of the recommended retardants at the beginning of the shooting (Cycotel (3 kg/ha), etc.).

Harvesting. Barley is harvested by direct harvesting and by separate methods. Direct harvesting is used at full ripeness, when the grain has 14-17% moisture, and the separate method - in the phase of waxy ripeness, when the grain's moisture content is 30-38%. It is very important to correctly combine these two methods.

Late harvesting usually leads to significant losses of grain. Barley grain ripens quickly. After ripening, the spike droops down and easily breaks off, so it is necessary to harvest in a short period of time. It has been established that seven days after reaching full maturity, when the physiological connection between the seed and the plant ceases, starch is partially transformed into 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 method allows you to start harvesting three to five days earlier. It is especially necessary on weedy areas. A gap of more than three to four days should not be allowed between mowing and picking up the swaths, especially for brewing varieties.

1.4.2 Spring wheat *(Triticum)*

Spring wheat grain has high baking and cereal qualities, contains more protein than winter wheat grain. The grain of soft and hard spring wheat has a high content of protein (14-16% soft, 15-18% hard) and gluten - 28-40%. Flour of strong varieties is an improver for weak varieties when baking bread. Hard spring wheat grain is used to produce the best varieties of pasta, vermicelli, and semolina.

Spring wheat also has fodder value. it is used for the production of compound feed, bran as a concentrated feed, straw and capes - as coarse feed.

The area sown under spring wheat in Ukraine increased significantly during the years of independence - from 9,000 hectares in 1990 to 495,000 hectares in 2016. Spring wheat, like winter wheat, is becoming an extremely important strategic grain crop of the state, increasing its food security.

In Ukraine, the conditions for its cultivation are quite favorable, and modern varieties have a high yield potential - 5.0-6.0 t/ha, contain 14-16% protein and up to 30-35% high-quality gluten.

According to experts' calculations, spring wheat crops should reach 1 million hectares, including 650,000 hectares of soft wheat, the grain of which is used to make flour for high-quality bakery products, and 350,000 hectares of hard wheat, the grain of which is used in cereals. industry, and flour for the production of pasta.

Biological features, varieties. In individual development, spring wheat goes through 12 stages of organogenesis, which correspond to the following phases of growth and development: seed germination, sprouting, tillering, shooting, earing, flowering, formation and pouring of grains, ripeness.

Wheat seedlings appear 8-12 days after sowing, tillering begins 12-15 days after the emergence of seedlings and lasts 15-26 days. At the beginning of tillering in spring wheat, ear formation begins. 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 tillering, earing begins, and 3-5 days after that - flowering. 15-18 days after flowering, milky ripeness occurs, and after another 10-15 - waxy, which lasts 8-10 days. The duration of vegetation of soft wheat varieties is 85-105, hard - 110-115 days.

The productive bushiness of spring wheat is lower than that of winter wheat, barley and oats, and is 1-2.

Before the beginning of tillering, the root system penetrates the soil up to 50 cm, and before the heading phase - 100-130 cm. Nodal roots appear in the phase of 3-4 leaves and develop only when there is soil moisture in the area of the tillering node. The period of formation of the secondary root system in spring wheat is short - from the formation of the stem node to the shooting (III-IV stages of organogenesis). The secondary root system is able to effectively use the moisture of summer precipitation.

Temperature requirements. Spring wheat seeds begin to germinate at a temperature of +1...2°C, sprouts appear at +4...5°C. Seedlings withstand frosts up to -8...10°C, and in the tillering phase - up to -7...9°C. Starting from earing and up to the milky ripeness of the grain, plants are damaged by frosts of -1...2°C. Optimum temperatures for tillering are +10...14°C, for earing and pouring grain +16...20°C, for ripening +23...25°C. High temperatures during the pouring period have a negative effect on grain formation. At a temperature of +38...400C, stomatal paralysis occurs in spring wheat plants after 17 hours, as a result of which a thin grain is formed. Hard wheat is more heat demanding than soft wheat.

Moisture requirements. During germination, spring wheat seeds absorb 50-55% of their own weight of water, while hard wheat seeds absorb 5-7% more water. The transpiration coefficient is 400-450. The critical period in relation to moisture is the period of tillering and shooting (IV–VIII stages of organogenesis). A lack of moisture during this period causes an increase in the number of barren ears.

Soil requirements. The best for wheat are loamy black soil, chestnut, gray podzolic soils with a pH of 6.0-7.5. Acid soils should be limed. Varieties of durum wheat are more demanding to the soil. 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 ton of spring wheat grain takes 35-40 kg of nitrogen, 10-12 kg of phosphorus, 20-30 kg of potassium from the soil.

Varieties of soft spring wheat are recommended for the forest-steppe and Polissia in the vast majority, among them varieties of hard wheat - Aranka, Elegia Myronivska, Suite, Bukuriya, Darina, Isolde, Chado, Kharkivska 27Azhurnaya; valuable - Etud, Krasa Polissya, Rannia 93, Stavyska, Struna Myronivska, Trizo, Vitka, Kolektivna 3, Pecheryanka, Skorospilka 99, Trizo, Kharkivska 28, Elegy Myronivska, Krasa Polissya... Of the zoned varieties of durum wheat suitable for distribution in the forest-steppe zone – Nashchadok, Slavuta, Spadshchyna, Kharkivska 27, Metiska; in the forest-steppe and Polish zones - Giselle, Isolde, Kharkivska 41, Chado, Bukuria.

Cultivation technology. The best *predecessors* for spring wheat are perennial and one-year leguminous grasses, leguminous-cereal mixtures, leguminous crops (peas, soybeans). Spring wheat effectively uses fertilizers that were applied to the previous crop. Therefore, it is advisable to sow it after row crops - potatoes, corn, which were grown on well-fertilized backgrounds. It is impractical to grow spring wheat after spring cereals, sunflower and other predecessors, which strongly dry the soil, resulting in a sharp decrease in yield and grain quality. Durum wheat should be placed after better leguminous predecessors, in particular soybeans, because it is more demanding on the content of moisture and nutrients in the soil.

Tillage. When growing wheat, semi-steam tillage is effective. After harvesting the predecessor, peeling is carried out to a depth of 6-8 cm and harrowing. After the appearance of weed seedlings (after 10-12 days), early ploughing is carried out to a depth of 20-22 cm (on sod-podzolic soils to the depth of the plow layer). After that, the soil is kept in a clean state with the help of cultivation and harrowing.

If the field is clogged with perennial weeds, use improved tillage. 10-12 days after the first peeling, the second is carried out. If there are more rhizome weeds, peeling is carried out with disk peelers to a depth of 10-12 cm, and if rhizome weeds - with plow peelers to a depth of 14-16 cm. 12-14 days after the second peeling, after the emergence of perennial weeds, ploughing is carried out to the depth of the arable layer, and on chornozem soils - to 25-27 cm. Until winter, the harrow is harrowed and cultivated as weed seedlings and soil crust appear. On heavy soils, before the onset of winter, it is advisable to carry out deep spudding or spudding without a shelf.

After harvesting corn, disking is carried out in 2 tracks, and then immediately ploughing with a 23-25 cm depth. After potatoes and beets, the soil is plowed without preliminary peeling.

Processing in the spring begins with closing the moisture with tooth harrows or rotary hoes and sanding in 1-2 tracks. After 3-4 days, cultivation is carried out in 1-2 furrows to a depth of 6-8 cm, and on heavy soils - 10-12 cm and harrowing. In arid conditions and on light soils, pre-sowing cultivation is carried out to the depth of seed sowing, so that the seeds fall on a compacted bed during sowing.

Fertilization. As already mentioned, wheat is demanding on soil fertility. It is economically beneficial to provide it with nutrients due to the use of the after-effect of organic fertilizers and the use of calculated mineral doses against this background.

In the case of insufficient precipitation and their deficiency in the spring period, nitrogen fertilizers, together with phosphorus and potassium, are applied completely under ploughing or pre-sowing cultivation. Under such conditions, the optimal dose of complete NPK mineral fertilizer in the main application is 40 kg/ha d.r. Under conditions of optimal moisture supply, the nitrogen dose can be increased to 60 kg/ha, with half of it applied at the IV stage of organogenesis. Spring wheat makes good use of fertilizers applied during sowing, therefore, depending on the predecessor, type of soil and moisture supply, it is advisable to apply 15-20 kg/ha d.r. in the rows during sowing. phosphorus or 10-15 kg/ha of complex fertilizers.

To obtain a high-quality harvest of spring wheat grain, it is necessary to provide plants with a sufficient amount of nutrients, first of all nitrogen, therefore, with an optimal water regime, its fractional application during the spring-summer vegetation period is necessary. The best results for increasing the yield and grain quality are provided by nitrogen fertilization of spring wheat crops at the IV stage of organogenesis (30% of the total norm) and at the VIII stage of organogenesis (the remaining 20% of the estimated norm).

Sowing. Field germination of spring wheat seeds often does not exceed 75%. Therefore, it is necessary to prepare the seeds very carefully before sowing. It must meet the requirements of DSTU 2240-93 and have a laboratory similarity not lower than 92% for soft wheat varieties and 87% for durum wheat varieties, purity - not lower than 98.5 and 98%, respectively. After winter storage, the seeds should be warmed 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 Baitan, Vitavax or Fundazol (2-3 kg/t) and others. For the treatment of spring wheat seeds against flying soot, it is better to use Raxyl Ultra, because (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, k.s. (2.0-2.5 l/t), Vincyt 250, hp. (2.0 l/t).

You can treat the seeds both in advance (in 2-3 weeks) and immediately before sowing. Early spraying is particularly effective in protecting plants from powdery mildew diseases. In the case of forced sowing after ear precursors to protect the crops from grain weevils, gnawing scoops and other soil pests in numbers exceeding the EPSH, pre-sowing seed treatment should be carried out Gaucho, z.p. (0.25-0.5 kg/t), Rubizh, k.e. (2.0 l/t).

Treatment of seeds with growth biostimulators and strains of nitrogen-fixing bacteria is also effective, but seed poisoning should be carried out 10-12 days before treatment with drugs.

Spring wheat must 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 a decrease in productive bushiness, damage to plants by grain flies, fusarium wilt.

The rate of sowing soft and hard wheat 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 south - 3.5-4.0 and 4.0-4.5, and in irrigation - 5.0 and 5.5 million pcs. similar seeds per 1 ha. It is necessary to take into account that spring wheat plants are weak, so the sowing rate should not be underestimated. In dry spring, the sowing rate should be increased by 10-15% of the recommended one. Sowing rates are also increased in weedy fields, on poor soils and in areas with sufficient moisture.

They are sown in the usual row or narrow-row ways with grain drills, and in areas of wind erosion - with stubble. When sowing in a narrow-row method, the sowing rate is increased by 10-15%. Spring wheat seeds are wrapped to a depth of 3-4 cm, in arid conditions and on light soils - 5-7 cm.

Crop care. The main agrotechnical measures for the care of spring wheat crops are rolling, harrowing, protection of plants from weeds, diseases, pests and lodging, fertilization with nitrogen and trace elements. Rolling crops after sowing is especially necessary in dry spring conditions. It is necessary to harrow spring wheat crops on heavy flooded soils, when intensive precipitation falls after sowing and a soil crust forms.

The entire complex of agrotechnical measures (crop rotation, tillage, sowing dates, sowing rates, selection of resistant varieties, etc.) should be aimed at protecting against harmful organisms in spring wheat crops. Under modern conditions, it is practically impossible to avoid chemical treatments of spring wheat crops without a significant reduction in yield due to the negative impact of harmful organisms. Therefore, pesticides should be applied to spring wheat crops only based on the results of monitoring the phytosanitary state of crops when the economic thresholds of damage by harmful objects are exceeded.

The terms of application of herbicides are differentiated depending on the species composition of the agrophytocenosis. If annual dicotyledonous weeds dominate, the crops are processed at the beginning of tillering, perennial rhizomes - in the phase of full tillering.

When crops are weeded, mainly by annual dicotyledonous weeds, the following herbicides can be used: 2,4-D 500, v.r. (0.9–1.7 l/ha), 2M–4X 750, v.k. (0.9–1.5 l/ha), Dikopur MCPA, v.r. (0.7–1.0 l/ha), Agritox, v.r. (1.0–1.5 l/ha), Luvaram, v.r.k. (1.2–2.0 l/ha). Spraying of crops should be carried out in the phase of tillering of plants before the beginning of shooting.

For the spread in spring wheat crops of weeds resistant to 2,4-D, the crops are treated with Satis 18WP herbicides, z.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 PAR Trend 90), Bromotrile 22.5, k.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), Dikam plus, v.c. (0.8 l/ha), Starane 200, k.e. (0.75–1.0 l/ha), Dialen Super 464 SL, v.r.k. (0.5–0.8 l/ha).

In order to prevent the laying of crops, especially on high agrophones, it is necessary to apply retardants at the beginning of the shooting (IV-V stages of organogenesis). This measure is relevant for varieties that are less resistant to lodging and on spring durum wheat crops. At the same time, it is combined with spraying against powdery mildew, brown leaf rust, root rot and other diseases with Tilt, Fundazol (0.6-0.8 kg/ha) or other fungicides.

In the interphase period, the shooting - the flowering of the crops is treated against damage to plants caused by the pathogens of leaf spots, powdery mildew, rust, septoriosis of leaves and ears, fusariosis of ears with one of the recommended drugs: Alto Super 330 EC, k.e. (0.4 l/ha); Abacus, m.e. (1.25–1.75 l/ha); Byleton 25, z.p. (0.5–1.0 kg/ha); Bumper Super 490, k.e. (0.8–1.2 l/ha), Derosal, k.s. (0.5 l/ha); Impact 25 SC, k.s. (0.5 l/ha).

From flowering to the end of pouring grain, if necessary, the crops are sprayed against the harmful beetle, bread leech and other pests with aqueous solutions of insecticides: Accent, k.e. (1.5 l/ha); Karate Zeon 050 ES, k.e. (0.15-0.20 l/ha); Svyatogor, k.e. (1.0-1.5 l/ha); Fury, V.E. (0.07 l/ha).

Harvesting. The spring wheat crop is harvested in two and one-phase ways. The technology and criteria for assessing the quality of harvesting are the same as for winter wheat. Separate harvesting begins at wax maturity. Grain is harvested at full ripeness by direct harvesting. Delay in harvesting leads to significant crop losses (wheat grain falls off).

1.4.3 Oats *(Avena)*

Oats belongs to ancient crops, although in distant times oats were a filler for wheat and barley. It is known in Europe for 1500-1700 BC. It has a fairly wide distribution, especially in regions with a humid and cool climate. When moving north and into the mountains, being more durable, it supplanted other crops.

The high content of protein (12-18%), starch (40-45%), fiber (10.5%), fat (4-5%), ash (4-2%), amino acids and minerals determines its feed quality: 1 kilogram of oats is taken as 1 feed unit. The digestibility of its organic matter is 70%. Oat protein has high solubility. 1 kg of grain contains 5.5 g of lysine, 0.69 g of tryptophan, 1.65 g of methionine, 2.27 g of cystine.

Oats contain sterols, steroidal saponins, coumarin, glycoside, vanillin, vitamin E, retinol, thiamin, riboflavin, 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, contains a large amount of polyunsaturated essential fatty acids and hormone-like substances.

Oats are considered dietary feed, highly valued in feeding horses, procreators and young animals of all kinds. Due to the high content of unsaturated fatty acids in the fat and a significant amount of fiber, they are included in the diet of fattening pigs in limited quantities. The film contains a lot of fiber, little protein, fat and minerals, and it is nutritionally equivalent to straw.

The world area of oat crops is about 20 million hectares or 2.8% of grain crops. The main areas are concentrated in Europe and North America, the largest ones among the countries are in Russia (14.8%), the crop is sown on large areas in Belarus (14.1%), Canada (8%), Poland (7.3%), Germany (6.3%). In terms of gross production, the leadership belongs to Russia - 31.5% or 9.2 million tons. Canada gathers 10.1%, the USA - 8.8% and Germany - 5%. In Ukraine, oats are grown mainly in the Forest Steppe and Polissia on an area of 0.4-0.5 million hectares. In terms of average productivity, it is inferior to barley. However, it is characterized by a fairly high productivity potential.

The share of oats in world resources is quite noticeable, but its production is decreasing. One of the main reasons is structural changes in animal husbandry, a decrease in the number of horses for which oats are the main fodder; the second reason - relatively low yield; the third one is the lower energy value of oats than other forage crops: if 1 kg of oats is equivalent to 1 unit, then 1 kg of corn grain - 1.34, barley - 1.2, sorghum - 1.1, peas - 1.14 , soy - 1.30. fodder beans – 1.15, lupine – 1.11, sedges and vetches – 1.19.

Biological features, varieties. Temperature requirements. Of the 10 types of oats, the common oat (Avena sativa) is the most important. This is a culture of a temperate climate, undemanding to heat. Its seeds germinate at a temperature of +2...30°C. In the phase of 3-4 leaves, tendrils and the formation of secondary roots begin. The optimal temperature for germination is +10...18°C. The plant’s shoots tolerate frosts up to -4...50°C. When the temperature drops to -10°C, the tillering node of oats is not damaged and with the onset of heat, plant vegetation continues. In the phase of flowering and milk ripeness, plants die at -20°C. The optimal temperature for flowering and ripening is +20...25°C. Oats tolerate summer high temperatures and droughts worse than wheat and barley.

Moisture requirements. Oats are the most moisture-loving crop from bread cereals. Sufficient relative humidity and frequent rains are the key to high yields. The yield of oats increases in parallel with the amount of summer precipitation. When germinating, seeds absorb 60-65% of their own weight of water. The transpiration coefficient is 450-500. The first period of life – from tillering to throwing out panicles – is critical in relation to moisture. Intense rains in the second half of the growing season cause the formation of additional shoots and delay the harvest.

Soil requirements. Oats have a well-developed root system, which is characterized by high digestibility. In the tillering phase, the roots penetrate the soil to a depth of 70-80 cm, and in the grain formation phase – to 1.5-2 m. The root system of oats is able to assimilate phosphorus from poorly soluble soil compounds. Therefore, it is less demanding on soils than other types of bread, except for rye. Oats grow well on sandy, loamy and clay soils and tolerate soil acidity better than other cereals (optimal pH 5-6). It grows well on drained peatlands, so it is recommended to sow it as the first crop when developing drained lands. The most suitable for oats are structural chernozems, dark gray podzolized soils with a slightly acidic reaction. It grows poorly on saline soils.

Oats is a self-pollinating, long-day plant. It grows well with early mowing. Grains in oat panicles ripen unevenly, and this makes it difficult to determine the optimal harvest time. Its growing season lasts 100-120 days.

Requirements for fertilizers. A characteristic feature of oats is the extended period of consumption of nutrients. It responds well to nitrogen fertilizers. With a harvest, 1 ton of grain (including straw) takes out 30-40 kg of nitrogen, 10-15 kg of phosphorus and 25-30 kg of potassium from the soil.

The best varieties of rolled oats: Skakun, Synelnikovskyi 1321, Zirkovy, Spurt, Busol, Slavutych, Rainbow, Neptune, Parliament, Zakat, Zirkovy, Polonaise, Arkan, whole grain ones - Abel, Marathon, Treasure of Ukraine, Solomon, Samuel.

Cultivation technology. *Predecessors.* Compared to barley, oats are a more flexible crop, so they are less picky about their predecessors. High oat yields are obtained when sowing after well-fertilized winter cereals and row crops, leguminous crops, flax, and lupine. With a high crop of agriculture, it can be sown after wheat. It is not recommended to sow it after oats and sugar beets, as they have a common pest - the nematode.

Tillage. Oat is a moisture-loving crop, so autumn and spring tillage should be aimed at accumulating and preserving moisture. After harvesting the predecessor, the stubble is husked once or twice to a depth of 8-10 cm and plowed or plowed without turning over the soil to a depth of 20-22 cm.

For oats, it is important to ensure soil settling with an effective capillary system, because oats, due to the filminess of the grains (25-30%), require more moisture for seed germination and further growth and development than wheat, rye or barley.

In the spring, harrowing and pre-sowing cultivation are carried out to the depth of seed wrapping (5-6 cm), but depending on the condition of the field before sowing, you can limit yourself to one of these operations.

Fertilization. Thanks to a well-developed root system, oats use soil fertility and nutrients left over from their predecessor quite effectively.

Oats make good use of the after-effects of organic fertilizers, so they are sown as a second or third crop after their application. Oats respond positively to the application of mineral fertilizers on all soils. Against the background of phosphorus-potassium fertilization, nitrogen fertilizers always provide the greatest efficiency. On soils with an acidic reaction, the most effective physiologically alkaline nitrogen fertilizers are sodium and calcium nitrate.

Depending on the characteristics of the soil and precursors, fertilizers are applied to oats at the rate of 30 to 60-90 kg/ha of active substances of nitrogen, phosphorus and potassium. With average soil nutrient availability, 30-40 kg/ha of NPK are applied to oats. Phosphorous and potash fertilizers are applied during the main tillage or during spring cultivation. Nitrogen fertilizers, if their calculated dose does not exceed 40-60 kg/ha, should be applied under pre-sowing cultivation. If the dose is higher than 60 kg/ha, then part of the nitrogen fertilizers should be added to the top dressing at the beginning of tube growing.

50 kg/ha of granulated superphosphate or Nitrophoska (P10) are applied to the rows during sowing. Copper, boron and manganese fertilizers are also used on peatlands.

Sowing. When preparing the seeds for sowing, they are sorted so that the grains from the first flowers in spikelets, which are much larger than the others, get into the seed material. If it is not possible to provide all areas with such seeds, it should be calibrated in terms of size and sown in larger quantities. Seeds must meet the requirements: germination must be at least 92%, purity - not lower than 98.5%, weeds - no more than 20 pcs. per 1 kg. In autumn, before storage and in spring, air-thermal or solar-thermal heating is carried out. 5-10 days before sowing, the seeds are treated to protect from Ustilago tritici and Tilletia caries, seed mold, fusarium root rot with Benlat (2-3 kg/t), Vincyt (2 l/t), Raxyl (1.5 kg/t), Fundazol (2–3 kg/t) or other poison using the encrusting method.

Oats are sown at the beginning of field work after wheat and barley. The best method of sowing is narrow-row sowing. In areas where seed sowing rates do not exceed 4 million similar seeds per hectare, the usual row method is also effective. The estimated rate of sowing in Polissia is 5.5-6.0 million, in the Forest Steppe - 5.0-5.5, in the Steppe - 4.5-5.0 million similar seeds per 1 ha.

Oat seeds are buried in the soil to a depth of 3-4 cm. On light soils and when the seed layer dries out - by 4-6 cm, and on heavy clay soils and by excessive moisture - by 2 cm.

Crop care. Oat crops are an effective natural means of protection against diseases of other grain crops, which is of great importance in environmental protection due to the reduction of the use of pesticides. Only pre-sowing seed treatment is a mandatory preventive measure. All other chemical protection measures should be carried out only if necessary on the basis of a thorough analysis of the phytosanitary state of crops.

In dry weather, after sowing or simultaneously with it, the field is rolled with ring rollers, under conditions of sufficient moisture - harrowed. If a soil crust forms on the field after sowing, then in order to destroy it and protect it from weeds, the field is harrowed with light harrows before the emergence of oat seedlings. During weeding, crops are sprayed with aqueous solutions of herbicides: Amin salt 2.4-D (1.5-2 kg/ha), Dialen (1.75-2.25 l/ha), Lontrel (0.3 -0.6 kg/ha) or 2M–4X (1.4–2.3 kg/ha). On crops where perennial grasses are sown, Bazagran M (2-4 l/ha) is used at the appearance of trifoliate leaves in grasses.

During the growing season, oats can be damaged by Swedish fly, aphids, oat thrips, the cereal leaf beetle; underground organs of young plants suffer from wireworms, false wireworms and other pests. Spraying against pests is carried out when their number exceeds the limit of economic damage. For this, the following insecticides can be used: Karate Zeon 050 EC (0.15-0.20 l/ha); Svyatogor (1.0-1.5 l/ha); Fastak (0.1-0.15 l/ha); Fury (0.07 l/ha) and others.

In the case of forecasting severe damage to crops by linear stem rust, crown rust, powdery mildew, ascochitosis (white spot), red-brown spot, red-brown bacterial spot, the following fungicides can be used: Alto Super 330 EC, (0.4 l/ha); Abacus(1.25-1.75 l/ha); Byleton 25 (0.5-1.0 kg/ha); Bumper Super 490 (0.8-1.2 l/ha), Derosal (0.5 l/ha); Impact 25 SC (0.5 l/ha); Rex Duo (0.5 l/ha); Topsin M (1.0 l/ha); Fundazol (0.5-0.6 kg/ha); Tilt 250 ES (0.5 l/ha); Folikur BT (1.0-1.25 l/ha).

Harvesting. Oat grains ripen very unevenly in the panicle - first in the upper branches, then in the middle ones, and finally in the lower ones. If the general ripeness of the grain makes it possible to start harvesting, then the vegetative mass (stems, leaves) is still green and too wet. Due to this feature, the timing and methods of harvesting oats must be approached very carefully.

The oat harvest is harvested separately (two-phase method) or by direct combining. Oats are harvested separately at the end of the grain's waxy maturity, when 30–40% of the grains reach full maturity in the upper part of the panicle. Fallen crops with high humidity and littered crops are collected, as a rule, only in a separate way, using harvesters. It is advisable to start direct harvesting when the massif reaches more than 90% of grain with a moisture content of 14-18%. In this way, low-growing, thinned and uniformly maturing unweeded crops, without additional shoots, which are distinguished by their resistance to lodging and shedding of grain, are usually harvested. Harvesting should be carried out in a short period of time, because the oats fall off quickly (the largest grain of the first ripening period is lost).

After harvesting, the grain is immediately cleaned and dried, because dust with fungal spores accumulates on the films of the grains, which germinate during storage of wet grain and cause its spoilage.

1.4.4 Triticale *(Triticale)*

Triticale grain contains 13-16% protein, in which up to 350 mg/% of the essential amino acid - lysine. The content of carotenoids is 1.5–2.0 mg. This ensures its high nutritional value. The nature of triticale grain is slightly lower, compared to wheat, and is 680-730 g/l, which is due to greater elongation of the grains and lower hardness of the endosperm.

Triticale grain is effectively used for feeding cattle, sheep, goats, pigs, and poultry. Combined fodder produced with triticale content of up to 40-50% of the grain component is more valuable.

In compound feed for poultry, triticale grain increases their energy and biological value due to better balance in the content of protein, its easily soluble fractions, essential amino acids, carotene and other important components. Balanced compound feed contains up to 40-45% triticale as well as corn, soy and other mineral and biological additives.

Triticale grain is also a valuable raw material for the production of high-quality alcohol. The yield of alcohol from triticale grain exceeds rye by 1.7-1.9% and wheat by 0.3-0.6%.

The use of spring triticale is expanding every year, both for the production of food and fodder, and in other areas: green mature and mulching cropping system, production of disposable dishes, etc.

Spring triticale is less picky about growing conditions than spring wheat. Plants have a well-developed root system, leaf apparatus, which enables them to tolerate drought better and actively absorb nutrients. Due to the functioning of rye chromosomes in their genome, triticale is more resistant to sharp temperature fluctuations at the beginning of the growing season.

Cultivation technology. Predecessors. The best precursors for spring triticale are perennial and one-year leguminous grasses, leguminous mixtures, leguminous crops (peas, soybeans), corn, potatoes. To obtain marketable products, it is allowed to sow spring triticale after winter wheat and sunflower.

Soil preparation. The optimal method of the main tillage for spring triticale sowing on chernozems is spudding without a shelf to a depth of 20-22 cm with preliminary husking with disc huskers to a depth of 6-8 cm.

After corn for grain, it is advisable to carry out ploughing in all zones by 20-22 cm. For spring triticale, especially when it is placed after sugar beets, it is necessary to carry out tillage without a shelf using tools of the chisel type in order to destroy the plow sole, which significantly improves the agrophysical properties of the soil, contributes to the accumulation of soil moisture, makes it possible to start spring sowing works 5-6 days earlier and ensures an increase in the yield of spring triticale.

Fertilization. The composition and doses of mineral fertilizers for triticale are determined depending on the availability of nutrients in the soil, which is related to the fertility of the soil, the predecessor, etc. According to the summarized results of the researches of the scientific institutions of the Forest Steppe and Polissia on black soil and dark gray soils under triticale, it is necessary to use $N_{45–60}P_{45–60}K_{45–60}$ after fertilized precursors. For sod-podzolic, light gray soils, the dose of fertilizers is increased to $N_{60–90}P_{60–}$

$_{90}K_{60-90}$. Potash and phosphorus fertilizers are recommended to be applied during the main tillage, during sowing – 10-15 kg of superphosphate per hectare per year, and on poor soils – complete mineral fertilizer at the rate of 20 kg per hectare per year of each element. It is advisable to apply nitrogen fertilizers for pre-sowing cultivation (70%), and the rest should be applied for top dressing in the phase of shooting.

Sowing. Among the varieties of spring triticale with a high level of productivity potential, the following should be noted: Kobzar, Kharkiv Lark, Kharkiv Oberig, Kharkiv Nightingale, Kharkiv Korovai, Kharkiv Legin, Losynivske, Zgurivsky, Arsenal, Victoria, Veresoch, etc.

The seeds are treated with one of the recommended substances included in the "List of pesticides and agrochemicals approved for use in Ukraine" for the current year. This measure achieves the disinfection of seeds from pathogens of external infection (hard, stem and dwarf smut, Claviceps purpurea, mold) and internal (Ustilago tritici, fusarium), protection of germinating seeds and seedlings from damage in the soil by pathogens of stem and dwarf smut, root rot, septoriosis, increasing field germination of plants. In addition, broad-spectrum poisons protect seedlings against such dangerous diseases as powdery mildew, rust, septoriosis and other spots for a certain period of time.

Sowing must be carried out as early as possible when the soil is physically ripe (when it is well spudd). The warming of recent years makes it possible to sow spring triticale even earlier, using the "February-March windows" for this, which is quite effective. Seedlings of spring triticale can withstand a drop in temperature to -8...9°C, so a drop in air temperature after sowing will not harm the plants.

The highest productivity of spring triticale forms at the sowing rates of 4.5-5.0 million/ha of similar seeds after the best predecessors, and after the worst - 5.0-5.5 million/ha. The depth of spring triticale seed wrapping is within 4-5 cm.

Crop care. Immediately after sowing triticale, the spring field is rolled with ring-spur rollers, if the seeder did not ensure proper rolling of each row. In the event that a soil crust appears after sowing, harrowing with light harrows is necessary before the emergence of seedlings. The main thing in the care of spring triticale crops is protection from weeds, primarily rhizomes. To destroy them in the budding phase of spring triticale crops, it is recommended to treat them with the herbicide Lontrel 300, water solution (0.16-0.66 l/ha) or Lontrim, WC (1.5-2.0 l/ha).

When pests appear above the harmfulness threshold, apply insecticides Karate Zeon 050 CS (0.15-0.20 l/ha); Svyatogor (1.0-1.5 l/ha); Fastak (0.1-0.15 l/ha); Fury BE (0.07 l/ha).

Due to high resistance and immunity against common foliar diseases, fungicides are not used on spring triticale crops. Powdery mildew, stem rust, Ustilago tritici and Tilletia caries do not affect modern intensive varieties. Brown leaf rust and leaf septoria show signs of damage late, which do not spread. An exception can be only the epiphytotic development of septoriosis of the leaves. In this case, crops are treated with one of Vincyt 050 CS fungicides (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 the crops are inhabited by the larvae of the turtle bug (6 specimens/m2) and bread beetles (5-6 specimens/m2) in the phase of the milky and pasty state of the grain, the crops are treated with Karate preparations, 5% – 0.15 l/ha; Decis doublet, 2.5%– 1.2 l/ha or Volaton, 50% – 1.6-2.0 l/ha (against bread beetles). Spring triticale is more resistant to damage by these pests, compared to other ear crops

Harvesting. Features of harvesting spring triticale are similar to rye. The grain is tightly covered by flower scales and does not fall off when ripe. It is more difficult to be threshed out than wheat grain and, having a deep groove, it can be more injured, which must be taken into account when organizing harvesting.

1.5 LATE SPRING CEREAL AND GRAIN CROPS

Cereal crops, which are sown later than other ceraal crops, are called late spring crops. Plants are drought-resistant (except for rice) and heat-loving, physiologically active at temperatures above +10oC. They have an exceptionally vigorous type of development, growth and development at the beginning of the growing season is slow. These are short day plants. The late spring crops include cereals of the second group or millet-like cereals: corn, millet, sorghum, rice and buckwheat, which according to the identity of the use of the main product are classified as late grain crops, although it differs from them in many morphological features and biological features.

1.5.1 Maize *(Zea mays)*

Maize is one of the most valuable crops in world agriculture. One of the most ancient bread plants of the earth, an aboriginal plant of America. Remains of wild corn pollen, panicles, grains and cobs of primitive forms found by archaeologists in Mexico date back to 80 thousand years BC. e., that before the appearance of man. Ancient remains of cultivated plants have also been found in Mexico. Even before the arrival of the Spaniards in America, all subspecies of corn were common in the fields of the Indians. At the end of the 15th century, it was brought to Europe by X. Columbus (a gift to the Spanish king). Initially, it was grown as an ornamental crop. Through Spain and Portugal, it spread to Europe, Asia and Africa. First as a valuable food crop, and later as fodder.

Maize ranks first in world grain production. The versatility of use is unparalleled. In the world, 15-20% of grain is used for food needs, 10-15% for technical purposes, and 70% for fodder. In recent years, its use in phytoenergy has been increasing.

Its grain contains 65-70% of nitrogen-free extractive substances, 10-12% of protein, 4-8% of fat (up to 40% in the germ), vitamins A, B1, B2, B6, E, C, essential amino acids, mineral salts and trace elements. This composition of grain determines its high food, fodder and technical value.

1 kg of corn grain contains 1.34 feed units, 78 g of digestible protein. However, corn protein is depleted of such important essential amino acids as lysine, methionine, and tryptophan, the deficiency of which in feed causes metabolic disorders in animals, but it is rich in zein, a protein of little value in terms of feed. The use of corn with high-protein crops (rape, fodder beans, lupins, soybeans), in which 1 fodder unit accounts for 130-250 g of digestible protein with a sufficient amount of essential amino acids, will make it possible to balance feed in terms of protein and prevent their unproductive consumption.

In 100 kg of corn silage, harvested in the phase of milky grain ripeness, there is 0.17-0.18 fodder units, 0.22-0.24 in milk-waxy, 0.28-0.30 in waxy. Corn is used for green fodder. 100 kg of green fodder corresponds to 16 fodder units. In terms of feed nutrition, 1 hectare of corn provides about 6,000 feed units and up to 300 kg of digestible protein, which is significantly higher than other grain crops.

Corn is the most valuable among grain forage crops in terms of energy nutrition, it is characterized by a high content of starch (up to 70%) and fat (4-6%), and a low content of fiber (2-5%). Corn lipids are rich in unsaturated fatty acids, namely oleic and linoleic ones.

Since there is little fiber in the grain of corn, it is especially effective in feeding it to poultry. The high energy content of grain (361 kcal per 100 g) makes it an important component of compound feed. In the composition of compound feed for pigs, the optimal share of corn is 70-80%, for poultry - 60-70%, for cattle - 55-60%.

From 1 t of grain, you can get 56 kg of starch (or 60 kg of fructose or 38 l of alcohol), 23 kg of feed with a protein content of 21%, 5.2 kg of gluten flour and 2.5 kg of corn oil, which belongs to the semi-drying group (one number 113–133), that is, it has high taste qualities.

As a row crop, corn is a good predecessor for crop rotation, it helps to clear fields of weeds, and has almost no pests and diseases in common with other grain crops. Thus, when harvested for grain, it is one of the best predecessors of spring cereals, and when harvested for silage, it is one of the best predecessors of winter wheat. When grown for green fodder, it is a good vapor-absorbing culture. Corn is widely used in post-harvest and post-harvest crops.

Maize ranks second in the world after wheat. However, according to FAO forecasts, it will take first place in the next 2-3 years. In the world, corn is grown on an area of about 220 million hectares, including 33 million hectares in the USA, 30 million hectares in China, 13 million hectares in Brazil, 8 million hectares in Mexico, and 6 million hectares in India, where 48.5% of the world's corn sown area is concentrated.

In Europe, the sown area is 14.2 million hectares: Ukraine – 4.6 million hectares, Romania – 3 million hectares, France – 1.7 million hectares, Hungary – 1.1 million hectares.

Corn grain production increased from 104.5 to 669.6 million tons, or 6.5 times, which is 34.2% of world grain production. By continent, it is concentrated as follows: North America - 286.3 million tons (50.3% of world production), Asia - 139.2 (24.4%), Europe - 53.9 (9.5%), South America – 47.9 (8.4%), Africa – 37.8 million tons (6.6%). Over the past 14 years, its gross yields have increased by 35.5%.

Currently, 22.4% of the world's corn crops are concentrated in the USA and 45.1% of its grain is produced. The second place in the world in corn grain production belongs to China - 105.6 million tons with a yield of 3.52 tons per hectare. The average yield of corn grain in the world is about 5.5 tons per hectare.

In Ukraine, modern corn production provides 133% of the domestic market, with an annual demand of 13–15 million tons. According to official statistics of the State Committee of Statistics of Ukraine, corn is sown on an area of 5.3 million hectares. A record amount of corn grain was obtained in 2013 - almost 32 million tons with a yield of 6.44 tons per hectare.

Biological features, hybrids. In the ontogeny of corn, 12 stages of organogenesis and phenological phases are distinguished: seed germination, sprouting, formation of the third leaf, formation of each unpaired leaf, formation of spike flowers, flowering of spike flowers, flowering of the ear, formation of the grain, milky stage, milky-waxy,

waxy and full ripeness (table 4). Phases are determined by the number of leaves on the main shoot, including the phase of shooting, which is difficult to determine by probing.

Table 4 – Phases of growth and development and stages of organogenesis of corn (according to F. M. Kuperman)

Phases of growth and development	Stages of organogenesis		Elements of productivity
	panicles	cob	
Seed germination, sprouts	I. The growth cone is undifferentiated	–	–
The third - fifth leaf	II. Differentiation of the growth cone	I. Undifferentiated growth cone of the lateral stem	Optimum plant density
	III. Growth in the length of the growth cone. Formation of panicle lateral branches	II. Differentiation of a shortened stem into nodes and internodes	The number of leaves, coefficient of tillering
Beginning of stemming	IV. Formation of spike flowers	III. Further extraction of the growth cone, segmentation of its base	–
Output to the tube (11–13 leaves)	V. The formation of flowers in spikes	IV. The formation of the spike scales. The formation of the spike tubercles	The number of joints of the cob
	VI. The formation of the pollen	V. Differentiation of the spike tubercle	The formation of the length of the cob and the number of the spikes in the rows
Discarding the panicle	VII. The growth in the length of the joints of the inflorescence, completion of the state flower formation	VI. The formation of the embryo sac, the growth of stamen columns	Number of the flowers in the cob
	VIII. Discarding the panicle	VII. The completion of the formation of the state flowers	Fertility of the flowers
Blooming the panicles. Throwing out the cob threads	IX. Blooming the panicles	VIII. Discarding the threads of the stigmas	Thermal resistance
		IX. Blossoming, pollination, fertilization	Graininess of the cob
		X. The formation of the embryo and grain, the beginning of the milk ripeness	The size of the grains
Milk ripeness	–	XI. Milk ripeness, accumulation of nutrients in the grain	The weight of the grain
	–	XII. The transformation of nutrients into spare	–

The seedling phase continues until 5-6 leaves of the germ bud develop (2-3 leaves in breads of the first group). At this time, the first layer of nodal roots is formed, the transition to autotrophic nutrition is completed. In the phase of seven or eight leaves, tillering begins, the roots close in the interrows, which must be taken into account when establishing the depth of loosening of the interrows and the width of the protective zones.

In medium-ripe hybrids, the phase of emergence into the tube coincides with the appearance of 11-14 leaves; in early-ripening hybrids, it begins with a smaller number of leaves, in late-ripening ones with more. In the phase of emergence into the tube, the panicle grows more actively than the stem. Active growth of the stem (stemming) begins after the panicle is thrown out: the internodes of the stem are elongated, including the last one, which completely removes the panicle from the sheath of the upper leaf.

Grains within the cob mature unevenly. This is caused by the non-simultaneity of the appearance of columns and the fertilization of flowers located in different places on the cob.

In the phase of milk ripeness, the grains of the upper part of the cob contain the most moisture, because they were the last to start their development. In the following phases, the grain of the upper part of the cob loses moisture faster than the grain of the middle and especially the lower part, therefore, in the phase of harvesting ripeness, the moisture of the grain of the lower part of the cob is higher than the moisture of the middle and upper parts.

This is due to the fact that the bottom of the cob is tightly covered with wrappers throughout the development period until harvesting, while the wrappers at the top of the cob at maturity separate, exposing the grain, which accelerates its drying.

The agroclimatic conditions of corn sowing zones in our country are characterized by extreme diversity. 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 crop productivity (Table 5).

Table 5 - Agroclimatic conditions of the corn growing areas

Area	During the period with a temperature above 10 °C				Annual amount of precipitation, mm
	duration of the period, days	sum PAR, MJ/m2	sum temperatures, °C	GTC	
Steppe	175	1671	3155	0,7–1,1	406–514
Forest steppe	161	1491	2660	1,2–1,6	547–632
Polissia	157	1432	2595	1,4–1,9	609–838

When growing corn for grain in different areas of the country, it is extremely important to take into account the heat needs of hybrids of different biological types. Corn's need for thermal resources for intensive plant growth and development is limited, as a rule, to the date of a steady transition of average daily air temperatures through the +10°C mark.

The relationship to temperature. Corn is a heat-loving plant. The minimum temperature for seed germination is +6..8 °C. In the field, seedlings appear at a soil temperature of +8..10°C. The sprouts are damaged by frosts of -2...3°C. At the same time, leaves damaged by frost turn yellow and partially die, but the growth point remains undamaged. The siliceous forms of corn are more cold-resistant.

Cold nights (temperature below +14 °C) and sharp fluctuations in daytime and nighttime temperatures slow down growth processes in plants and contribute to the extension of the vegetation period of the crop. Air temperature below +15 °C causes yellowing of leaves in young plants, which is a consequence of a decrease in the intensity of photosynthetic activity.

During the vegetation period until the appearance of generative organs, an increase in air temperature up to +25 °C does not harm the growth and development of corn plants. In the future, after the flowering of the panicles and when the spikes appear on the cobs, a temperature of +25 °C and above has a negative effect on the plants. Temperatures above +30 °C lead to disruption of flowering and fertilization processes. 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 reducing the yield of corn in different growing regions. Temperatures close to 0 °C damage the green leaves of plants, and their decrease to -2...3 °C is accompanied by damage to mature grain if its humidity exceeds 20%.

For corn hybrids that differ in terms of ripening, the necessary amount of effective temperatures (above +10 °C) is established, which, along with the provision of heat in each climatic zone and taking into account the biological features of the culture, makes it possible to scientifically substantiate the zoning of biotypes of hybrids of different maturity groups according to their needs in heat resources by country areas (Table 6).

Table 6 - Corn requirements for temperature conditions

Group of ripeness	Sum of temperatures, ^{0}C		Vegetation period, days	Number of leaves, pcs.	FAO, points
	active, > 5 ^{0}C	effective,> 10 ^{0}C			
Early ripening	2200	900–1000	90–105	12–14	100–199
Mid-early	2400	1100	105–115	14–16	200–

Group of ripeness	Sum of temperatures, ${}^0C$		Vegetation period, days	Number of leaves, pcs.	FAO, points
	active, > 5 ${}^0C$	effective,> 10 ${}^0C$			
ripening					299
Medium ripening	2600	1150	115–120	17–18	300–399
Mid-late ripening	2800	1200	120–130	19–20	400–499
Late ripening	2900–3000	1250–1300	135–140	21–23	500–599

The term FAO is used to estimate the ripening period - a complex indicator that takes into account not only the temperature, but also the yield potential, the intensity of light use, and the yield of moisture by the grain during ripening.According to this indicator, hybrids are divided into early-ripening (FAO 100-199), medium-early (FAO 200-299), medium-ripening (FAO 300-399), medium-late (FAO 400-499) and late-ripening (FAO more than 500).Corn seeds with higher FAO have higher yield potential. For Polissia, it is better to choose hybrids with FAO up to 180, Forest Steppe - 180-380, Steppe - 260-500.

Moisture requirements. Corn is a drought-resistant plant. 37-40% of water from their weight is needed for seed germination. The transpiration coefficient is 220-300. Corn consumes the largest amount of water during 30 days, starting 10-15 days before the panicle is thrown and ending with the state of milk ripeness of the grain (this period of time is considered critical).Optimal soil moisture during the growing season should be at least 75–80% RH.

Corn does not tolerate waterlogging of the soil, sharply reducing grain yield. Due to the lack of oxygen in overmoistened soil, the absorption of phosphorus by the roots slows down. As a result, the processes of phosphorylation, energy processes in the root system and protein metabolism are disturbed.

*Relquirements to light.*Corn is a light-loving, short-day plant. When the day is longer than 12–14 hours, its growing season increases. Corn does not tolerate shading well - in thickened crops, the development of plants is delayed and the beginnings are not formed.

Soil requirements. Corn is moderately demanding on soil fertility. Corn must be placed on well-aerated soils with a deep humus layer and high water-holding capacity.

Loamy and sandy black soils, dark gray, dark chestnut soils are most suitable for corn. The optimal density of the soil is 1.1-1.25 g/cm3. It grows well on floodplain and peat soils. The optimal pH is 6.5-7.5.

Requirements for power cells. For the formation of 1 ton 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, nutrients are absorbed unevenly by corn plants. Nitrogen use continues until the grain is waxy, with peak demand from panicle shedding to flowering. Absorption of phosphorus takes place more uniformly almost until the grain is fully ripe. Plants use potassium most intensively in the first half of the growing season and during the period of vegetation and formation of grain.

In all countries of the world, most of the cultivated areas under corn are occupied by its hybrids. Corn hybrids in the first generation provide a higher yield than parental forms (the phenomenon of heterosis), therefore, hybrid seeds of the first generation are used for sowing. 45–50 hybrids are grown in Ukraine every year. More than 500 hybrids of different maturity groups (FAO 150–500) are entered in the State Register of Plant Varieties of Ukraine, of which about 42% are of domestic selection.

Among the recommended corn hybrids for grain and silage, the most common early ripening ones are: Borysfen 191 MV, Kharkivskyi 199 MV, Dniprovskyi 172 MV, Dniprovskyi 177 SV, Dniprovskyi 203 MV, Slavutych 162 SV, Mariyin 160 SV, Luch 170 MV, PR39G12, PR39G83, Delfin, Kadr 195 SV, Growth of SV, Restoration of SV; mid-early

Dniprovskyi 288 SV, Kadr 267 MV, Slavutych 224 SV, Bastion MV, Elita, Sandryna, PR39D81, Titus; medium ripening Borysfen 301 MV, Sensor, Lebid MV, Dniprovskyi 310 MV, Cadre 327 MV, Currency, Helga, Clarika, Anasta, PR37D25, Pelikan; mid-lateripening Borysthenes 433 MV, Hercules 450 MV, Dniprovskyi 450 AMV, Cadre 443 SV, Furio, PR38A24. In Ukraine, three varieties are recommended: Zakarpatska yellow tooth-shaped, Dniprovska 298, Odeska 10.

Cultivation technology. In the conditions of the Steppe, the best predecessors for corn for grain are winter wheat after black and busy steam, legumes, permissible - early grains, corn, undesirable - Sudanese grass, sunflower.In the farms of this zone, it is better to place corn for grain in the following links of crop rotation: black and busy steam - winter wheat - corn; winter wheat after steaming - winter wheat - corn; corn for silage - winter wheat - corn.In the northern and northwestern more humid areas of the Steppe, corn is placed in the following sections of the crop rotation: a steam occupied by perennial grasses on one cutting - winter wheat - corn; winter wheat on a layer of perennial grasses - winter wheat - corn.

In the forest-steppe, good predecessors are winter wheat, legumes, corn, potatoes. In more humid areas (northern, northwestern, and western), where sufficient moisture accumulates in the autumn-winter period, corn yields high grain yields after sugar beets.

In Polissia, the selection of predecessors depends primarily on the fertility of the soil. The best predecessors for corn are legumes, potatoes, sugar beets, winter corn, lupine.

Corn tolerates repeated sowings well within 5-7 years, provided that fertilizer rates are increased and protection from pests and diseases is strengthened. Corn can be placed in crop rotations of short rotation after favorable predecessors, where its share can be 30-75%.

Tillage. When growing corn, tillage is used. If the field is clogged mainly with annual weeds, a system of semi-steam weeding is used, and if it is perennial - improved weeding. The entire system of cultivation in all zones should be aimed at maximally cleaning the soil from weeds, and in conditions of insufficient moisture - at preserving and accumulating moisture in it.

After the stubble predecessors, husking is carried out with LDH-5A, LDH-10A, LDH-15A, LDH-20 disc huskers, and on compacted and dry soils - with plows PCL-10-25, PPL-5-25 or BDT-7 disc harrow to the depth 6–8 cm. If the field is covered with annual weeds, after the weeds have germinated, plowing is carried out with plows with PTK–9–35, PNL–8–40, PNI–8,40, PLP–6–35, PLN–5 front plows –35, PL.5–35, PLN–4–35, PLN–3–35 to a depth of 25–30 cm (on sod-podzolic and gray podzolic soils to the depth of the arable layer).Plowing should be carried out in a unit with sections of ring-spur rollers and harrows. After that, the field is looked after like steam, keeping it in a clean state with the help of a system of harrowing and cultivation.

When the field is littered with perennial weeds before plowing, after the first peeling during the mass emergence of these weeds, 1-2 more peelings are carried out on the peeled field. If rhizome weeds prevail, for example wheatgrass, after the first peeling, when wheatgrass spikes appear, carry out the second again with disc peelers across the direction of the first and to a greater depth - 8-10 cm or 10-12 cm. After sprouting of wheatgrass, the soil is peeled again once, they wait for the emergence of seedlings and carry out field plowing (or carry out it after the second peeling).

If the field is dominated by rhizome weeds, for example, field and yellow thistles, bitter gorse, field birch, the second and third peeling is performed with plow peelers to a depth of 12-14 cm with a time interval determined by the appearance of rosettes of these weeds.

With intensive technology, peeling must also be done after row crops (tobacco, sunflower, corn, and even sugar beets), because without preliminary peeling, the post-harvest residues are plowed poorly and reduce the quality of sowing and crop care. After late crops, plowing is carried out immediately after peeling, if the soil is so moist that it crumbles well and no lumps are formed. After potatoes, plowing is carried out without preliminary peeling.

Corn grows well on soils with a deep cultivated plow layer, therefore, in all zones, the main cultivation (ploughing or flat-cut loosening) should be carried out to a depth of 25-30 cm. On gray podzolic and sod-podzolic soils, the depth of plowing should not exceed the depth of the plow layer, i.e. 20-22 cm.

Spring cultivation begins with the closing of moisture with heavy BZTS-1.0 tooth harrows. After that, the soil surface is leveled with levelers-planners to improve the thermal regime in the seed layer and accelerate the germination of weeds, as well as increase the effectiveness of basic herbicides. To level the soil surface, use a VP-8 trailed leveler, VPN-5,6 trailed harrow, ShB-2,5 harrow trail or KSHU-12, KSHP-8, USMK-5.4A cultivators.

In farms with a high level of agricultural culture, where an integrated weed control system is used, shallow tillage is carried out under the corn to a depth of 12-14 cm. In recent years, the soil-protecting, energy-saving technology of direct sowing of corn without tillage - "No-Till" has become widespread.

In fields covered with rhizome weeds, such as thistles (species), creeping heather, field birch, wild lettuce, Tatar lettuce, milk thistle, it is necessary to apply herbicides of general exterminating action in autumn: Roundup - 4.0-6.0 l/ha , Glyphosate – 4.0-5.0 l/ha, Glyphos Super – 1.6-3.2 l/ha, Hurricane – 3.0-6.0 l/ha.

Pre-sowing soil preparation involves early spring harrowing in order to seal moisture and level the soil surface. The latter is carried out with the onset of physical maturity of the soil with trail harrows or levelers at an angle of 450 to the main cultivation. If the fields are heavily littered, it is advisable to carry out 1-2 pre-sowing cultivations. The first cultivation is carried out after the emergence of weed seedlings to a depth of 10-12 cm. The second wave of sprouted weeds is destroyed with the help of combined units such as RVK-3,6, Europak, KOMBI-8,8, BP-8 and others. Processing is carried out to the depth of seed wrapping. The time gap between pre-sowing treatment and sowing should be as small as possible. Soil herbicides are applied before or immediately after sowing.

With high potential clogging of crops with one-year cereal and dicotyledonous weeds, it is advisable to apply soil herbicides: Dual Gold 960 EC, k.e. (1.0-1.3 l/ha), Trophy 90, k.e. (2.0-2.5 l/ha), Typhoon, k.e. (1.6-2.1 l/ha), Frontier Optima, k.e. (0.8-1.4 l/ha), Harness, k.e. (1.5-3.0 l/ha), Herb 900, k.e. (1.5-3.0 l/ha), Gezagard 500 FW, k.c. (2-4 kg/ha), Primekstra Gold 720 SC, k.s. (2.5-3.5 l/ha), Merlin 750, v.g. (0.1-0.15 kg/ha), Stomp 130, k.e. (3-6 l/ha) and other recommended preparations, which must be applied during pre-sowing cultivation or immediately after sowing corn, but before the crop sprouts.

The corn fertilization system includes basic fertilization, seeding and top dressing. The largest amount of fertilizers is applied to sowing in the main fertilizers. With intensive technology and corn cultivation in conditions of minimal tillage, the entire rate of fertilizers is often applied to sowing, making fertilizers at different depths.

Fertilizers are mainly effective mineral and organic fertilizers. Organic matter is applied in autumn under the deepest processing 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 turf-podzolic and podzolic soils of Polissia. On poor soils, when high doses of organic fertilizers are applied, corn better tolerates a drop in temperature at the beginning of the growing season, grows and develops well, and the gap in time between the flowering of panicles and buds decreases.In Polissia, organic fertilizers can also be applied in the spring during plowing of the sedge. When growing corn outside crop rotations on podzolic and podzolic soils, organic fertilizer rates are increased by 1.5-2 times. In these conditions, there is an effective green fertilizer.

The average rates of mineral fertilizers on sod-podzolic and gray forest soils are $N_{90–130}P_{80–90}K_{60–120}$, in the forest-steppe on gray forest soils, podzolized, leached, typical chernozems – $N_{90–120}P_{60}K_{60}$, in steppe areas on ordinary, carbonate and southern black soils, and also on chestnut soils – $N_{30–60}P_{30–60}K_{30}$, on irrigated lands of the Steppe – $N_{120–150}P_{60–90}$. Under conditions of insufficient moisture, it is better to apply fertilizers for the main fertilizer in the fall, and in areas with sufficient moisture and on soils of light mechanical composition, phosphorus and potassium fertilizers for tillage, and nitrogen fertilizers for cultivation in the spring.

In order to improve the nutrition of young plants, increase resistance to adverse conditions, strengthen rooting, post-sowing local fertilizer is used. At the same time, fertilizers are applied at the same time as sowing with seed drills at a distance of 3-5 cm from the side of the row and 4-5 cm below the depth of seed wrapping. Row fertilization increases productivity by 2-4 t/ha. Phosphorous fertilizers (50-60 kg/ha of granulated superphosphate) are used on the black soils of the Steppe, in the forest-steppe and Polissia, it is advisable to apply mineral fertilizer in the form of nitrophoska at the rate of N10-15 kg/ha of phosphorus.

Fertilization is carried out during the growing season of corn. The optimal periods of feeding fall on the period from the 3rd to the 6th leaf and during the most intensive growth - before shedding and during the shedding of panicles.

In conditions of an unstable moisture, the traditional fertilization of corn in the initial phases of the growth with mineral nitrogen fertilizers (N_{20}) is often not effective, therefore it is more appropriate to replace it with a more technological foliar fertilization of the plants in the phase of 6-7 leaves with liquid complex mineral macro- and microfertilizers "Reacom Plus" at a dose of 4 l/ha or with water-soluble microfertilizers "Nutrivant Plus corn" at a dose of 4 kg/ha, which ensures an increase in grain yield by 7-10%.

A significant reserve for increasing yield with improvement of quality indicators of grain products is the use of growth regulators in the phase of 9-10 leaves, namely: Humisol (8-10 l/ha), Emistym C (15-20 ml/t) and others. They help to improve the growth and development of plants and increase their resistance against environmental stress factors, which contributes to an increase in yield by 10–15%.

*Sowing.*The system of seed preparation for sowing includes: drying to a moisture content of 13-14%, inlaying, application of growth regulators, etching.

Seed inlay – is the application of a solution of a polymer film-former, which includes biologically active substances, to their shell. The solution of the latter is partially absorbed by the seed, and the rest penetrates into the cracks and protects it from pests and diseases. The polymer film begins to swell, allowing water and air to reach the seeds, when the soil temperature at the depth of seed wrapping will be +8...100C.

To protect the seeds during the germination period from mold, root and stem rot, bubbly and volatile soot, it is mandatory to treat and inlay the seeds with the addition of trace elements and growth regulators to the working solution - Alios, etc. (1-2 l/t), Vitavax 200 FF v.s.k. (2.5-3.0 l/t), Granivite, V.S.K. (2.5-3.0 l/t), Corriolis, t.k.s. (0.2 l/t), Lamardor 400, t.k.s. (0.2 l/t); in the absence of volatile carbon black - Fluosan, t.k.s. (3.0 l/t) and 10 l of water; Maxim 035, t.k.s. (1.0 l/t) and 5 l of water. In case of a lack of trace elements, the seeds are treated with zinc, manganese, and molybdenum salts at 0.5-0.6 kg/t with the addition of film-forming agent Na, KMC - 0.2 kg/t or PVA - 0.5 kg/t.

In order to fight against soil pests (larvae of weevils, blackworms, and caterpillars), seed treatment with insecticides using the incrustation method is effective. At seed factories, corn seeds are treated with Cosmos 250, t.c.s. (4 l/t); Cruiser 350 FS, t.k.s. (6-9 l/t); Semaphore, t.k.s. (2-2.5 l/t) with the addition of 10 l of water per 1 ton of seeds.

According to the generalized data of scientific research institutions of corn sowing zones, the optimal term for sowing corn is a steady warming of the soil up to +8...10°C at the depth of seed wrapping. Both too early and too late sowing times reduce crop yield. Experimental studies show that at early (stable warming of the soil up to +6...8°C) periods of sowing in corn plants, the flowering of panicles occurs earlier than at late periods. Early sowing makes more rational use of soil moisture reserves and avoids the negative impact of droughts during the growing season.

Corn for grain and silage is sown in a wide-row dotted method with a row width of 70 cm. The rate of sowing corn for grain is 15-25 kg/ha (1 sowing unit - 80 thousand units), for silage 30-40 kg/ha, for green fodder it is advisable to sow corn in wide rows with a row spacing of 45 cm and a seeding rate of 50-60 kg/ha, which ensures a stem density before harvesting of 200-250 thousand plants/ha. For sowing, seed drills "Kinze" are used (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 corn seed wrapping depends significantly on the physical properties of the soil, its humidity and temperature regime. The optimal depth of wrapping corn seeds when sowing on heavy loamy soils is 4-5 cm, on light loamy soils - 5-6, on black soil - 5-7, and on sandy soils - 6-8 cm. When the top layer dries out, the depth of seed wrapping is increased by 1- 2 cm.

The correct choice of plant density makes it possible to increase the productivity of corn by 20–30%. The optimal density of plants, depending on soil and climatic conditions and biotypes of hybrids, ranges from 40 to 80 thousand/ha. For early-ripening hybrids, the density of plant stands can increase to 90-100 thousand/ha (Table 7).

Table 7 – Optimum pre-harvest stand density of corn hybrids, thousand/ha

Zone	Early-ripening	Mid-early ripening	Medium-ripening	Mid-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
Polissia	85–90	–	–	–

When placing corn after the best predecessors and a good moisture supply, you should focus on the upper limit of density, and after the worst ones and in conditions of insufficient moisture - on the lower one.

Crop care. Under arid conditions, after sowing, it is advisable to roll the field with ring-spur rollers, which will ensure better contact of the seeds with the soil and contribute to the rise of soil moisture through capillaries into the upper layers of the soil.

It is not recommended to carry out pre- and post-emergence harrowing in fields where soil herbicides were applied. Since the protective "screen" is destroyed and the effectiveness of herbicide application decreases to 30-35%.

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, in the phase of 5-7 leaves of corn, insurance herbicides are used: Milagro 040 SC, k.s. (1.0-1.25 l/ha), Titus 25, v.g. (40-50 g/ha), Basis, 75%, v.g. (20-25 g/ha + 200 ml/ha PAR Trend 9), Myster, v.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 Metolate (1.0-1.25 l/ha).

Inter-row cultivation of the soil regulates its water-physical properties and destroys weeds. The first inter-row processing of corn crops is carried out in the phase of 5-7 leaves, the second - in the phase of 9-10 leaves. If the volumetric mass of the soil (1.2 g/cm3) corresponds to the biology of the crop and the number of weeds does not exceed the EPSH, it is not advisable to carry out inter-row cultivation.

In the event that more than 18% of the corn plants are colonized by the caterpillars of the stem-corn moth, to achieve their number, it is necessary to spray the crops with Denis-f-Lux, k.e. – 0.4-0.7 l/ha; Karate Zeon 050, m.k.s. (0.2 l/ha), Regent 20, g (5-10 kg/ha), Kaizo, v.g. (0.2 kg/ha).

In the phase of throwing out panicles against the corn butterfly, the fire-shaped form of the trichogram is released in two periods: at the beginning and during the period of mass laying of eggs by the pest.

Harvesting. The yield of corn for green fodder and the quality of the green mass depend on the time of harvesting. At relatively early harvest times (in the phase of 11-13 leaves), 80-90% of the harvest falls on leaves and 10-20% - on stems. The share of leaves in the green mass decreases to 40-50% in the phase of cob formation, to 10-20% in the milk ripeness of the grain. Therefore, when using corn for green fodder, it is advisable to collect it in the flowering phase of panicles - the share of leaves is 60-70% and 30-40% of the stem. The height of the stem cut should be no more than 8-10 cm.

In the phase of milky-wax grain ripeness, when the moisture content of the green mass does not exceed 65-70%, and the dry matter content is 25-30% - corn is harvested for silos with KS combines - 2.6; KSK - 100, Maral, Jaguar. The crushed mass is ensiled with subsequent tamping in trenches and covered with a film or straw. Silage humidity should not exceed 75%.

Depending on the direction of use and storage conditions, corn grain is collected without threshing the cobs or with threshing them in the field. Harvesting of crops without threshing of cobs is started when the moisture content of the grain is no more than 40%, and with threshing - at 30%.

1.5.2 Millet *(Panicum)*

The homeland of millet is 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 grain is used to make groats (millet) and animal feed, particularly poultry. 100 kg of grain contains 96 fodder units, 8.4 kg of digestible protein. Green mass, chaff and straw are good fodder for cattle and sheep. Millet grain is an indispensable feed for chickens, feeding it to adult chickens increases egg production and egg shell strength.Millet grain contains a lot of protein (10-14%), starch (70-74%), little fiber, and also contains manganese and zinc. In terms of starch content, millet is not inferior to other cereals, and it contains more protein than rice, pearl barley and buckwheat groats, and in terms of fat content, it is inferior only to oat.In veterinary practice, thanks to the content of lipotropic substances, millet lowers the level of cholesterol in the blood of animals and is therefore used in diseases of the cardiovascular system and liver. Under its influence, hematopoiesis accelerates, which is important in the treatment of anemia. It is believed that a decoction of millet husks helps to remove excrement. Green mass has fodder value, millet straw and chaff exceed wheat and oat in terms of fodder qualities, and come close to hay. It has been observed: the taste and nutritional value of milk improves in cows whose diet includes millet straw.

Now, millet occupies more than 40 million hectares in global crop production. Millet is widely grown in India (14 million hectares), Nigeria (5.5 million hectares), Sudan (3.0 million hectares) and China (2.1 million hectares). Millet production in the world is 29 million tons, of which 10.5 million tons are harvested in India, 5.9 million tons in Nigeria, and 4.0 million tons in China.

In Ukraine, about 160,000 hectares are under millet crops, which are mainly concentrated in the forest-steppe and steppe. The average yield is about 2.0 t/ha, and advanced farms harvest 4.5–5.0 t/ha.

Biological features, varieties. In the ontogenesis of millet, the following phenological phases are distinguished: seed germination, sprouting, tillering, emergence into the tube, throwing out panicles, flowering, formation, pouring and ripening of grain.

Millet seedlings appear 7-9 days after sowing. Bushing begins 15-20 days after the emergence of seedlings and lasts 10-15 days. Ejection of panicles occurs 40-45 days after the emergence of seedlings. After 3-5 days, flowering begins, which lasts 13-18 days within the panicle, and 30-35 days within the field. From flowering to economic maturity, 25-30 days pass. The period of maturation of millet in different parts of the panicle is 13-18 days. The vegetation period of early-maturing varieties is 60-80 days, late-maturing varieties - 100-120 days. By the time the grain of straw reaches maturity, it is wet and partially green.

*Relation to temperature.*Millet is a heat-loving 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 vernalization stage occurs at a temperature of +18...20°C for 7–10 days. Millet is demanding on the temperature regime during the growing season. During the period of seedling-shooting, it grows best at a temperature of +18°C, shoot-shooting of panicles +20°C, shooting of panicles-flowering +23°C, flowering-reaching +21°C. As a drought-resistant crop, millet is better than bread of the first group, tolerates temperatures of +30...40°C.

Moisture requirements. An important feature of millet is its drought resistance and economical use of water. Only 25% of the water from the weight of the seed is used for germination. The drought resistance of millet is determined by the ability to temporarily stop growth, curl the leaves, which reduces the evaporation of moisture. Millet is able to form nodal roots with minimal soil moisture. It makes good use of the precipitation of 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% RH. The critical period in relation to moisture begins 20 days before the panicle is thrown out and lasts until the end of flowering. A lack of moisture during this period causes flower sterility.

*Light requirements.*Millet is a light-loving plant with a short day.

When placing the rows from north to south, the lighting conditions improve, as a result of which the yield increases by 6-8%. Gloomy weather in the second half of the growing season suppresses growth processes and lengthens the growing season. In the northern regions, vegetation is longer than in the southern regions.

Soil requirements. Due to the low assimilative capacity of the root system, millet grows well on fertile soils with sufficient reserves of readily available nutrients. Structural black soils, chestnut, dark gray podzolized soils with a high content of readily available nutrients and a pH of 5.5-7.5 are best for it. Sandy, swampy and saline soils are unsuitable for millet. Millet tolerates soil salinity better than other crops.

Millet removes 30 kg of nitrogen, 14 kg of phosphorus, 35 kg of potassium, and 10 kg of calcium from the soil per 1 ton of produced grain.

Millet is a precocious, drought- and heat-resistant crop, suitable for cultivation in arid regions and on saline soils. An exceptionally valuable biological feature of millet is the ability to provide good harvests at late sowing times, which allows it to be used as an insurance crop for reseeding winter and spring crops, as well as for post-harvest and post-harvest crops. The disadvantages of millet are slow development at the beginning of life, in connection with this, weak resistance to weeds, as well as easy shedding of grain.

According to the duration of the vegetation period, varieties are divided into early ripening (50-60 days), medium early (60-80), medium ripening (80-100), late ripening (100-120), very late ripening (more than 120 days).

The best varieties are considered to be adapted to the soil and climatic conditions of the growing area, resistant to lodging, diseases and shedding of grain, highly productive, with good technological indicators.

The "Register of plant varieties suitable for distribution in Ukraine" includes 20 varieties of millet, in particular Veselpodilske 16, Kyivske 87, Kyivske 96, Myronivske 51, Kharkivske 31, Slobozhanske, Omriyane, Konstantinivske, Zolushka, as well as new varieties: Vitrylo, Kozatske, Jubilee

Cultivation technology. *Predecessors.* Millet is very demanding of its predecessors, because it grows slowly before tillering and is suppressed by weeds. The best predecessors for it are a layer of perennial grasses, a layer turnover after winter cereals, legumes, potatoes, and beets. Millet grows poorly after Sudan grass, barley, sunflower, sorghum, millet and corn in the area of the corn moth.

Tillage. The main task of preparing the soil for millet is to clean the top layer of weeds by provoking the seeds to germinate in the spring. This is achieved by semi-steam or improved tillage.

After grain and leguminous crops, it is necessary to begin the cultivation by peeling the stubble to a depth of 6-8 cm, which helps to preserve moisture. Fields covered with perennial weeds should be plowed with heavy harrows to a depth of 6-8 cm, a second time after 10-15 days - to a depth of 10-12 cm.

If millet is placed after perennial grasses, after harvesting, the field is disked in order to grind the post-harvest residues and their better prioritization.

Spring cultivation for millet begins with loosening the soil with harrows or cultivators diagonally or across the field. To actively provoke the germination of weed seeds and preserve moisture in the seed layer after the first and subsequent spring loosening, the soil should be rolled with ring-spur rollers. At the same time, the agrophysical properties and water and air conditions of the soil improve.

It should be noted that the number of cultivations in the spring period, including pre-sowing, should not exceed three.

Pre-sowing soil cultivation for millet is carried out with combined tillage units that create a fine-grained structure and compact the seed bed.

Fertilization. With a yield of 4.0 t/ha of grain and the corresponding amount of straw, millet takes 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, it is recommended to apply half-rotted manure under the main tillage: in the Steppe - 12-15 t/ha, in the Forest-Steppe - 18-20, in Polissia - 25-30 t/ha. If there is no half-rotted manure, it is advisable to sow millet after the fertilized predecessor. In the Steppe, mineral fertilizers are more effective than organic fertilizers.

Mineral fertilizers are applied at the rate of 45-60 kg/ha of active substance. In the forest-steppe, the effect of organic and mineral fertilizers is almost the same. In Polissia, complete mineral fertilizer is applied at the rate of $N_{80}P_{60}K_{90}$, and in the Forest Steppe - $N_{45}P_{60}K_{45}$.

*Sowing.*For sowing, seeds with a purity of not less than 98% and a germination rate of more than 92% are used. There should be no more than 75 weeds in it. per 1 kg, fallen seeds - 7%.

Against sooty and other pathogens, it is necessary to pretreat with incrustation of seeds (2-3 weeks before sowing). Aqueous solutions of NaKMC adhesives (2.5%) and polyvinyl alcohol - PVA (5.0%) are used as film formers, to which Vitavax stain remover is added at the rate of 1.5-2.0 kg/t of seeds. 10 liters of working solution are used per ton of seeds.

Millet is sown when the soil temperature at the depth of seed wrapping is +13...15^{0}C, which in the southern and eastern part of the Forest Steppe occurs in the 3rd decade of April - 1st decade of May, in the northern and central part - in the 2nd - 3rd decade of May. On clogged fields, it is sown 7-10 days later, using this period for additional cultivation.

Millet seeds have low field germination: 50–55% in Polissia, 55–65% in Forest Steppe, and 75% in Steppe. This should be taken into account when calculating seed sowing rates under appropriate conditions. The optimal rate of sowing millet using the row sowing method is 4.0–4.5 million/ha of similar seeds. With the wide-row method of sowing, the norm is reduced by 25%, and with the strip method - by 10-15%. It is recommended to increase the seeding rate by 7–10% due to the lack of moisture in the soil, as well as for post-emergence harrowing.

The method of sowing depends on the fertility of the soil, its predecessor, and the weediness of the field. On fertile soils, after the best predecessors, under the conditions of sufficient soil moisture and weed-free fields, the usual row method of sowing is used. When there is a lack of moisture, on weedy fields, preference is given to wide-row sowing according to the scheme of 45+15 cm, and in the Steppe - 60+15 cm.

On heavy soils, if there is moisture in the upper layer, millet seeds are wrapped to a depth of 2–3 cm. On soils that are light in terms of granulometric composition, or if the upper layer is overdried, the depth of seed wrapping is increased to 5–6 cm.

Crop care. To improve the conditions for the germination of millet seeds and weeds, after sowing, the soil is rolled with ring-shaped or smooth water-filled rollers 3 KVH-1.4. Do not roll crops on heavy soils and with high soil moisture.

Weed protection on millet crops should be carried out in an integrated way, combining agrotechnical and chemical methods.

Crop care begins with pre-emergence (3–4 days after sowing) harrowing with medium toothed harrows across or diagonally to the sowing direction. The speed of movement of the unit is 5–6 km/h. In the case of the appearance of a significant number of weed seedlings, when plants are rooted in row crops, harrowing is repeated. On wide-row and strip crops, inter-row loosening is carried out. The first time, the inter-rows are loosened after the appearance of three real leaves of millet to a depth of 4–5 cm.

During the growing season, Agritox should be used against annual dicotyledonous weeds. (0.7–1.7 kg/ha) before exiting the tube, Bazagran, v.r. (2.0–4.0 kg/ha) in the phase of 3 leaves. In addition to the above, herbicides Granstar 75, v.g. are also effective on millet. (15–20 g/ha), Primekstra Gold 720 SS, k.s. (2.5–3.5 kg/ha), Lontrel 300, v.r. (0.16–0.60 kg/ha), which should be applied no later than the tillering phase. Millet is least sensitive to the action of herbicides in the period from the emergence of seedlings to the end of tillering.

In the phase of throwing out panicles, millet crops are examined in order to detect the intensity of the flight of the millet mosquito. If a threat is detected, the edge strips (50–100 m), and if necessary, the entire field, should be treated with a new Bi-58, k.e. (0.7–1.0 l/ha).

Fertilizing crops improves plant nutrition conditions and, as a result, ensures an increase in millet yield. The first fertilization 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 added to the main fertilizer, in the same amount at the VII and IX stages of organogenesis.

Harvesting.Millet is characterized by an uneven and long ripening period. The harvest begins when the panicles reach 75% of the grain. The main method of collection is separate. So that the grain does not get crushed in the swaths during mowing, rubberized pads are attached to the reel and its installation height is adjusted. The swaths are picked up with grain harvesters on the 3rd–5th day after mowing. New combine harvesters should not be used for threshing millet, because undeveloped threshing machines collapse the grain. Millet is threshed twice on seed plots: the first time with a drum rotation frequency of 500–600 min. and the removed bottom of the tiller.

Under these conditions, 70–75% of the grain is threshed and the films are minimally collapsed. Such grain is used for seeds. On the same day or the next day, the grain is threshed, increasing the frequency of rotation of the drum a second time. Grain after the second threshing is used as food or fodder.

Sometimes millet is harvested by direct harvesting. When harvesting millet, special attention should be paid to the sealing of channels through which grain losses are possible. Immediately after threshing, the grain must be thoroughly cleaned of impurities and dried. Store cleaned grain with a moisture content of no more than 15%. The drier the grain, the longer and better it preserves not only its seeds, but also its food and consumer qualities.

1.5.3 Sorghum*(Sorghum)*

One of the most ancient cultures of world agriculture. The center of origin of sorghum is Africa, where it is an important food crop. It has been known since Neolithic times - 3000 BC. in India, China, Egypt and in 2500 BC. e - in Central Asia. In Russia, it began to be grown in the 17th century, in Ukraine - at the end of the 19th century. In Europe, the first memories of sorghum come from Pliny the Elder (23–79), who says that this crop was brought to Rome from India.

Sorghum is a widely used crop. In terms of nutrition, it is close to corn. Its grain is a valuable concentrated feed and raw material for compound feed, starch-molasses and alcohol industry. In many countries of Africa, India and East Asia, it is an important bread plant, in temperate latitudes it is a forage plant.

Sorghum grain contains an average of 70% starch, 12–15% protein, 3.5% fat. 100 kg of grain contains 119 feed units, about 15% protein, a lot of lysine. The grain of sorghum is small and very hard, which should be taken into account when grinding, since part of it remains unground on ordinary crushers and is poorly digested by animals.

Due to the unique combination of carbohydrates in the grain, its grain is widely used as a raw material for the production of food products in the form of cereals, flour, as well as liquid sugar and an alternative energy carrier - ethanol.

The green mass of sugar sorghum is fed to cattle and used to make silage, which is inferior to corn silage in terms of fodder quality. Therefore, grain and sugar sorghum are widely grown in many countries, which in arid conditions are 25–30% more productive than corn. Unlike other drought-resistant crops grown for grain, in remontant sorghum hybrids, the stems and leaves remain green and juicy at the time of harvesting, they can be used for ensiling and for green fodder. When feeding a crop of sorghum harvested from 1 ha, the yield of pork is 100–200 kg higher than when using corn.

Sorghum grain is processed into ethyl alcohol as an additive to gasoline (bioethanol). 330 liters of ethanol can be obtained from 1 ton of sorghum grain.

Sorghum is grown in 85 countries, mainly in arid regions, where it out-yields other forage crops, including barley, corn and oats.

In terms of global production, sorghum is the second only to wheat, corn, rice and barley. According to the forecasts of the US Department of Agriculture (USDA), sorghum production is estimated at 65.2 million tons. Sorghum crops are concentrated in Asia, Africa, and South America, with a few in Europe. The largest areas of grain sorghum are in India, significant - in the USA, Nigeria, Sudan, Mexico. In the countries of North America, it is produced 21.1 million tons, in Asia - 18.6, in Africa - 15.8, in Oceania and Australia - 0.9, in Europe - 0.61 million tons. The first place in terms of its production among countries belongs to the USA, the second - India, the third - China.

In Ukraine, sorghum is sown on an area of about 100,000 hectares. In the acutely arid region, which includes the Autonomous Republic of Crimea, Kherson, Odesa, Zaporizhzhya, Donetsk, Luhansk, Mykolaiv, Dnipropetrovsk and some other regions, sorghum has great prospects and can stabilize grain and fodder resources. Sorghum is characterized by stable productivity in harsh soil and climatic conditions (the coefficient of yield plasticity is half that of barley). According to the state variety testing stations of the Kherson, Mykolaiv, and Odesa regions, sorghum yields are 19–58% greater than corn yields under rainfed conditions and by 14–15% under irrigation. According to the forecasts, sorghum crops (grain sorghum, sugar sorghum, wine sorghum, sorghum-Sudanese hybrid) can occupy an area of 1.7 million hectares.

Biological features, varieties. Temperature requirements. Sorghum is the most heat-loving crop among cereals. Sorghum seeds begin to germinate at the temperature of +12...13°C, the optimum temperature is +25...30°C. Seedlings cannot withstand temperature drops below 0^0C.

In terms of heat resistance, it surpasses all bread grains, it is not damaged by high temperatures of +40°C or more. The sum of active temperatures for the completion of vegetation is 2250–2500°C.

Moisture requirements. Sorghum is the most drought-resistant crop. The transpiration coefficient is 180–200. Water consumption by sorghum plants occurs unevenly: they use a large part of it in a relatively short period of time - 10 days before the start of panicle shedding and 10 days after flowering. This period is usually 25–30 days, that is, 20–25% of the entire vegetation period, and moisture consumption reaches 45–50% of the total water consumption.

Economical consumption of moisture and a well-developed root system, adaptability of sorghum plant tissues to hot and arid conditions determine its high drought resistance and significance when growing in the steppe area.

However, sorghum, despite its high drought resistance, reacts significantly to moisture conditions and provides significant yield increases when irrigated.

Light requirements. Day length, intensity and composition of sunlight are important environmental factors for sorghum. This is an exclusively light-loving short-day culture. The steppe area of Ukraine is a fairly favourable region for meeting the needs of sorghum in the light factor.

Soil requirements. Sorghum is undemanding to soils. It grows well on different types - light sandy and heavy clay. Fertile loamy and light black soils are most suitable. Sorghum should not be placed on waterlogged, cold soils with high groundwater levels.

Unlike other crops, sorghum tolerates saline soils well. It can withstand a concentration of soluble salts 1.5 times higher than corn. Based on this, sorghum can be placed as the first crop when developing saline soils. Contributes to the reduction of salinity, since a significant amount of sodium, chlorine and magnesium is removed with the crop.

Varieties and hybrids of sorghum are divided into three groups: grain - with open, easily milked grain (Kraevyd, Vinets, Anna, Slavyanske 210, Sprint 2, Maxim, Keiras, Donetske 8, Henicheske 209, Dniprovsky 39, Kovcheg, Skif, Hudok , Lan 59); sugar - with semi-open grain and up to 15% sugar content in the stalks (Agrarny 5, Krymske 15, Silosne 42, Favorite, Medovy, Troisty, Dovista); flagellates, which have a membranous grain and panicle branches up to 40–90 cm long (Fermerske, Tavriyske 1, Tavriyske 2, Lyubime 80, Raivske, Karlykove 45, etc.).

In production, we also use varieties of grassy sorghum or Sudanese grass, which are grown for green fodder, hay and silage (Golubkivska 25, Donetska 5, Dniprovska 54, Luhanska 3, Myronivska 36, Myronivska 10, Fioleta), sorghum-sudanese hybrids (Yuvileyn 75, Jubilee 50, Slavic Field 15, Socratom 87, Pochyn 11).

Cultivation technology.*Predecessors.*The best predecessors of sorghum are crops that leave behind fields free of weeds - cereal grains, legumes and row crops. Do not sow sorghum after millet, sudan grass.

When sorghum is returned to the same field after 2 years, the soil is almost completely cleared of pathogens of soot and rot, the number of corn moths is significantly reduced. Sowing sorghum no earlier than three years later in a layer of perennial grasses removes the risk of seedling thinning by wireworms and false wireworms.

Tillage. Considering the arid climate of the region where sorghum crops are grown, all tillage measures are aimed at preserving moisture.

Cultivation of the soil for sorghum, when it is placed after winter or spring ear crops, begins with peeling the stubble after harvesting the predecessor, to a depth of 6–8 cm. For a significant number of perennial weeds, when the rosettes appear, a second peeling is carried out to a depth of 10–12 cm. 10–15 days after peeling, plowing is carried out to a depth of 25–27 cm. In the case of using herbicides (Roundup or its analogues), plowing begins 15–20 days after the application of the herbicide.

In order to preserve and accumulate reserves of productive moisture in the soil, the plowing must be leveled in the fall. Unleveled frost both in the autumn-winter period and in the spring, before the physical maturity of the soil, loses a significant amount of moisture in the seed layer (0–10 cm).

Pre-sowing tillage includes early spring closing of moisture with heavy tooth harrows in one or two tracks across or diagonally to plowing. In the fields, where the main cultivation was carried out in the fall with shelfless tools, for harrowing in the spring, it is necessary to use the BIG-3A or BMSh-15 needle harrows in an active state. If the field is clean of weeds, then one pre-sowing cultivation to a depth of 5–6 cm is sufficient. In case of significant weeding, 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, rolling the soil with ring-spur rollers after the first cultivation is an effective measure, which helps to increase the temperature and humidity of the upper soil layer, intensive germination of weeds, which are then destroyed by pre-sowing cultivation.

*Fertilization.*Undemanding to the soil, sorghum is very sensitive to fertilizers 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 from 1 ha.

Sorghum is very sensitive to organic fertilizers, especially in combination with mineral fertilizers. As research has shown, when 10–20 tons of manure are applied in fall under plowing and $N_{10}P_{10}$ in spring during sowing, the increase in sorghum grain yield was 0.4 t/ha, and in some years up to 1 t/ha. In general, fertilizers not only increase yield, but also improve quality.

During sowing, nitrogen and phosphorus fertilizers ($N_{10}P_{10}$) are applied to the rows. A one-time application of a full dose of fertilizers in the spring before sowing or post-sowing application of phosphoric or complex fertilizers at 10 kg/ha per year is also effective. In irrigation conditions, $N_{90}P_{90}K_{90}$ is applied due to higher crop productivity. Potash fertilizers are not applied to saline soils.

It should be remembered that the spring application of mineral fertilizers is less effective due to the rapid drying of the top layer of the soil.

*Sowing.*Pre-sowing seed preparation is an important and responsible element of sorghum cultivation technology. The seeds of sorghum in grain varieties and hybrids are whole grain or semi-membranous, in sugar - membranous and semi-membranous. The seeds are colored in different colors and shades. The colored shells of sorghum grain usually contain the glucoside tannin. The presence of tannin in the grain of this crop 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 unfavorable conditions for seed germination, tannin prevents it from becoming moldy and helps increase field germination.

Preparation of sorghum for sowing must necessarily include heating the seeds for 4-5 days in the sun, which increases the energy of germination and germination by 6-10%. A mandatory measure is seed treatment against pathogenic microflora and soil pests, especially bare-grain varieties and hybrids that do not contain tannin in the shell. Fungicides Vitavax 200 FF, v.s.c. (2.5–3.0 l/t), Maxim XL 035 FS, t.s.c. (5.0 l/t). To protect seedlings from wireworms and false wireworms (when the number is more than 3–5 individuals per 1 m2), aphids and other pests of seedlings, at the same time as spraying with fungicides, the seeds are treated with the insecticide Kruiser 350 RS, t.c.s. (4.0 l/t).

Weeds reduce sorghum yield by 20–35%. It is known that sorghum plants in the initial period of growth have an increased sensitivity to herbicides. When using soil herbicides Primekstra gold 720 SC or Dual gold 960 EC, the sensitivity of plants to them is reduced by mandatory seed treatment before sowing seeds with the antidote Concept III 960 EC, k.e. (0.3 l/t).

Sowing of sorghum is started when the soil at a depth of 10 cm is constantly warmed up to +10...12°C. Membranous varieties and hybrids are better able to withstand a drop in soil temperature and can be sown 3-4 days earlier than bare grains. The depth of wrapping sorghum seeds is 4–5 cm. When the seed layer of the soil dries, the wrapping depth is increased by 2 cm.

The method of sowing is dotted wide rows with rows 45–70 cm apart. In the southern Steppe, the density of standing grain 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 fertilizers, it can be increased to 160–200 thousand/ha. Sowing rate by seed weight is 15–20 kg/ha. It should be noted that excessive thickening of crops is worse than moderate thinning, because sorghum is able to bush and to some extent compensate for thinning with stems. Excessive tillering leads to uneven ripening of panicles and an increase in grain moisture.

For green fodder, sorghum is sown in wide rows with rows 45 cm apart, with a seeding rate of 0.5–0.75 million/ha in the south, and 0.75–1.0 million/ha of similar 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 with ring-toothed rollers. Due to slow growth in the initial period, sorghum is suppressed by weeds, which develop intensively at this time. Therefore, one of the first agrotechnical measures is harrowing crops with light tooth harrows 4–5 days before the appearance of seedlings, when sorghum sprouts are at a depth of 3–4 cm from the soil surface, and weed seedlings are destroyed by harrow teeth. If after sowing there are heavy rains and a soil crust is formed, which has a detrimental effect on obtaining simultaneous seedlings, it must be destroyed with harrows. When the sorghum sprouts are less than 1 cm from the soil surface, rolling is carried out in order to loosen the crust.

Since weed seedlings do not appear at the same time, it is advisable to harrow crops after the appearance of sorghum seedlings. Depending on the weediness and density of the crops, 1–2 harrowings are carried out: the first when the sorghum plants have 4–5, and the second – in the phase of 6–7 leaves. Plowing is best done in the afternoon, when plants are less damaged. Fairly effective harrowing with mesh and light harrows that reduce damage to sorghum plants.

On wide-row crops, after the rows are clearly defined, the soil is worked between the rows: the first time to a depth of 8–10 cm, the second time – to a depth of 6–8 cm with the use of the harrows.

In order to plan chemical measures to protect against weeds and determine the preparations for their destruction, an operational survey of crops for weediness is required. Herbicides should be used in fields where there are more than 20 annual weeds and more than 1 shoot of perennials per 1 m2 of sowing. Herbicides 2.4–D amine salt (0.9–1.7 l/ha) are applied to vegetative plants against dicotyledonous weeds, Luvaram 50% v.r.c. (1.2–1.6 l/ha), 60% of the annual (1.0–1.3 l/ha), Dialen (0.8–1.2 l/ha), Agritox v.r. 50% (0.7–1.7 l/ha), Peak 75WC yr. (15–20 g/ha), as well as new Ladok (2.5–3.0 l/ha). It is necessary to treat crops with these herbicides, except for the last one, in the phase from 3 to 5 leaves in sorghum. In later phases (6–8 leaves), the use of herbicides has a detrimental effect on sorghum plants. To enhance the effect of insurance herbicides, 5–8 kg/ha of ammonium nitrate is added to the solution.

Herbicides Banvel 4S 480 SL v.r.k. (0.15–0.2 l/ha), Dialen Super 464 SL v.r.k. (0.5–0.6 l/ha) must be applied in the phase from the third to the fifth leaf. Applying these herbicides in later periods and exceeding the recommended rates will lead to the effect of "sheaths". That is, when a strong twisting of the stem is noted, the sixth leaf cannot emerge from the fifth, which even leads to the tearing of sorghum tissues.

Herbicide Peak 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 greatest biological efficiency, especially for the control of field birch and thistle, it is necessary Peak 75 WG v.g. to be used together with Side Kick South Africa (0.25%). Particularly high efficiency of Peak herbicide is shown against the sunflower carrion, and it destroys not only the carrion, the seedlings of which appeared during spraying, but also the later sunflower seedlings, which cause problems when harvesting sorghum.

The best time to protect sorghum crops from aphids (common grain and sorghum) is the period from germination to the phase of 5–6 leaves in crops, when harmful organisms are on top of the leaves. Later, in the late stages of plant development, the aphid hides in the sheaths of the leaves and is much more difficult to detect. In addition, in this case, systemic insecticides are used against harmful objects.

During the period of mass appearance of the caterpillars of the corn moth and in the presence of more than 18-20% of plants with ovipositions of the pest, the crops are sprayed with one of the insecticides: Decis, 2.5% of (0.5–0.7 l/ha), Decis Forte, 12.5% k.e. (0.05–0.08 l/ha), Karate, 5% k.e. (0.2 l/ha), Karate Zeon, 5% k.e. (0.2 l/ha), Sherpa, 25 KE k.e. (0.32 l/ha).

The root system and stems of young sorghum plants are damaged by gnawing suckers. To prevent this, it is necessary to keep the crops clean from weeds. If caterpillars of scoops appeared on the crops, which at the beginning of their development settle and feed on weeds, they must be destroyed by spraying with insecticides.

It is necessary to remember that when planning chemical treatments, it is necessary to adhere to an anti-resistance strategy for the use of 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.*In order to avoid losses during harvesting, it is necessary to optimize the timing of harvesting, its timeliness and quality. The period of harvesting sorghum is determined by the direction of its use. Grain sorghum is harvested in the period of full maturity, when the seeds on the main mass of panicles have fully ripened and become hard. A morphological sign of full ripeness of grain sorghum is the yellowing of the stem at the base of the panicle. The spilling of sorghum grain in the field during ripening is not observed not only in sugar filmy varieties and hybrids, but also in grain - bare grain and semi-filmy. It is also worth taking into account the peculiarities of varieties and hybrids, which lose the elasticity of the stems when standing, and under the influence of winds they bend and can break. Such sorghum should be collected when it is ripe, without wasting time.

Sorghum grain when harvested by harvesters, as a rule, has increased moisture, so it should be immediately cleaned and dried. To reduce the moisture content in grain, desiccation of crops is used at the beginning of full grain maturity. On seed crops, when there is a threat of frost in the fall, it can be carried out in the phase of waxy grain maturity. Urea and ammonium nitrate are inferior in effectiveness to Reglon Super 150 SL v.r.c. (3 l/ha), especially in years when the weather is cold and rainy in autumn. The most effective desiccation in dry and warm weather.

In order to obtain high-quality raw materials for the intended purpose or silage, sorghum is harvested when the grain is waxy, during this period the yield of sorghum syrup is up to 60–65% of the leaf mass, and the sugar content is up to 12–15%.

For green fodder and hay, mixtures and single-species sorghum crops are harvested 7–10 days before the panicles are thrown out. When mowing is delayed, the fiber content in the vegetative mass of sorghum increases significantly, the quality of fodder significantly deteriorates, and the productivity of grass stands decreases.

The fresh green mass of sorghum and Sudan grass may contain poisonous cyanide compounds, so it should be fed after wilting (the cyanide compounds decompose).

1.5.4 European Madder*(Sorghum orizoideum)*

European Madder is a culture of universal use, in taste and chemical composition it is close to rice. Its cereal contains 11.1% protein, 0.17% lysine; 1.1% - crude fat and 88% starch. In polished rice, these indicators are, respectively: 9.11; 1.12 and 84.3%.

European Madder groats can be used for dietary and baby food and as a raw material for extruded products and concentrates. European Madder groats contain enough easily digestible carbohydrates, little fiber, which has a positive effect on the digestive glands and allows it to be used for baby food. The high presence of protein binds water during cooking, which extends the shelf life of ready-made dishes, which have a delicate consistency with a pleasant taste and smell. The value of groats lies in the fact that it contains tocopherol (vitamin E), which is able to remove radionuclides from the human body. Therefore, it is important to increase grain production, which will allow optimizing and stabilizing grain production in Ukraine.

European Madder has the ability to partially desalinate salt marshes. Considering that there are more than 1 million hectares of saline and saline soils in Ukraine in the southern and steppe areas, the cultivation of sorghum here is obvious.

European Madder is a young culture. Only 20 years have passed since the researches on the practical use of remote hybridization between grain sorghum and its wild relatives were launched with the aim of obtaining thin-stemmed forms of cereals. Selection from sorghum is carried out in two main directions: the first is the creation of new and better lines of grain sorghum for yellow grain and vitreous grain by repeated backcrossing and selection; the second is the creation of grass-type lines with a thin stem by crossing grain sorghum with Sudan grass and wild relatives. The created material is characterized by low growth, precociousness, thin stemness, which allows the synthesis of hybrids, including for growing in thickened crops on sloping lands in order to reduce soil erosion. Initial forms and hybrids of sorghum with glassy grain are allocated to the economic group of rice-grain sorghum (Sorghum oryzoidum) or European Madder.

The yield and gross harvest of grain vary significantly from year to year, depending on weather and climate conditions. In recent years, there has been an increase in temperatures, an increase in dry days and a decrease in precipitation. The average yield of wheat in the arid zone on non-irrigated lands over the past 10 years was 4.24 t/ha, corn grain – 2.83, spring barley – 2.09 t/ha.

Biological features, varieties.*Temperature requirements.* In terms of biological features, European Madder is close to grain sorghum. This is a heat-loving culture. The minimum temperature for seed germination is +10...12^{0}C, the optimal temperature is +25...30^{0}C. Seedlings are very sensitive to low temperatures and die already at -2^{0}C. The optimal temperature for flowering and pollination is +18...20^{0}C, and at the beginning of panicle shedding it can withstand temperatures of +45...50^{0}C, without reducing productivity.

It is characterized by high heat resistance. It tolerates a temporary increase in temperature up to +75^{0}C without significant damage, as it can fall into an anabiotic state and resume vital activity when water and thermal regimes are normalized.

Moisture requirements. Transpiration coefficient 150–200. For the formation of a unit of dry matter, 2.0–2.5 times less water is needed than corn, sunflower or spring barley. Uses moisture very economically.

Picky about moisture during the germination period, because the seed has a high hardness and glassy endosperm. The deep penetration of the root system and the high suction power make it possible to use moisture inaccessible to other crops, which allows you to tolerate long periods without rain.

The critical period for moisture supply is the interphase period between seedlings and tillering. The insufficient amount of water during this period cannot be fully compensated by subsequent hydration.

Soil requirements. European Madder is undemanding to soils. High productivity is noted both on heavy clay and light sandy soils. It can be grown on chernozems, chestnut soils and eroded slopes. Withstands the increased concentration of salts in the soil.

Soriz is a light-loving, cross-pollinated crop with a short day and a growing season of 90 to 120 days.

Varieties: Culinary purpose - Odessa 302; food concentrate use - Druzhny, Quartz, Salut; technical purpose - Titan.

Cultivation technology. *Predecessors.* In the crop rotation, European Madder is placed after grain crops, legumes, potatoes, and melon crops. It is not advisable to sow after sunflower, Sudan grass, sugar sorghum and vine sorghum in order to avoid carrion. Seed crops should be placed with spatial isolation of at least 500 meters from all other sorghum crops.

Tillage. The main and pre-sowing tillage for European Madder is the same as for grain sorghum and corn. The same soil herbicides (Dual Gold, Harness, etc.) are applied under it.

*Fertilization.*European Madder uses 23 kg of nitrogen, 10 kg of phosphorus, and 33 kg of potassium to form 1 ton of grain and the corresponding amount of above-ground mass. Complete mineral fertilizer at the rate of $N_{60}P_{60}K_{30}$ is applied, as a rule, under plowing. Unlike other crops, it is not recommended to add superphosphate or ammophos to the rows during sowing, as this can lead to a decrease in field germination and yield.

It is better to apply nitrogen fertilizers to soils that are light in terms of mechanical composition in the spring under cultivation. On soils with low fertility and, especially, on washed-out soils, manure is quite effective - up to 40 t/ha. European Madder also reacts well to the after-effect of manure.

Sowing. Although European Madder is not affected by soot, its grain, unlike sorghum, completely lacks tannins, which makes it vulnerable to soil-borne pathogens and pests. Therefore, it is necessary to sow soriz with poisoned seeds. Air-thermal or solar heating gives good results (field uniformity improves by 10–15%).

Sowing begins when the soil warms up at a depth of 10 cm to +12...14^{0}C. With earlier sowing, seedlings are weakened, plants grow slowly and are quickly suppressed by weeds. To obtain friendly seedlings, a leveled field and sowing in moist soil to a depth of 5–6 cm is required. It is better to sow in wide rows (70 cm) with a density, at the time of harvesting, for the south of the country of 70–75 thousand/ha, for the middle strip of 80–85 thousand/ha With narrowed rows (45 cm) and irrigated - 120–150 thousand/ha.

The direction of sowing should not coincide with the direction of plowing and pre-sowing cultivation, as this can lead to various depth wrapping of seeds and liquefied seedlings. Vegetable and combined seed drills are used for sowing. Sow 10–12 pcs. of seeds per linear meter of row (7–8 kg/ha), if sowing is delayed, the sowing rate is increased to 10 kg/ha.

Crop care. All crop care measures should be aimed at keeping the soil in a weed-free state. Post-sowing rolling is mandatory. Pre-emergence (when the length of seedlings is 0.5–0.8 cm) and, if necessary, post-emergence (in the phase of 4–5 leaves) harrowing are also used.

During the vegetation period, it is advisable to carry out inter-row loosening: the first - in the phase of 4-5 leaves of the soriza, the second - when the plants have a height of 25-30 cm by cultivators with harrows.

When weeds form 1–2 leaves, Loddock new herbicide (3 l/ha) is quite effective. Unlike the 2,4-D amine salt, it can be used at any stage of the development of ringworm.

In order to reduce damage by aphids and eliminate edge treatments with insecticides, European Madder crops can be sown with dry-stemmed sudanica, which is mowed for livestock feed before harvesting European Madder.

Harvesting. European Madder culture is remontant and is characterized by uneven ripening. In addition, at full technical ripeness of the grain, the stalks of European Madder remain juicy.

During separate harvesting, the plants are mowed into swaths already in the second decade of September, leaving a stubble 15 cm high capable of holding a relatively heavy swath. In 10–12 days, the grain matures intensively in the rolls, a full-fledged starch structure, vitrification and hardness are formed, and the stems and leaves are dried. The panicles are threshed at a grain moisture content of 18–20% and reduced drum rotations to 500–600 per minute.

European Madder are harvested by direct harvesting after desiccation in the phase of full grain ripeness. Cleaned European Madder grain with a moisture content of 14% is ready for long-term storage.

1.5.6 Rice *(Oryza)*

Rice is the main food crop in many countries of subtropical and tropical latitudes of the globe. Rice is one of the oldest, most common and most important high-yielding crops of the world's crop production. It is grown on all continents. It comes from areas of South and South Asia (eastern part of India, Indochina, southern part of China) and tropical Africa (top of Niger). Rice is cultivated in the northern regions of India, in the north of Indochina, and in southwestern China. Later, it spread to all 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 Earth's population, rice is the main food product, especially in densely populated areas of Asia with a monsoon climate, where up to 80% of it is in the diet. It is believed that there are more than 7,000 cultivated varieties of rice, of which more than 1,000 are in India alone.

Rice grain cleaned of films contains 14% moisture, 75.2% carbohydrates, 7–10% protein, 1.5–2.5% fat, within 12.5% fiber, 4.5–5% ash.

Due to its high nutritional value and assimilation, rice cereal is considered one of the best products for dietary nutrition. Rice grains are processed into flour, starch, powder, alcohol, etc. Good paper, very thin and strong (cigarette paper of the best grades) is obtained from rice straw, hats, woven decorative products, and baskets are made from it. Rice oil is used in the soap industry.

Rice is characterized by a relatively high calorie content: 100 g of its grain contains 360 calories (wheat – 330, corn – 348, sorghum – 332), up to 77.4% of nitrogen-free extractive substances, which is also more than in other grains. Rice protein has a relatively high content of essential amino acids, especially lysine, valine, methionine, it is more useful than the protein of other cereals. The digestibility and assimilation of rice starch and protein is 95.5%. In many Asian countries (zones of the tropics and subtropics), due to rice, each inhabitant receives a good half of the total number of calories per day. Rice consumption in countries with a temperate climate is 2–6 kg per person per year, tropical Latin America – 50–80 kg, Africa – 40–70 (up to 100 kg), Asia – 80–150 kg.

Rice mucilaginous decoctions obtained from rice and starch paste are used as anti-inflammatory for gastrointestinal diseases. Rice broth slows down peristalsis, which is important for dyspepsia. Rice bran is used for hypovitaminosis.

Rice grain is rich in starch, it is used to make groats and flour, but it is more often consumed in the form of whole grains, especially by the peoples of Asia. In China, for example, there is a distinction between the main food (zhuchi) prepared from its groats and flour, as well as sushi - dishes made from vegetables, fish, and meat.

Currently, the main rice crops are concentrated in Asian countries - 130 million hectares, or 88.8%, in South and North America - 6.2 million hectares (4.3%), Africa - 7.2 (4.9%) . The first place in the area of rice cultivation belongs to India, the second to China, the third to Indonesia.

By continent, rice grain production is concentrated as follows: Asia - 90.7%, South America - 3.3%, Africa - 3, North America - 2.0%, Europe - 0.4%. In three countries - China, India and Indonesia, a total of 64.1% of the world grain production of this crop is received.

In Ukraine, rice is grown in Odesa, Kherson, Mykolaiv regions and Crimea. Its total cultivated area in Ukraine is about 25,000 ha. In advanced farms, 6.5–9.0 t/ha of grain are harvested.

Biological features, varieties. In the ontogenesis of rice, the following phenological phases are distinguished: seed germination, seedling, tillering, emergence into the tube, throwing out the panicle, flowering, formation and pouring of grain, ripening.

*Temperature requirements.*Rice is a heat-loving culture. The minimum temperature for seed germination is +11...13°C. Seedlings appear at a water and soil temperature of +14...15°C. A drop in temperature to -1°C when seedlings appear can cause their death. During budding, the average daily temperature of water and soil should not be lower than +15...18°C, and during the flowering period +18...20°C. The optimal temperature for growth and development is +25...30°C. When the temperature drops to +11...12°C, plant growth stops.

Moisture requirements. According to some characteristics, rice occupies an intermediate position between water and land crops. However, most researchers attribute it to hygrophytic cultures.

The high need of rice in water is caused by the peculiarities of the root system, in particular, the insufficient number of root hairs and the low absorption power of roots and leaves. When germinating, seeds absorb only 25–28% of water by weight. The transpiration coefficient reaches 800–1000, but when grown in flooded conditions (under a layer of water) it significantly decreases and does not exceed 400–500.

After ringing, respiration intensifies, the need for oxygen for seeds increases, and in the absence of it in flooded soil, germinating seeds die. Therefore, after sowing in the period from swelling to seed germination (10–15 days), the field can be flooded with a layer of water of 5–10 cm for 5 days. After ringing and the formation of a 3–5 mm long coleoptile, the water from the checks should be removed. Seedlings appear without a layer of water.

During the tillering phase, during the formation of stem roots, crops are filled with a small layer of water (3–5 cm), since the tillering node is formed almost near the soil surface. During the emergence of the plants into the tube and throwing out the panicles, the rice's need for water is maximum. It can be flooded with a layer of water of 10–12 cm, and later increased to 15–20 cm. Plants should be covered with water for 1/3 of the height. A layer of water of 12–15 cm is kept until the stage of milk ripeness. With insufficient water, the ratio between photosynthesis and respiration is disturbed. At wax maturity, the checks are freed from water to dry the soil before harvesting.

Soil requirements. For the formation of 1 ton of grain (including straw), rice removes an average of 24 kg of nitrogen, 12 kg of phosphorus, and 30 kg of potassium from the soil. Cohesive heavy clay soils with a high content of organic matter are best for rice. It tolerates significant salinity and soil acidity well. The optimal pH is 5.0–6.5.

Rice is a self-pollinating plant, the anthers mature and crack even before the flower opens. However, cross-pollination is also possible, which in some cases reaches 7%. Under unfavorable conditions, part of the ovaries does not develop, the number of empty spikelets (cross grain) may exceed 30%.

The following varieties of rice are common in Ukraine: Dniprovsky, Danube, Zubets, Mutant 428, Perekat, Spalchyk, Slavutych, Slavyanets, Ukraine 96.

Cultivation technology.*Predecessors.* Rice is grown under periodic or permanent flooding. For this, special rice irrigation systems are being built. They are built on fields with leveled relief or a slope of no more than 0.003–0.005. The field where irrigation will be applied is divided by longitudinal shafts into irrigation maps with an area of 15–50 ha (700–1500 m by 150–200 m). An irrigation channel is laid along one long side of the map, and a diversion (discharge) channel is laid along the other. The maps are divided by transverse shafts 30–35 cm high and 20 cm wide from above into rectangular checks with an area of 5 hectares. Water is supplied to the checks through special passes. When placing checks, the soil surface must be horizontal and level. The deviation from the horizontal should not exceed ±5 cm. Now they practice arranging check cards with an area of 10–20 hectares. A channel is laid along the check card, with the help of which the check card is flooded with water with a wide inlet and the water is discharged.

Rice grows well in permanent crops for 2-3 years. However, the maximum yields at lower costs are obtained when alternating its unchanged crops with other crops and when growing intermediate crops in steam fields. The following crop rotations are common in rice-growing areas: I. 1,2 – alfalfa; 3–5 – rice; 6 – spring with alfalfa subsowing (rice in this crop rotation occupies 50%); II. 1–3 – rice; 4 – legumes; 5, 6 – rice; 7 – winter with lucerne sowing; 8, 9 – alfalfa (55% under rice); III. 1–3 – rice; 4 – busy steam (under rice 75%); IV. 1–3 – rice; 4 – legumes (occupied steam); 5, 6 – rice; 7 – winter with lucerne sowing; 8 – grasses for green fodder and siderates (under rice 62.5% of the area).

Tillage. When growing rice, they use plowing of the soil with plows with front plows to a depth of 25–27 cm, and when plowing perennial grasses - up to 30 cm. The peculiarities of soil cultivation are that when growing rice, specific weeds multiply intensively in one place for several years (tuber, millet, etc.), which must be destroyed. Shallow wrapping of seeds in the soil and flooding of crops with an even layer of water require the mandatory leveling of the soil surface. Under the layer of water, the soil is compacted, it accumulates reduced harmful compounds that do not decompose without access to oxygen and nutrients are not released from them.

After plowing, the soil surface is not leveled so that it is better ventilated and freezes. 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 leveled by planners. Pre-sowing cultivation with simultaneous application of fertilizers is carried out to a depth of 8–12 cm, and after that - harrowing with rolling with heavy rollers. When minimizing tillage, a KFS-2,4 cultivator-miller-planter is used.

Fertilization. Rice is grown mainly on chestnut saline soils, where its need for potassium is almost completely satisfied due to soil reserves. Therefore, potash fertilizers ($K_{30–60}$) are applied only on chernozem and dark chestnut soils. Nitrogen and phosphorus fertilizers are applied in the first year of rice cultivation at 90–120 kg/ha, and in the second year, the rate is increased by 20–25%. Most of the fertilizers are applied before sowing, and if sowing is carried out with seed drills, then 50 kg/ha of granulated superphosphate is applied to the rows. During the growing season, 1–2 fertilizing with nitrogen-phosphorus fertilizers ($N_{30}P_{30}$) is carried out. Fertilization is carried out in the phase of 3–4 leaves and during tillering. The most effective phosphorus fertilizers are superphosphate and precipitate, and nitrogenous fertilizers are sulfuric acid and ammonium chloride. Nitrate nitrogen fertilizers are unsuitable for rice because they are easily washed out of the soil. Organic fertilizers are very effective on rice crops. They are applied at the rate of 40 t/ha of manure. The green mass of sideral crops is also plowed.

Sowing. In the countries of ancient rice sowing (India, China, Pakistan, Vietnam, Indonesia), seedling rice culture is the most common. In countries where rice began to be grown relatively recently, including in Ukraine, rice is grown by sowing seeds in a permanent place. The seed must have a purity of at least 98.5% and a laboratory germination of at least 90%. Before sowing, the seeds are warmed in the sun for 5–7 days, then treated. A specific method is to soak the seeds in a 30% solution of ammonium sulfate a day before sowing. Seeds that do not settle to the bottom in the solution are discarded.

Rice is sown when the soil at a depth of 10 cm warms up to +12°C, and the water - to +12...15°C. It is sown in a narrow row or cross way. The depth of seed wrapping is 1–2 cm. A technology for growing rice has been developed, which involves sowing it to a depth of 6 cm. At the same time, the seedlings must not be flooded. If for some reason the seeds cannot be sown with a seeder, aviation is used. After the emergence of seedlings, the crops are treated with herbicides and then flooded with water.

The similarity of rice seeds in the field often does not exceed 50%. In order to have 250–300 plants per 1 m^2 during the harvest period, it is necessary to sow 7–8 million seeds per 1 ha. When the seeds are deeply wrapped, the sowing rate is increased.

Crop care. There are three ways of irrigating rice: permanent flooding - a layer of water on the field is maintained throughout the growing season; reduced flooding - there is no layer at the beginning and at the end of the growing season; intermittent flooding - the water layer is maintained periodically. In Ukraine, rice is grown using the reduced flooding irrigation regime (Table 8).

After sowing, the checks are immediately flooded with a 12–15 cm layer of water and supported until the seeds germinate. When the seeds sprout, the layer of water is reduced to 5–7 cm, and as the seedlings grow, it is increased to 15 cm. During tillering1, the water is dropped to

5 cm and the crops are fertilized with nitrogen fertilizers. This level of water is maintained while the plants are growing. After that, the thickness of the water layer is again brought up to 15 cm and maintained at this level until the pre-harvesting discharge of water. Water from the checks is drained 2 weeks before harvesting, so that the soil dries out and machines can move on it.

Table 8 - Terms and agrotechnical requirements for rice flooding (according to O.S. Alekseeva, 1998)

Flooding period	Basic agrotechnical requirements
Gap between sowing and flooding no more than 2 days	Flooding with water heated to +12...14^{0}C until wetting the soil on the hills. A layer of water of 10–12 cm. The duration is 4–5 days, after which the water is dumped.
The appearance of seedlings (2nd–3rd decade of May)	Seedlings should appear on May 25-30, the seedling phase begins with the appearance of spikes and ends with the formation of the 4th leaf. The soil is kept moist. After treatment with herbicides against grass-like weeds, a permanent layer of water is created so that it covers the plants by $^1/_3$of their height.
Bushing (2nd–3rd decades of June)	Bushing 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. A layer of water of 8–10 cm. Crops are fed with nitrogen fertilizers. Formation of the density of thinned crops is possible until July 5–10.
Tubing (2nd-3rd decades of July)	The duration is 20–25 days, the water layer is at least 20 cm. Water supply interruptions are not allowed.
Throwing	Lasts 5-8 days. The layer of water is not less than 20

panicles and flowering (until August 15)	cm. The duration of grain ripening is up to 36 days after throwing out panicles and flowering. Before the beginning of wax maturity, the water layer is at least 18–20 cm, during the phase of wax maturity, the supply of water to the checks is stopped.

Ordram herbicide (6 l/ha) is used to destroy annual grass weeds under pre-sowing cultivation. Annual grass weeds are also destroyed with the drug Auro plus (1.3–2.0 l/ha) in the phase of 1–2 leaves in rice. Facet (1.5 l/ha) is applied in the phase of 2–3 leaves of rice and 3–4 leaves of weeds. The herbicide Sirius (0.2 l/ha), in addition to millet, destroys reed tuber. It is applied in the phase of 2–3 leaves in millet and 5–6 leaves in reed tuber. When the main mass of weeds is 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 rice with a reduction in the flooding period, seeds are sown to a depth of 4–6 cm, moisture-charging irrigation is carried out, and only after the emergence of seedlings 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 bushes, the water layer is reduced, the plants are fed and treated with herbicides, and then flooded again with a 12–15 cm layer of water.

At the beginning of tillering, crops are sprayed with an aqueous solution of insecticides - Actellik (1-1.5 kg/ha), Sumithion (1.0 l/ha) or pyrethroids against the rice midge, coastal fly and other pests. If signs of pyriculariosis appear on the plants, the crops are treated with a solution of Fundazol (1–1.5 kg/ha).

*Harvesting.*The grain of rice in the panicles ripens not at the same time and earlier than the straw dries. Therefore, the harvest is mainly harvested separately. Harvesting begins when 85–90% of the grain on the plants reaches full maturity. Rice is mowed with ZhRS-5, ZhRK-5, ZhNU-4.0 harvesters at a cutting height of 15 cm. When the moisture content of the grain drops to 15-18%, the fields are threshed with SKPR-

6, SKD-6R combine harvesters with straw spreading with rolls. After 2–4 days, the swathes are threshed again at high drum rotation frequencies.

Rice can also be harvested by direct harvesting. To do this, 4–5 days before harvesting, the crops are treated with Reglon super (1.5–2.0 l/ha). The harvest is harvested after the moisture content of the grain has decreased to 16–15%, using double threshing.

Desiccation is carried out in the phase of full ripeness of the grain to reduce the moisture content of the grain, stalks and leaves 4–5 days before the start of direct harvesting.

1.5.7 Buckwheat*(Fagopyrum)*

A very valuable food cereal crop. Contains 70–80% starch, 10–12% easily digestible protein, useful organic acids, many vitamins B1, B2 and PP, mineral salts and glycoside R (rutin), which has therapeutic value, trace elements (boron, iodine, copper, cobalt) .

Buckwheat protein is dominated by easily soluble globulins and glutenins, which is why it is better absorbed and more nutritious than the protein of cereal crops (closer in quality to the proteins of cereal crops). Contains many essential amino acids: arginine (12.7%), lysine (7.9%), cystine (1%), histidine (0.59%) and others. Buckwheat ash contains a lot of phosphoric acid (48.7%), potassium oxide (23.1%) and magnesium oxide (12.4%). In terms of iron content (1.7%), it is superior to other cereal crops, and it is also rich in copper. Buckwheat groats contain much more lysine than wheat, and in terms of the amount of argonine, it exceeds rice groats.

An important feature of buckwheat groats, unlike millet, is the ability to preserve its nutritional and taste qualities for a long time. This is due to the fact that the fats contained in buckwheat do not oxidize.

Buckwheat is a valuable honey crop, bees can take 60–100 kg of honey from 1 ha of its sowing. Buckwheat honey is dark yellow, dark brown, and reddish in color, pleasant to the taste, and has medicinal properties.

In terms of physiological value, the proteins of buckwheat groats are close to the proteins of chicken eggs and cow's milk. Buckwheat porridge in dietetics is compared with meat in terms of composition and structure of amino acids.

Buckwheat has a certain importance in fodder production. For feed, they use small, thin grain, as well as bran, which is obtained during grain processing. Buckwheat straw is similar in fodder quality to barley and oat straw (100 kg of straw - 35 fodder units). Chaff (100 kg corresponds to 50 fodder units) is also nutritious feed, which is most valued for feeding pigs. However, an excess of straw and chaff in the diet of animals causes their diseases (hair loss in sheep, reddening of the skin, etc.).

The husk that remains after processing buckwheat into groats and contains up to 40% potassium oxide is used as a valuable local potash fertilizer and raw material for the production of potash(K_2CO_3).

The agrotechnical importance of buckwheat lies in the fact that, as a crop of late sowing periods, it is used for reseeding dead winter crops and early spring crops. Due to its early maturity, it is grown in post-mowing and post-harvest crops, as well as for green manure, but in areas with sufficient moisture it is inferior to legumes.

Buckwheat is a good precursor in crop rotation for other crops, especially when it is grown in a wide-row method. Crops grown in crop rotation after buckwheat are well supplied with phosphorus and potassium due to its post-harvest residues.

A short vegetation period (60–80 days) allows buckwheat to be used as an insurance crop for reseeding winter and early spring crops, and in some areas it can be grown even after harvest.

Buckwheat is not only a food, but also a medicinal crop. Buckwheat porridge is recommended for gastrointestinal diseases, anemia, nervous disorders. From the leaves and flowers of buckwheat, a valuable medicinal substance is obtained - rutin, which is used in vascular diseases. Buckwheat has been used in traditional medicine for the treatment of bronchitis and hypertension since ancient times.

Buckwheat appeared in agricultural culture about 2500 years ago. It has been established that it originates from the spurs of the Himalayan Mountains (India), where it gradually spread to Mongolia, Tibet, Japan, the regions of Eastern Siberia and the Far East. In the 1st century buckwheat penetrated to the south of Russia, after which it became known to the Slavic peoples. However, it became widespread in our country only in the 15th–16th centuries.

The worldwide sown area of buckwheat is about 4 million hectares, including 2.4 million hectares in European countries. it is grown in Germany, Poland, Austria, Hungary, France, Sweden, China, the USA, Canada, Korea, Japan. In Ukraine, buckwheat covers about 280,000 hectares. The main sowing areas are located in Chernihiv, Sumy, Poltava, Kyiv, Vinnytsia, Khmelnytskyi, Zhytomyr, Kharkiv, and Kirovohrad regions.

The average yield of buckwheat in Ukraine does not exceed 0.7–1.0 t/ha, advanced farms harvest 1.5–2.0 t/ha, and in favorable years – 2.5–3.3

t/ha.

Biological features, varieties. According to the peculiarity of development, buckwheat is a remontant plant. It has a very long flowering period. Plants have buds, flowers, unripe and mature fruits at the same time. It can develop under conditions of both short and long global day.

F. M. Kuperman identifies 12 stages of organogenesis in buckwheat: I - the period before the first true leaf unfolds; II - differentiation of the initial stem into nodes and internodes, laying of the first true leaves; III – formation of the axis of inflorescences and bracts; IV – laying of the blade of the inflorescence; V – laying of rudimentary organs of flowers; VI – formation of stamens and pistils; VII – pulling out the peduncle and generative organs; VIII – removal of the bud from the bract; IH - flowering and fruiting; X – fetal formation; XI – waxy ripeness and ripening of seeds; XII - full ripeness.

Temperature requirements. Buckwheat is a heat-loving and temperature-demanding culture. Its seeds begin to germinate at a temperature of +6...7°C. At a temperature of +15°C, seedlings appear after 7–8 days (they die at –2°C). At a temperature above +25°C, buckwheat is suppressed, especially during the flowering phase. Nectar trees dry up, fertilization worsens, plants drop half-formed fruits, many unripe fruits are formed - "rudyak". It develops better at a temperature of about +20°C and a relative humidity of at least 60%.

An increase in temperature up to +30...35°C leads to burning and dying of the ovary, the yield decreases sharply, especially in dry years. A prolonged flowering period also leads to a decrease in buckwheat productivity.

Moisture requirements. Buckwheat is a moisture-loving culture, which is evidenced by its morphological features: the absence of pubescence and wax coating - adaptations to drought and high temperatures, as well as a large evaporative surface of the leaves. For seed germination, 50–60% of its mass needs water. Buckwheat consumes 3 times more water than millet and 2 times more than wheat and barley. The transpiration coefficient of buckwheat is 400–600. Plants need moisture the most in the phases of flowering, fruiting - 50-60% of the total need. With a lack of water, plant growth stops, but the development continues. Buckwheat is especially negatively affected by the combined effect of air and soil drought, when the temperature rises to +30°C, and air humidity decreases to 40%. Under such conditions, the ovaries on the plants die within 2-3 days.

Light requirements. Buckwheat belongs to crops that grow and develop well in conditions of short and long daylight. A reduction in daylight leads to a reduction in vegetation. Changeable cloudiness is most favorable for the formation of a high yield.

Soil requirements. Structural soils with increased aeration and sufficient nutrient reserves are best for buckwheat. These are dark-gray podzolized, gray forest, black soils with coarse silt and light loam with optimal soil acidity (pH 5.5–6.5). Very heavy, overmoistened and saline soils are not suitable for it. Buckwheat should not be grown on soils excessively fertilized with manure, on which there is "fattening" of plants - excessive development of vegetative mass and a decrease in generative capacity.

For 1 ton of grain, 30–45 kg of nitrogen, 13–26 kg of phosphorus, and 36–72 kg of potassium are removed from the soil, which is 1.5–3 times higher than the removal of nutrients by, for example, wheat. Buckwheat shows the highest demand for nutrients, especially nitrogen, at the beginning of the second half of the growing season, that is, during the period of rapid development and accumulation of dry matter and the formation of fruiting bodies.

The main reasons for low and unstable buckwheat yields are: an underdeveloped root system, a discrepancy between the size of the assimilation surface of the leaves and the number of flowers on the plant, a long period of flowering and fruiting and its dependence on meteorological conditions, features of flower pollination associated with sexual dimorphism, etc. . One of the reasons for the low seed productivity of buckwheat is also the long-term intensive growth of vegetative organs during simultaneous flowering and fruit formation, due to which the products of photosynthesis are not distributed in favor of the latter. However, the main reason should be considered the imperfection of buckwheat cultivation technology, treating it as a secondary crop.

The introduction of new productive varieties of buckwheat with grain of high technological qualities is an important direction of increasing the production of grain of this crop. The "Register of plant varieties suitable for distribution in Ukraine" includes 21 varieties of buckwheat: Ukrainka, Antaria, Krupnozerna, Devyatka, Dikul, Oranta, Yelena, Rubra, Slobozhanka (ordinary morphotype) and Sumchanka, Krupinka, Yaroslavna, Ivanna (determinant morphotype). At least two or three zoned varieties should be sown, which differ in the type of growth and duration of the growing season.

Cultivation technology. *Predecessors.* Demanding to predecessors due to sensitivity to herbicides. Winter cereals, row crops, beets, flax, grain legumes, and corn are equal predecessors for it. Buckwheat is also grown post-harvest and post-harvest after annual grasses and early cereals. It is not advisable to sow it after oats, barley and in repeated crops.

Buckwheat, due to its rapid growth and suppression of weeds under a thick leaf-stem cover, is a good precursor for other agricultural crops. According to research institutions, ears sown after it are less affected by root rot than after grain predecessors. Buckwheat improves the agrophysical properties of the soil and significantly reduces its density. It absorbs phosphorus and potassium from difficult-to-dissolve compounds and transfers them from the lower soil horizons to the upper ones.

Tillage. Autumn tillage is carried out according to the type of semi-pair or improved zaab. Deep loosening should be avoided in early spring. It is desirable to close the moisture and give the opportunity to germinate the maximum number of weeds. If the soil is overmoistened, as weeds sprout, it is necessary to carry out cultivation to a depth of 10–12 cm. When the field is weeded by rhizomes, additional cultivation is carried out, in dry springs - with rolling of the field.

Immediately before sowing, soil cultivation is carried out to the depth of seeding with combined units that ensure complete destruction of weeds, leveling of the field surface, preservation of moisture, creation of optimal agrophysical conditions for seed germination.

Fertilization. Buckwheat responds well to fertilizers, although they often affect the accumulation of vegetative mass more than seed productivity. For the formation of 1 centner of buckwheat grain, 4.5 kg of nitrogen, 3 kg of phosphorus, and 7.5 kg of potassium are removed from the soil. Organic fertilizers cause increased growth of vegetative mass, which reduces the yield of buckwheat grain. Complete mineral fertilizer ($N_{45}P_{45}K_{45}$) is applied to sod-podzolic soils. Phosphorous fertilizers ($P_{45–60}$) are mostly used on chernozems. Potassium chloride-containing fertilizers cause leaf spotting, reduce the intensity of photosynthesis. It is more expedient to apply chlorine-free potassium fertilizers under buckwheat - kalimagnesia, potassium sulfate, potassium nitrate, ash. It is better to apply a full dose of fertilizers under one of the spring cultivations, and chlorine-containing potash fertilizers - under plowing.

After a well-fertilized precursor for buckwheat, it is advisable to apply mineral fertilizers to the rows during sowing at the rate of $N_{20}P_{20}K_{20}$ and to carry out nitrogen fertilization at a dose of 15 kg/ha d.r.y. In fields with a sufficient level of fertility, you can limit yourself to feeding plants at the IX stage of organogenesis with nitrogen at a dose of 15 kg/ha per year.

Late non-root feeding of buckwheat with urea (10 kg/ha of active substance) or microfertilizers increases the content of proteins in grain. Potash fertilizers, which contain chlorine, negatively affect the productivity of buckwheat, suppress plants.

On fertile soils that contain humus more than 3%, plant-available forms of phosphorus and potassium more than 10 mg/100 g of soil, as well as when buckwheat is placed after well-fertilized predecessors, the fertilization system includes: post-sowing application of granular phosphorus or complex fertilizers in doses of 10–20 kg/ha of active substance; on wide-row crops - feeding plants during the growing season with nitrogen or complex fertilizers at a dose of 10–15 kg/ha of the active substance

Sowing. For sowing, filled seeds are used, the purity of which is not lower than 99%, the laboratory germination is higher than 92%. Before sowing, the seeds are treated with Vitavax, Fundazol or other drugs at the rate of 2–3 kg/t.

For better plant growth and development, seed poisoning is combined with seed treatment with trace elements (manganese, zinc, copper, boron) at the rate of 25–50 g/ha; nitrogen-fixing and phosphorus-mobilizing bacteria (100 g/t), diazobacterin (200 g/t). In order to increase the resistance of plants to stressful situations, it is advisable to treat the seeds with growth regulators. In order to prevent the plants from being affected by diseases, it is advisable to treat the seeds with Agat 25-K at the rate of 20 ml/t.

Buckwheat should be sown after a steady warming of the soil to +10...12°C. When sowing under these conditions, its seedlings appear on the 6–8th day, and it begins to bloom at the end of May or the beginning of June on the 30–33rd day. With later sowing dates, buckwheat blooms in hot, dry summer, which leads to burning of crops and a significant decrease in yield. Determinant varieties at late sowing times reduce productivity. During the early sowing period, there is a possibility of crop losses due to spring frosts.

Two methods of sowing are used - wide-row sowing with a row spacing of 45 cm and ordinary row sowing - 15 cm. It should be remembered that buckwheat has increased requirements for lighting, especially at the IV-VII stages of organogenesis, when the number of inflorescences and flowers and the fertility of pollen are established, so when when choosing a method of sowing, the degree of cultivation of the soil, its weediness and provision of the farm with equipment are taken into account. Wide-row is the most suitable for the biology of the crop, in addition, in such crops, weeds can be combated by an agrotechnical method, the density of the soil decreases, and root feeding of plants is possible. The advantage of the ordinary row is manifested on fertile soils, clean of weeds and when sowing early maturing varieties.

The rate of seed sowing depends on soil and weather conditions, methods and terms of sowing and laboratory germination of seeds. Under optimal moisture conditions, it is: for the wide-row method of sowing - 2.0-2.5, for determinant varieties - 1.5-2.0 million pieces/ha of similar seeds; for ordinary row - 3.0-3.5, for determinant varieties - 2.5-3.0 million pcs./ha of similar seeds. In the absence of nitrogen fertilizers, as well as when planning post-emergence harrowing, the sowing rate is increased by 10–15%. The rate of seed sowing in normal row sowing in areas with sufficient moisture is 80–100 kg/ha, and in dry conditions – 50–70 kg/ha. 35–40 and 50–60 kg/ha are sown on wide-row and strip crops, respectively.

The depth of seed wrapping depends on the granulometric composition of the soil, its humidity and temperature: on gray forest soils - 3–4 cm; on structural black soils - 4–5 cm; with insufficient moisture - 5–7 cm.

Crop care. After germination, buckwheat plants quickly build up vegetative mass, cover and shade the soil surface, which inhibits seed germination, emergence of seedlings, and weed growth. There is evidence that the root system of buckwheat has an inhibitory effect on the development of weeds, due to the release of toxic substances called bioherbicides into the soil.

When buckwheat is sown in an insufficiently moistened soil layer, post-sowing rolling is carried out, which improves the contact of the seeds with the soil. To destroy weeds and compact the soil, pre-emergence harrowing is advisable, and in the phase of the first true leaf on ordinary row crops - post-emergence harrowing (the speed of the unit is no more than 4-5 km/h). When harrowing with medium harrows in the phase of 1–2 true leaves, buckwheat crops are thinned by 15–20%.

When the first true leaf of the buckwheat crop appears in the plants, the buckwheat is harrowed across the rows or at an angle to them to destroy weeds. It is best to harrow during the day, when the plants lose turgor and are less likely to be broken by the harrow teeth. On wide-row crops, the inter-row loosening is carried out two to three times, thanks to which the water regime is improved and weeds are destroyed. The first time the interrows are loosened when the first true leaf appears in the plants (II stage of organogenesis) to a depth of 5–6 cm, the second time – at the beginning of budding (III stage) to a depth of 6–8 cm, the third time – at the beginning of flowering before closing the rows (IX stage) to a depth of 6–8 cm with fertilization with nitrogen fertilizers, leaving a protective strip along the rows with a width of about 10 cm. During the third cultivation, the buckwheat in the rows is turned over 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 mass flowering of plants begins.

Harvesting. Buckwheat is characterized by high humidity of the above-ground mass, uneven ripening, laying, and a tendency to fall. The main method of collection is separate. Mowing in rows is carried out when 70–75% of the fruits on the plant ripen in the early or late evening hours at a cut height of not less than 15 cm in order to quickly dry the entire above-ground mass. The delay in harvesting leads to significant losses due to shedding of the fruits of the first periods of setting. It is advisable to start threshing the rolls after 4–5 days, when the mass dries up, the humidity of the stems and leaves decreases to 30–35%, and the grain – to 15–16%. Inadmissible delay in threshing the rolls, which leads to significant losses due to grain spillage.

By direct harvesting, it is advisable to collect only precocious and short-growing varieties that ripen together under the usual row sowing method. Grain collected by direct combining is characterized by increased moisture and clogging, so it requires additional drying and cleaning.

1.6 GRAIN LEGUMES

1.6.1 General characteristics of grain legumes

The world's need for protein determines the intensive spread of one-year grain leguminous crops. Currently, in terms of the total cultivated area (together with soybeans), they occupy the second place after grain crops. Cereal legumes are among the oldest crops on the globe. They were grown as early as 7000 BC. (lentils, peas, plantain) and 4000–6000 years ago (soy, chickpeas, fodder beans).

There are about 60 types of grain leguminous crops. Among them: soybeans, peas, beans, beans, lupins, mung beans, vetch, vetch, chickpeas, chickpeas, lentils, peanuts, kayanus (pigeon peas), delichos (hyacinth beans), velvet beans, etc. Due to the fact that there are cold-resistant and heat-loving, drought-resistant and moisture-loving legumes among grain legumes, they are grown on all continents. Grain legumes have a special role in solving the protein problem. This is the main source of balanced amino acid, the cheapest, environmentally friendly protein. In terms of protein, grain legumes are 1.5–2.5 times more abundant than cereal crops. (Table 9).

The grain of one-year grain legume crops (soy, peas, forage beans, lupine, vetch, chickpea, chickpea, etc.) contains more protein (20–50%), but less fat (except for soybeans - 20%). Proteins are valuable for their amino acid composition. The content of essential amino acids (lysine, tryptophan, arginine, valine, etc.) in the seeds of legumes is 1.5–3 times higher than the protein of cereal crops. Legumes are richer in riboflavin, but poorer in carotene. In terms of energy content, they are close to barley, slightly inferior to corn. Contains a significant amount of essential and critical amino acids, and soy also contains essential fatty acids.

Table 9 – Chemical composition of the seeds of grain legumes, %

Crops	Water	Protein	Starch	Fat	BER	Crude fiber	Ash
Peas	10–15	16–35	20–46	1,3–1,5	48–55	3,0–6,0	2,0–3,1
Lentil	12–14	25–34	47–60	1,3–1,4	48–55	3,5–4,0	2,0–2,5
Bean	12–15	22–30	50–56	2,0–2,3	45–52	5,0–5,5	2,5–3,0
rank	12–14	25–34	24–25	1,0–1,2	42-52	4,0–5,4	2,5–3,0
chickpeas	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
Soy	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

Legume protein contains more than 80% fractions soluble in water and saline solution, which determines the high efficiency of its use in the body of monogastric animals. In ruminants, due to this, the protein is quickly broken down into ammonia, which is soon excreted from the body. The grains of almost all legumes contain various anti-nutritional substances (enzyme inhibitors, in particular trypsin, alkaloids, etc.), which reduce their value. Most of these antinutrients are protein-based and can be inactivated (destroyed) by heat treatment.

An important feature of grain leguminous crops is the biological fixation of atmospheric nitrogen, which occurs due to the development of nodule bacteria on their roots. At the same time, plants not only provide the basic need for nitrogen, but also enrich the soil with ecologically clean nitrogen, increase its fertility. Peas, soybeans, lupins, chickpeas, chickpeas, vetch, and beans, as a rule, do not require nitrogen fertilizers to be applied to the soil.

Cereal legumes in symbiosis with nodule bacteria absorb nitrogen from the air. Research has established that 100 to 400 kg of air nitrogen is fixed per 1 ha of leguminous crops. Most of it is removed with the harvest, and only 25–40% remains in the post-harvest residues. Lupins are especially active in absorbing atmospheric nitrogen (up to 400 kg/ha), which is why it is especially poor sod-podzolic ones.

The fodder value of legumes is not only that they themselves have a high fodder value, they also improve the quality of fodder of other crops, enriching them with protein. It is known that for complete feeding of animals in one fodder unit, the content of digestible protein should be 110–115 g, but in fact it contains 95–98 g or 83–87% of the norm. At the same time, leguminous seeds contain 174–276 g, and green mass 160–205 g of digestible protein per feed unit. Therefore, at the expense of leguminous crops, it is possible to bring feed rations to physiologically complete.

Leguminous crops, in addition to enriching the soil with nitrogen, are also able to improve its structure, enrich the arable layer with phosphorus, potassium, calcium, and improve its chemical properties. Lupine, fodder beans and, to a lesser extent, peas are able to assimilate phosphorus from poorly soluble compounds (phosphorus from their root residues becomes available for subsequent crops). Thanks to this, they are good predecessors in crop rotation for grain and industrial crops.

In world agriculture, grain leguminous crops are grown on an area of 100–110 million hectares with a gross harvest of about 90 million tons. The largest areas of sowing are concentrated in China, India, and the USA. Among them, soybeans (50 million hectares), beans (25 million hectares), peas (14–15 million hectares), and chickpeas (10–12 million hectares) are the most common.

Taking into account the value of grain leguminous crops, it is necessary to constantly increase their production in Ukraine, including due to the expansion of the sown areas, which today occupy about 1.6 million hectares, and the gross harvest of grain reaches 3.2 million tons.

Biological features of leguminous crops. When growing leguminous crops, it should be remembered that their seeds can germinate when absorbing water twice as much (110–140% of their weight) than the seeds of grain crops, which is especially important for heat-loving crops that are sown in late spring and in the south of Ukraine.

Grain legumes that carry cotyledons to the surface of the soil do not tolerate deep seed wrapping, which can lead to significant seedling thinning.

After the appearance of the first true leaves, the growth of legumes is often delayed, especially in the cold spring, the plants turn yellow, which is due to insufficient nitrogen, since nodule bacteria have not yet fixed 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 during pre-sowing cultivation are extremely effective.

A characteristic feature of legumes is the tendency to long-term flowering and fruiting, which complicates harvesting and may lead to the loss of the most valuable seeds of the lower beans. Harvesting of leguminous crops is also complicated by the fact that some of them (peas, plantains, lentils, beans) are very prone to lodging; others (lupine, fodder beans) have high humidity of stems and leaves at the time of harvesting, and some (soybeans, bushy forms of beans) have a very low placement of beans on the plant.

In individual development, grain leguminous crops go through the following phases: seed germination, seedling, branching, budding, flowering, formation of beans, ripening, full seed maturity.

Seed germination begins with the emergence of a root from under the seed coat, which quickly grows and takes root. There are two types of germination: above-ground (epigeal) and underground (hypogeal). During aerial germination, the cotyledons are carried out of the soil due to the growth of the hypocotyl. The hypocotyl descends in the form of a loop, straightens and pulls out the cotyledons, which open, turn green and carry out photosynthesis. After the cotyledons, the bud leaves open. Above-ground germination is typical for plants with pinnate and pinnate leaves (soy, most types of beans, lupins), underground - for plants with pinnate leaves and some plants with pinnate leaves.

During underground germination, the cotyledons remain in the soil, and the bud is carried out of the soil as a result of the growth of the epicotyl and the internode between the nodes of the lower leaves.

From a biological point of view, plants with underground germination are more perfect than with above-ground germination, because they have a greater "safety margin" of ontogenesis: in the case of the death of the above-ground part of the main shoot, they can form side shoots from buds placed in the axils of the lower leaves, sometimes even seeds juniper.

Seedlings with one or two unfolded leaves are called seedlings. In plants with tripartite leaves, the first leaves are simple, so-called primordial, in all other plants they are true leaves with a smaller number of leaves than usual.

The first leaves of plants with tripartite leaves are opposite, with pinnate and pinnate leaves - mostly consecutive, which appear almost simultaneously.

Other phenophases of various leguminous crops 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.

The formation of the fruit and seed begins after fertilization of the ovary. At first, fertilization, which develops from the walls of the ovary, actively grows. Products of photosynthesis and water accumulate in it, the mass of dry matter increases and reaches maximum values 10–17 days after flowering(in peas). During the entire period of formation, the green color of the bean almost does not change. Simultaneously with the formation of the embryo in the embryo sac of the ovule, embryogenesis occurs - the gradual transformation of the zygote into an embryo.

Ripening, from an economic point of view, is the process of forming a crop and consumer qualities of fruits, seeds or other organs (parts) of plants. The ripening of leguminous crops, as well as grain breads, is accompanied by pouring: it is as a result of pouring - the accumulation of photosynthesis products in the seeds - that the harvest is created, and the quality of the grain is formed.

In grain legumes, the maturity of the grain is determined by the ripeness of the bean (the color of the fruit). The ripening of the bean is indicated by a change in the color of the pericarp. In beans, for example, the green color first acquires a whitish tint, then changes to yellow-green, green-yellow, yellow, straw-yellow, or another characteristic of a ripe bean. According to the color of the fruit, the stages of maturity of the bean are marked: yellow-green, green-yellow, etc.

During the ripening of grain legumes, the products of photosynthesis accumulate in the cotyledons (bulk); polymerization of organic compounds, transformation of soluble substances into insoluble (reserve); metabolic, and after completion of pouring, physical dehydration of seeds; dehydration of the fruit, the humidity of which is always higher during the period of pouring, and after the completion of pouring, it is lower than that of the seed; a decrease in the dry weight of the pericarp as a result of the outflow of a certain amount (sometimes up to 50%) of its substances to the seed; increase in mass and size of cotyledons and germ axis; the acquisition by seeds of the ability to germinate and reproduce productive plants in natural conditions, that is, the formation of its sowing and yielding qualities.

The seeds of grain legumes (except lupine) do not have a 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 at the same time as technical ripeness, due to which, under favorable conditions, it can germinate in beans both on the "root" before the plants are mowed, and in swathes. Mowing the plants at the optimal time (technical ripeness) and timely threshing of the rolls can to some extent prevent this undesirable phenomenon.

Requirements to temperature. Leguminous crops react differently to environmental conditions. Peas, lentils and fodder beans are the least heat demanding. Their seeds germinate at a temperature of the upper layer of the soil +2...3^{0}C. These crops can withstand spring frosts. Thus, peas and lentils in the seedling phase can withstand temperature drops to -7...8^{0}C, and lupine and fodder beans can withstand temperatures down to -60C. They are insensitive to cold weather during the growing season, but they are very demanding on moisture and produce high yields only in areas with sufficient moisture.

Unlike peas, lentils and beans, chickpeas and plantain are drought-resistant crops, although they have the ability to germinate at +6...7^{0}C.

Soy and beans are the most demanding of heat. The minimum temperature for seed germination of these cultures is +8...10^{0}C, and bean seedlings die when the temperature drops to -0.5...1^{0}C, and soybean - to -2.5^{0}C. At the same time, soybeans are very demanding on moisture.

One-year lupine seeds germinate at +4...6^{0}C, but can grow and develop in cool weather, tolerates drought well.

Requirements to moisture. The high fastidiousness of legumes to moisture is revealed already during seed germination, which germinates and germinates when absorbing 100–160% of water from its weight. The optimal soil moisture for all crops, which ensures active fixation of atmospheric nitrogen by nodule bacteria and the highest yield, is moisture in the range from 90% RH to the moisture of capillary rupture (about 60% RH). It should also be noted that excessive humidity is harmful to all leguminous crops, which causes the plants to be affected by diseases and crops (peas, linseed) to fall.

Light requirements. Grain legumes are divided into three groups according to their requirement for light: plants with a long day (peas, lentils, plantains, lupins, fodder beans); short-day plants (soy, most types of beans); neutral plants to the length of the day (some varieties of beans, chickpeas). However, each culture has day-length-neutral varieties. Short-day plants extend the growing season in northern areas, and long-day plants in southern conditions. It should be noted that many legumes (soy, beans, peas, forage beans) are shade-tolerant plants that grow and develop well in thickened crops, so they are valuable components for mixed crops.

Requirements to soils. Medium loamy slightly acidic or neutral soils that contain enough phosphorus, potassium and calcium are most suitable for grain legumes. Light sandy soils with an acidic reaction of the soil solution are not suitable for most legumes. Microfertilizers containing molybdenum must be applied to acidic (pH<5.5) soils.

Among the legumes, yellow and blue (narrow-leaved) lupins are the least picky about the soil, which form a significant crop on sandy soils, even with an acidic reaction of the soil solution (pH 4–4.5). The only exception is white lupine, which needs fertile slightly acidic or neutral soils. Forage beans are the most picky about soil fertility.

1.6.2 Pea *(Pisum)*

Peas are grown mainly as a food and fodder crop. On average, pea seeds contain up to 28% protein, 52% carbohydrates, 1.6% fat, and 2.5–3% ash. Pea protein is absorbed better than wheat protein, which is explained by its higher content and better ratio of amino acids.

100 g of its grain contains 336 calories (100 g of wheat - 347, beef -

171). Protein is about the same as in raw meat.

Pea seeds are well digestible, and food products made from them are highly nutritious and have a pleasant taste. Pea groats, flour, canned seeds and unripe sugar pea beans are used for food purposes. Green unripe seeds ("green peas") and unripe fruits of vegetable varieties of peas contain up to 25-30% sugar, many vitamins (A, B1, B2, C) and minerals.

Pea grain is used as a concentrated feed and as a protein component for compound feed. 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 pea straw are used for animal feed, the fodder value of which, due to the high protein content, is much higher than that of cereal crops. Pea-cereal mixtures are used to prepare silage, grass flour, and green fodder.

With high agricultural technology, peas leave 50–70 kg/ha of nitrogen in the soil and are a good precursor for grain crops. It is important as a vaporous and sideral culture.

Introduced into culture, apparently, together with wheat, barley, millet, beans. The homeland of field peas is considered to be Central Asia - the regions between the Mediterranean and the Himalayas. In the Mediterranean countries (Spain, Italy, countries of the Balkan Peninsula) it was known for 5 thousand years BC. Appeared on the territory of Ukraine, probably in the III-II millennium BC, as evidenced by archaeological excavations in the territory of Chernivtsi and Ivano-Frankivsk regions.

Pea grain production has increased almost 1.8 times over the past 14 years. The world area of its cultivation is 14–15 million hectares. It is growing rapidly in France, Ukraine, Canada, and other countries. In Ukraine, the cultivated area has decreased significantly and, according to the data of the State Committee of Statistics of Ukraine, amounts to about 350 thousand hectares. The largest cultivated areas are concentrated in the forest-steppe (55% of the total cultivated area). Peas are grown in the Steppe (25% of cultivated areas) and Polissia (up to 20%).

Biological features, varieties. *Requirements to temperature.* Peas are the most precocious among leguminous crops. Peas are less picky about heat than lentils, beans, plantains, chickpeas and other legumes. Peas are an early-sowing crop, their seeds germinate when the soil warms up to +1...2°C. However, under such conditions, the seedlings weaken and appear late (after 15–20 days). The minimum temperature necessary for the normal development of seedlings and the formation of vegetative organs is +4...5°C. With its increase to +10°C, seeds germinate within 5–7 days. Seedlings tolerate short-term spring frosts up to -4...5 °C. More cold-resistant diaper varieties, many of which are wintering. The optimal average daily air temperature during the formation of vegetative organs is +12...16°C, for the formation of generative organs and seeds +16...22°C. Temperatures above +26°C have a negative effect on the quantity and quality of the pea harvest.

Requirements to moisture. Peas are more picky about moisture than beans, lentils, chickpeas, and chickpeas. For swelling and germination, the seed requires 110-115% of water from its weight, and the brain varieties - up to 150%. The critical period before the lack of moisture is quite long - from the laying of generative organs to full flowering. Transpiration coefficient 400–450.

Requirements to light. Pea is a light-loving plant. In conditions of shading, it is stretched and fruiting is suppressed in it. The photoperiodic response of peas is closely related to the spectral composition of light. In the light of a long day, long-wave rays prevail, which contributes to the accelerated development of peas and significantly increases its yield. It is characterized by self-pollination, but in dry and hot weather, cross-pollination is also possible.

Pea is a long-day plant. In this regard, in the southern regions, under the conditions of a short day, the first period is lengthened, and the second period is shortened under the influence of high temperatures and a lack of moisture. In the northern regions, it is the opposite: the germination-flowering period is shortened, and the flowering-reach period is extended under conditions of sufficient moisture and low temperatures.

Requirements to soils. The best for growing peas are chernozems and cultivated varieties of other types of soils, loamy in mechanical composition and with a high content of phosphorus, potassium, molybdenum, boron, calcium. The optimal pH is 6.8–7.4. On heavy, very dense and acidic soils, the root system is located shallowly, the vital activity of nodule bacteria is suppressed. Heavy, clayey, acidic, overmoistened soils are unsuitable for growing peas. On light, poor soils, field peas provide a low yield, they are more suitable for growing field peas.

According to the use of the main products, pea varieties are divided into three groups: grain, fodder, and vegetable. Grain varieties are characterized by a high grain yield, fodder varieties produce a larger yield of green mass than grain varieties, vegetable varieties are grown to obtain "shovel" and green peas.

More than 40 pea varieties are included in the Varieties Register, most of them are recommended for growing in the Forest Steppe and Polissia zones. Worthy of attention are the varieties Ulus, Bersek, Glyans, Gotivsky, Motto, Caddy, Jezero, Camelot, Tuner, Starter, Cardiff, Modus, Necklace, Petronium, Rialto, Svit, Hardy, Tsarevich, Sycamore, Zinkivsky, Laurel, Cleopatra, Oplot, Ataman, Veselyk.

Cultivation technology. *Predecessors.* Due to the slow growth of plants in the first stages of organogenesis and the insufficient level of development of vegetative organs, it is desirable to place pea crops in fields with minimal clogging and the absence of perennial rhizome weeds.

Peas should be placed in crop rotation after well-fertilized predecessors. The best among them in the forest-steppe zone are row crops, corn, as well as winter and spring cereals; in Polissia - corn, winter wheat, row crops. In crop rotation, it is more appropriate to place peas between two cereal crops or between a cereal crop and a technical non-legume crop. The saturation of crop rotations with peas should not exceed 15%, and the term of returning it to the previous place of cultivation should not be earlier than in 5-6 years. When peas are returned to the same field earlier, they suffer from "pea rot" of the soil, which is caused by the development of various diseases, especially root rot, and has a negative effect on productivity.

In areas with an arid climate, it should not be sown after sugar beets, sunflowers, Sudanese grass, and sorghum. It is not necessary to grow peas after other legumes and peas, because this contributes to the development of fusarium wilt, the reproduction of nematodes, tuber weevils and grainy. Pea crops should not be placed close to crops of perennial leguminous grasses, on which tuber weevils overwinter.

Tillage. The system of measures for soil cultivation involves ensuring a good phytosanitary condition of crops and creating favorable water and air regimes of the soil for the growth of pea plants and the vital activity of nodule bacteria.

When growing peas, maximum attention should be paid to protection against weeds. Therefore, it is necessary to use improved or semi-steam tillage with two-time husking of the stubble and early flail plowing or another type of basic tillage. In general, the main cultivation of the soil for peas is the same as for early spring grain crops.

When sowing peas after cereals, it is necessary to peel the stubble, and after 2–3 weeks deep (25–27 cm) plowing to create favorable conditions for the life of nodule bacteria. According to the results of the research of the State Institute of Agricultural Sciences of the National Academy of Sciences of Ukraine, timely peeling followed by plowing reduced the number of weeds in pea crops by 64–78%.

After sugar beets, plowing 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 plowed layer, spring leveling of the soil should be avoided, which ensures mixing of the dry upper layer with the lower, wetter one. In this case, it is expedient to sow as soon as possible immediately after performing the generally accepted spring cultivation, which is cultivation to the depth of seed production. On light soils, rolling is used before sowing.

It should be noted that peas respond positively to in-depth loosening of the arable layer by heavy cultivators of the КРЕ-3,8, АГЧ-4 type. The use of such aggregates will improve the nitrogen-fixing capacity of the culture.

Fertilization. Peas, especially grain food varieties, require fertile soils. To form 1 ton of grain and the corresponding amount of straw, he 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 the use of organic and mineral fertilizers. However, organic fertilizers in the form of half-rotted manure or compost at the rate of 18–20 t/ha are applied only on poor sandy soils, supplementing them with phosphorus. On more fertile soils, such fertilization causes intensive growth of green mass (fattening), which delays the harvest.

Doses of fertilizers are set depending on the precursor, taking into account the reserves of nutrients in the soil. According to the generalized research data of scientific institutions, in the Forest Steppe they are $P_{30–60}K_{45–60}$. It is better to apply nitrogen fertilizers in the amount of 30–90 kg/ha of active substance in the spring. When determining the dose of nitrogen fertilizers, it is necessary to take into account the ability of peas to biologically fix nitrogen (50% of the total removal by elements with the crop).

Phosphorous fertilizers are very effective when growing peas. Potassium is effective on non-black soils of Polissia.

It is possible to use crushed straw of the predecessor as fertilizer for peas. At the same time, in the early autumn period, in order to optimize the processes of mineralization of by-products, nitrogen is applied at the rate of 10 kg of active substance per 1 ton of straw

To improve nitrogen nutrition due to symbiotic nitrogen, plants are infected with nodule bacteria by inoculating seeds with rhizorthorphin.

Nitrogen fixation is enhanced by molybdenum and boron fertilizers. Seeds are treated with molybdenum and boron fertilizers or molybdenized or boron-enriched superphosphate is applied to the rows when sowing, when 1 kg of soil contains less than 0.3 mg of plant-available molybdenum or boron. It is better when one of the microfertilizers is applied to rows with superphosphate, and the other - with treated seeds.

Sowing. Preparation of pea seeds for sowing includes etching, treatment with microelements and inoculation, and in case of high humidity, it is also necessary to carry out preliminary air-heat treatment.

3–4 weeks before sowing, semi-dry poisoning of pea seeds with Fungicides Fundazol, 50% z.p. (2 kg/t), Vitavax 200 FF (2.5 kg/t), Maxim 025 FS, t.k.s. (1 l/t), Maxim 035 FS (1 l/t). The effectiveness of poisoners increases when used in tank mixtures of growth regulators.

In order to stimulate the formation of nodule bacteria in the rhizosphere of the pea root system and increase grain yield, it is advisable to carry out nitrification of seeds with the preparations rhizorthorphin, rhizoagrin or rhizogumin at a dose of 0.6–1.2 kg/t on the day of sowing peas. Inoculation with rhizorthorphin can be carried out only when the seeds are poisoned with Fundazol. It is not advisable to combine inoculation with other drugs, because most of the bacteria are killed. At the same time as nitrification, it is best to treat the seeds with molybdenum preparations at the rate of 20–30 g of ammonium molybdenum per 1 t of seed material. Treatment with trace elements should be planned if non-molybdenized superphosphate was used as phosphorus fertilizers.

When liming acidic soils or when the amount of boron in the soil does not exceed 0.3 mg/kg, pea seeds should be sprayed with boric acid (25 g/h). In this case, it is also recommended to apply fertilizers containing boron under pre-sowing cultivation.

Peas are sown in the optimal early period, when the physical maturity of the seed layer of the soil is reached, when high-quality and uniform wrapping of the seeds to a given depth is ensured. A delay in sowing by 7–12 days in Polissia can cause a decrease in yield by 2–3, and in the Forest

Steppe by 3–4 t/ha.

The method of sowing is ordinary row sowing with a row spacing of 15 cm. The depth of seed wrapping is 4–5 cm on medium and heavy soils, 6–8 cm on light soils. When using soil herbicides, the depth of seed wrapping should be 6–8 cm.

The seeding rate is set depending on the biological characteristics of the variety, quality and class of seeds with the calculation that at the time of harvesting, 1 m^2 should have at least 130-140 plants. The following seed sowing rates are recommended: in the Steppe – 0.8–1.0, Forest Steppe – 1.0–1.3, Polissia – 1.1–1.4 million pieces/ha. For tall varieties, the sowing rate is reduced to 0.8–0.9 million units/ha, for medium-sized varieties, it increases by 0.1–0.2 million units/ha. For large-seeded varieties, the norms are reduced by 10–15%, for small-seeded varieties, they are increased by 10–15%. Weight standards for large-seeded varieties - 240-300 kg/ha, small-seeded - 150-200.

Crop care. The first step in the care of pea crops in a dry spring is post-sowing soil rolling, which promotes better seed-to-soil contact, draws water to the seed layer, increases plant germination and resistance to disease and pest damage. It is not carried out in case of high humidity.

The complex of crop care operations involves protecting them from weeds, pests and diseases. At medium and high levels of weediness, pre- and post-emergence harrowing of crops with medium harrows is an effective and proven measure. Harrowing of pea crops provides loosening of the field surface with the elimination of soil crust, contributes to the destruction of weed seedlings in the "white thread" phase and creates optimal aeration conditions for improving the symbiotic activity of nodule bacteria. The first is carried out 3–6 days after sowing, when the length of the seedling does not exceed 1.5 cm, the second - in the phase of 3–4 pea leaves at a plant height of 8–10 cm. To prevent injury to the plants, harrowing is done in the afternoon, when the plants lose turgor and are less damaged.

The greatest effect in protection against weeds is achieved by a combination of agrotechnical and chemical methods. In the fields heavily littered with annual cereal and dicot weeds, pea crops are treated with the herbicide Gezagard 500 FW, hp, 3–5 l/ha (pre-emergence spraying); Pivot, v.r.k., 0.5–0.75 l/ha (pre-emergence or post-emergence spraying, in the phase of 3–6 pea leaves); for one-year dicotyledonous weeds apply Agritox, v.r., 0.5 l/ha; Bazagran, v.r., 3 l/ha in the phase of 5–6 pea leaves; for annual cereals and dicotyledons - Fusilade Forte 150 EC, k.e. (0.5–1.0 l/ha – against annual cereals and 1.0–2.0 l/ha – against perennial cereals); Efes, v.r.k., 3 l/ha – against annual dicotyledons (spraying crops in the 5–6 leaf phase); Pulsar, v.r., 0.75–1.0 l/ha – against cereals and annual dicotyledons (spraying crops in the phase of 3–6 leaves), Select 120, 1.2–1, 6 l/ha – against perennial grasses (at a weed height of 15–20 cm).

Protection measures against pests and diseases. In the conditions of Ukraine, root rot, transferporosis and ascochitosis are the most harmful to pea crops. Against root rot and ascochitosis, seeds are treated 2–3 weeks before sowing. Fundazol, is effective against diseases (ascochitosis, peronosporosis, rot). (1 kg/ha), Rex T (0.5–1.0 l/ha) when applied in the phase of budding–beginning of pea flowering.

Of the pests on pea crops, tuber weevils, aphids, pea fruit eaters, fireflies, and thrips are the most common. Pea mosquito, pea seed.

To protect against tuber weevils, at the beginning of pest infestation, edge treatments are carried out, and when the number increases to 15–30 beetles per 1 m^2, continuous spraying is used during the growing season with drugs: Karate (0.1–0.125 l/ha), Fastak 10% (0.1–0.2 l/ha), Blyskavka (0.15–0.165 kg/ha).

Against aphids, which are found on the edges of the field and their number is 10–15 pcs. per plant, edge processing is carried out. In the case when aphids spread throughout the field, and the number reached 20-30 specimens per plant, Decis Profi, 25 WG is used for continuous spraying. (0.07 l/ha), Karate 050 EC (0.1–0.125 l/ha), Danadin 400 (0.5–1.0 l/ha), Aktara, 25 (0.1 kg/ha).

Against pea seeds, fireflies, fruit eaters, thrips, pea crops in the flowering phase are sprayed with the same preparations as against aphids.

It is fumigated to destroy the pea grain immediately after harvesting, before the beetles leave the seed.

Harvesting. The main method of harvesting is separate harvesting, which is carried out starting the harvest when the beans have browned 60–75% and the moisture content of the seeds is 33–38%. Peas are mown across the direction of laying, and short-stalked peas that lie down are cut against the direction of laying.

The selection and threshing of rolls should be started at a grain moisture content of 16–19%. In cases where pea crops are weeded or ripen unevenly, when 75% of the beans are browned, desiccation of peas is carried out with Reglon (3–4 l/ha) or Roundup (3.0 l/ha) at a grain moisture content of 45%. Clogging of crops when carrying out this agricultural measure should not exceed 5 weeds/m^2.

It is advisable to harvest weak and weed-free crops by direct harvesting, which improves its quality and seed suitability, reduces the risk of crop losses, and also saves time and material and technical resources.

The introduction into production of modern lodging-resistant short-stemmed semi-dwarf varieties with a moustached type of leaf makes it possible to use direct harvesting when harvesting peas. Peas are harvested when the beans are 100% ripe and the moisture content of the grain is 15–17%.

Taking into account the tendency of peas to uneven ripening, the harvested grain should be passed through grain cleaning complexes and dried with an active ventilation or on mine-type dryers. The main requirement for the process of drying pea grain is sufficient ventilation, heating it to a temperature of no more than 35-450C and reducing the humidity in one pass by no more than 4%.

1.6.3 Soy *(Glycine)*

Soy is the main protein-oil crop of world agriculture. The most valuable properties of the entire plant world are concentrated in it. Soy is a major legume crop 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% protein, 18–23% fat, 25–30% carbohydrates, enzymes, vitamins, and minerals. The protein content in soybeans and meal is 3-5 times, in concentrate - 6-7 times, than in cereals, and also 2 times more than in veal, 3 times more than in eggs, 11 times more than in milk In addition, soy protein is 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). Soy proteins, unlike the protein of other cultures, close to animal origin, have almost the same amino acid composition, which makes it possible to make many different food products from seeds. The peculiarity of the chemical composition of soybeans is the content of phosphatides in it - lecithin and nephalin, which are necessary for the nutrition of nervous tissue.

Milk, cheese, confectionery, food flour, etc. are made from soybean seeds. A new direction of food use of soy is the production of substitutes for sausages, chicken and turkey meat. Green beans are also used in food in boiled and canned form. Lecithin and gelatin are obtained from soy. Soy flour can be used as an admixture in bread baking and in the production of pasta.

Soy is used as an important fodder crop. It is grown for green fodder and silage in pure sowing and mixed with other crops: corn, sorghum, Sudanese grass, etc. The nutritional value of soybean feed is quite high. So, 100 kg of green mass corresponds to 21 fodder. unit and contains 3.5 kg of digestible protein. Soy hay, which contains 15.5% protein, 5.2% fat, and 38.5% carbohydrates, is also nutritious. Straw and chaff are valuable fodder for sheep. 100 kg of straw corresponds to 32 fodder units.

Valuable concentrated feed is soybean meal and cake. 1 kg of soybean seeds contains 1.31–1.47 fodder unit and 275–338 g of digestible protein. The amount of protein in the pulp reaches 47%.

As a row crop, soybean is of great agronomic importance. Thanks to nitrogen fixation, soybean plants meet their nitrogen needs by 70–80% and improve the nutritional regime by leaving in the soil after harvest with root and postharvest residues, on average per 1 ha: 60–80 kg of nitrogen, 20–25 kg of phosphorus and 30 -40 kg of potassium, which is equivalent to 10-15 tons of organic fertilizers. Therefore, it is a valuable precursor for most cultures. In areas with sufficient moisture, it can be grown as a siderable crop.

At first, soy was used only in the center of its origin - Southeast Asia, in particular in China. In China, it is known for 6 thousand years BC. It was the Chinese who introduced soy into culture. Methods of processing and using it for food needs were developed here. In Europe, it has been grown since the end of the 18th century. In Russia, soybeans have long been cultivated by settlers in the Far East, and in the European part - since the 70s of the 19th century.

Today, soybeans are grown on all continents. It plays an important role in the formation of grain, food and fodder balance. Soybean meal has become the protein basis of fodder mixtures, with the help of which the most intensive industries - animal husbandry, poultry farming, dairy cattle breeding, pig breeding - are successfully developed in America, Western Europe, Southeast Asia and other regions. Expanding the soybean acreage is a way to increase soil fertility, strengthen the economy, and increase food resources.

In terms of production and use, it ranks first in the world both among high-protein and oilseed crops. It is characterized by high adaptation to regional conditions, versatility of use, protein balance, and its functional activity.

The total area of soybean cultivation is more than 100 million hectares, in Africa - 0.8%, North America - 41.2, South America - 29.2, Asia - 26.9, Europe - 0.9%. Soy is an important crop in 50 countries. Its main crops are concentrated in the USA (27 million hectares), Brazil (13.3 million hectares), China (8 million hectares), Argentina (7.1 million hectares).

In terms of production volume, soybean is 2.3 times higher than all annual grain legumes combined. The countries of North America produce 53.0% of its world volume, South America – 28.5%, Asia – 16.6%, Europe

– 11%, Africa – 0.4%. The main soybean producers are the USA (75.1 million tons), Brazil (31 million tons), China (13.8 million tons) and Argentina (18.7 million tons). World production is more than 250 million tons.

In Ukraine, soybean acreage has increased significantly in recent years and, according to statistical data, amounts to 1.2 million hectares, the average yield is 1.62 t/ha. The biological potential of modern varieties is 14–17 t/ha. The record yield was recorded in the USA - 10.8 t/ha.

According to indicators of the availability of hydrothermal resources in the regions of Ukraine, the growing of soybean in Ukraine is distinguished, which covers the territory of the Northern and Central Steppes and the Forest Steppe. On this territory, soybeans can be grown on an area of up to 1 million hectares.

Biological features, varieties. In the ontogenesis of soybeans, the following phenological phases are distinguished: seed germination, seedlings, formation of the first trifoliate leaf, branching, budding, flowering, formation of beans, the beginning of yellowing of beans, maturation. The growing season is conventionally divided into three periods of growth and development: the formation of vegetative organs (I–II stages of organogenesis), the formation of generative organs (III–VIII stages of organogenesis), the formation and ripening of fruits (IX–XII stages of organogenesis). The growing season lasts 100–160 days.

Requirements to temperature. The culture is demanding on heat. The sum of the effective temperatures required for growth, development and formation of the crop depends to a large extent on the variety and ranges from 1700 to 3200^0C. Soybean seeds germinate at a temperature of +6...7^0C. Friendly shoots appear at a temperature of +12...14°C. In the phase of germination and seedling, the optimal temperature is +20...22^0C, during the flowering period +22...25^0C, formation of beans +20...23^0C, during the ripening period +18...20^0C. Temperatures above $+35^0$C have a negative effect on the growth, development and formation of nodules. Young plants tolerate frosts up to -2.5^0C relatively easily. Autumn frosts down to -3^0C do not have a negative effect on seed yield.

At the initial stages of growth and development, soybeans are characterized by high drought resistance.

Requirements to moisture. The moisture-lovingness of soybeans is determined by a high transpiration coefficient - more than 600. During germination, the seed absorbs 130-160% of water from its own weight, for which a reserve of water in the soil is required - about 30 mm in a layer of 0-20 cm. However, the requirements for moisture in different periods of growth are not the same. At the beginning of the growing season, soybeans can withstand drought. Plants are most demanding of moisture during flowering and bean filling, which lasts 40–48 days. During this period, the plant uses 10.2% of water from the total water consumption. The lack of water during this period leads to a violation of the processes of flowering and fruiting (falling of flowers and fruits). The coefficient of water consumption varies from 1500 to 2500 m3 of water for the formation of one ton of seeds. Favorable conditions for the growth and development of soybeans are at HTK from 1.0 to 1.7.

During the growing season, soil moisture should be within 75–80% of RH, and relative air humidity should be 70–75%. In conditions of overwetting of soybean crops, the activity of nodule bacteria decreases.

Relquirements to light. Soy is a light-loving plant with short daylight. When shading, its internodes are elongated, the ability to branch and form beans decreases. In early-ripening varieties, the light response is less pronounced, since the response of varieties to photoperiodism is closely related to the period of their vegetation. Early-ripening varieties are less responsive to day length than medium-ripening and especially late-ripening ones.

Requirements to soils. Soy grows well on a variety of soils, except for salt marshes and those prone to waterlogging. However, the demand for soil fertility in soybeans is quite high. If soybean plants are largely supplied with nitrogen due to biological fixation, then there should be sufficient amounts of phosphorus and potassium in the soil. In this regard, the most suitable for soybeans are sufficiently fertile loamy and sandy black soils rich in phosphorus, potassium and humus with a neutral reaction of the soil solution (pH 6.5–7).

Soy has high requirements for soil density. Its favorable parameters are within 0.9–1.3 g/cm3, optimal – 1.0–1.2 g/cm3. In compacted soil (more than 1.3 g/cm3), a weak symbiotic apparatus is formed in soybeans, the intensity of nitrogen fixation decreases, the main mass of the root system is located in the upper layer of the soil, so the plants can hardly tolerate drought and do not have enough nutrition.

Requirements to power cells. To produce 1 ton of soybeans, about 90 kg of nitrogen, 40 kg of phosphorus, 40 kg of potassium, 45 kg of sulfur, 150 kg of calcium and 50 kg of magnesium are consumed. During the period of growth and development from germination to flowering, soybean plants assimilate only 18% of nitrogen, 15% of phosphorus and 25% of potassium. The main part of nutrients enters the plant in the period from budding to grain pouring - 80% nitrogen, 80% phosphorus and 50% potassium.

In conditions of insufficient moisture and low moisture reserves, it is necessary to grow varieties of the early ripening group (the duration of the period from germination to ripening is 80–90 days): Annushka, Bilyavka, Legenda, Diona, and from early ripening (90–105 days) – Zolotysta, Omega Vinnytska, Artemisa, Angelika, Ustya, Yelena, Yug 30, Version, Vasylkivska, Vorskla. With sufficient moisture, medium-early ripening varieties are used - Themis, Podilska 416, Agat, Oriana, Znahidka, Feya, Almaz, Medea, Skelya, Yatran, Eldorado, Phaeton, Strategiya, the growing season of which is 105-125 days.

Promising varieties in the conditions of the Forest Steppe are Anastasia, Albina, Hoverla, Hudson, Danaya, Zlatovlaska, Iryna, Poema, Poltava, PVS-00.8, PVS-00.1

Cultivation technology. *Predecessors.* According to intensive technology, high yields of soybeans are obtained when they are placed in weed-free fields after winter wheat, spring barley, buckwheat, corn, potatoes, and in conditions of sufficient moisture and sugar beets. Special crop rotations can be saturated with soy up to 40% (with greater saturation, its yield decreases).

It is inappropriate to place it after legumes and perennial leguminous grasses, in the eastern and left-bank forest-steppe - after sunflowers. In field crop rotation, soybeans are returned to the previous place after 3–4 years, and in short crop rotations – after 2–3 years.

Tillage. Soy is extremely demanding on the quality of the main and pre-sowing tillage, which is not the same in different regions, and must be differentiated depending on the predecessor, topography, weediness of the field, etc.

The main cultivation includes one - two-time husking of the stubble after harvesting the predecessor, plowing to a depth of 25-27 cm, which effectively prioritizes the post-harvest residues and levels the field. Layered cultivation is used on field fields clogged with thistles and birches, 2–3 peelings are carried out along and across the field with peelers or cultivators-flat cutters. After harvesting the early precursors, high efficiency in the fight against weeds is achieved by peeling the stubble followed by plowing after the germination of the weed seeds. At the same time, the number of annual weeds decreases by 35–40%, perennial weeds by 95–98%. If husking is carried out annually, the number of weeds in the crop rotation fields is reduced by 40-50%, which is important when growing soybeans.

Fields after sugar beet and potatoes are mostly not discus, but are limited to plowing with a 22-25 cm depth.

In the presence of effective herbicides, no-till, minimal or zero tillage is possible. It is estimated that fuel consumption for soybean cultivation with no-tillage and minimal tillage is 20% lower than with traditional tillage, and 70% less with zero tillage.

Pre-sowing tillage should be aimed at creating favorable conditions for uniform sowing of seeds and promoting the mass emergence of seedlings. It includes closing moisture, leveling the ridge, cultivation, and, with the introduction of soil herbicides, their wrapping. It is enough to carry out one pre-sowing cultivation with cultivators of the KPS-4.0, USMK-5.4 type on the leveled, unweeded sedge; on fields littered with carrion and weeds, it is necessary to carry out two cultivations: I - destroys carrion seedlings and weeds (depth 8-10 cm), II - before sowing to a depth of 5-6 cm with simultaneous harrowing and leveling to create a dense seedbed for the seed to be sown.

Pre-sowing cultivation under soybeans is carried out on the day or on the day of sowing to the depth of seed wrapping at an angle to the direction of plowing and sowing. At the same time, it is necessary to preserve the structure from excessive soil compaction and process only the zone of seed wrapping. For pre-sowing cultivation, cultivators USMK-5.4, combined units RVK-5.4, RVK-3.6, ARV-8.1 and others are used to a cultivation depth of 4–6 cm. This is especially important for soybeans, which during seed swelling needs 130–160% of water from its mass. Pre-sowing cultivation and sowing should preserve the action of the capillary forces of the soil, so that the soybean seeds sown on the seed bed quickly swell, simultaneously germinate and give friendly seedlings.

Fertilization. Soy is characterized by high requirements for nutrients. Soy plants absorb much more nitrogen and phosphorus from the soil than winter wheat, corn, peas, buckwheat, etc. It was 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 ton of seeds and the corresponding amount of by-products. During the growing season, soybean plants receive nutrients unevenly. So, from seedlings to flowering, it assimilates 16.6% of nitrogen, 10.4% of phosphorus, 24.7% of potassium; from flowering to the beginning of seed formation and to the beginning of its pouring, respectively, 78.5; 50 and 82.2%. Therefore, it is possible to solve the problem of fully providing plants with available forms of macro- and microelements during the growing season due to the use of multi-component, chelated foliar fertilizers such as Kristalon, Reacom, Vuksal, Akvarin, etc. in the soybean fertilization system, which are characterized by a fairly high absorption coefficient.

he biological properties of the crop make it possible to make good use of the after-effects of both mineral and organic fertilizers, to fix molecular nitrogen in the air in symbiosis with nodule bacteria, and to assimilate hard-to-reach forms of phosphates.

It is recommended to apply manure or compost at the rate of 20–25 t/ha under the main tillage. For the conditions of the northern forest-steppe, on gray forest soils, it is recommended to apply 60–90 kg/ha d.r. phosphorus and potash fertilizers and 30–45 kg/ha d.r. of nitrogen in the spring, for the conditions of the Eastern Forest Steppe - 30–40 kg of the active substance NPK per hectare, for the Central Forest Steppe - application of $N_{60}P_{60}K_{60}$, or post-sowing application of superphosphate (50 kg/ha) or nitroammophos in the rows, for the Left Bank Forest Steppe - 20–25 kg/ha amophos in rows at the same time as sowing. On the chestnut soils of the Steppe, the dose of potassium is reduced to 30–45 kg/ha.

As a leguminous crop, soybean satisfies the need for nitrogen by fixing atmospheric nitrogen by only 30–50%, and therefore, in the initial period, nitrogen fertilizers are required. Nitrogen fertilizers in a dose of 30–60 kg/ha are applied for pre-sowing cultivation.

If mineral fertilizers were not applied during plowing in autumn, then they should be applied during pre-sowing cultivation in spring in a moderate dose of nutrients - $N_{60}P_{45}K_{30}$.

Soybean crops are also fed during budding with a complete mineral fertilizer of 20–25 kg/ha of nitrogen, phosphorus and potassium.

For normal growth, soybeans need to be fertilized with trace elements, of which molybdenum and cobalt play the biggest role. They are needed for the mobilization and assimilation of nitrogen and other functions. To relieve stress from herbicides and adverse factors, foliar foliar feeding is used in the most critical phases of growth and development: true leaf, budding, grain pouring.

Sowing. For sowing, cleaned seeds with high germination and germination energy are used, which are able to give friendly and strong seedlings. Before sowing soybeans, to protect against diseases (peronosporosis, white and gray rot), the seeds are treated with Fundazol, 50% (3.0 kg/t), Vitavax 200 FF (2.5–2.6 kg/t). On the day of sowing, soybean seed is treated with strains of nitrogen-fixing and phosphorus-mobilizing bacteria, or with Rizotorfin (200 g/ha) with the addition of trace elements (0.5–1.0% ammonium molybdenum solution) and growth stimulants. When processing, it should be remembered that direct sunlight has a detrimental effect on nodule bacteria.

Soy, compared to other crops, has increased requirements for heat during the sowing-seedling period. Sowing terms must meet these requirements. Their main criterion is the level of the thermal regime of the soil -12^{0}C at a depth of 10 cm. When soybean seeds are sown early in unheated soil, they are affected by diseases and, as a rule, the sprouts of the crop are thinned and unfriendly. It is also impossible to be late with sowing, delaying it by one day leads to an extension of the vegetation period of the crop by 1-2 days and a decrease in yield.

As a rule, soybeans are sown in wide rows with a row width of 45 cm. The seed sowing rate is 600–700 thousand pieces. (90–100 kg) per 1 ha. In farms with a high agricultural culture and when using highly effective herbicides, the usual row method of sowing with a row width of 15 cm is practiced, increasing the rate of sowing seeds to 0.8–1.2 million similar seeds per 1 ha.

Since soybeans bring cotyledons to the surface of the soil during germination, deep wrapping of its seeds is unacceptable, the optimal depth is 3–4 cm. When the seed layer of the soil dries out, the depth of wrapping is increased to 5–6 cm.

Crop care. The main task of caring for soybean crops is to reduce the harmfulness of weeds and the competition of cultivated plants for solar energy, mineral nutrients and water.

post-sowing soil rolling is effective To obtain friendly and uniform seedlings, , especially in dry weather. An effective measure is harrowing soybean crops (cotyledon leaf phase) when weeds are in the "white thread" phase or have just appeared on the soil surface. Harrowing is carried out with light or medium harrows at a tractor speed of 3–4 km/h across the sowing in the afternoon, when the turgor of plants decreases. If necessary, 15–17 days after the appearance of seedlings (phase 3–4 of a true leaf), inter-row tillage is carried out to a depth of 5–6 cm.

The introduction of soil herbicides to destroy weeds (chicken millet, schirytsia, mouse, white quinoa, etc.), as a rule, excludes the mechanical cultivation of the soil. In fields with a high potential soiling of the arable layer with seeds of annual, mainly grassy weeds, it is advisable to use Treflan 480, (2.0–5.0 l/ha) before sowing with immediate work into the soil, or after sowing Harness (1.5–3.0 l/ha) or Trophy 90, (1.5–2, 0 l/ha), which do not require immediate earnings.

During the growing season of soybeans, in the phase of 1–3 true leaves, for protection against weeds, Bazagran is effective, 48% (1.5–3.0 l/ha). In the phase of 2–4 true leaves, soybean crops are treated with Blazer 2C, (1.5–2.5 l/ha) for a weed height of 5–8 cm. Aramo 50, (1.0–2.0 l/ha), Fusilade Super 125 es, (1.0–3.0 l/ha), Galaxy Top, (1.5–2.5 l/ha).

For weed heights of 5–20 cm, it is advisable to use Targa, 10% (1.0–2.0 l/ha), Shogun 100 ES, k.e. (0.8–1.2 l/ha), regardless of the phase of culture development – Select 120, (0.4–0.8 l/ha). Against cereal and annual dicotyledonous weeds, Pivot is quite effective, 10% (0.5–1.0 l/ha) before sowing, before seedlings or in the phase of 2–3 true soybean leaves.

Soybean plants are most vulnerable to pests during the periods of establishment of generative organs and seed formation. When there is a threat of the spread of pests, the crops are treated with Bi-58 new preparations, 40% of (0.5–1.0 l/ha), Arrivo, 25% of (0.4 l/ha) and other insecticides, for the appearance of downy mildew, bacterial spotting, cercosporosis, anthracnose and other diseases, use Aliette, 80% z.p. (1.2–1.8 kg/ha), Rovral 50 vp (1.5 kg/ha) and other fungicides.

With the slow growth of nodules of nitrogen-fixing bacteria on the roots of plants (less than 5 pcs./plant) and the cultivation of intensive varieties, it is effective to apply nitrogen and phosphorus fertilizers in a dose of 20–30 kg/ha in the budding phase, as well as the use of fertilizers containing a set of macro- and microelements. In the phase of formation of green beans in the lower tier of the agrocenosis, foliar feeding is applied, which includes such components as nitrogen, phosphorus, potassium, molybdenum and boron.

When grown under irrigated conditions, soybeans are watered 4–5 times during the growing season (in the budding phase, during bean formation, during grain pouring). The irrigation rate is 500–700 m^3/ha.

Harvesting. In cases where ripening is prolonged due to excess moisture and weeding, it is advisable to desiccate the crops by 20% of the water. Reglon (2–3 l/ha).

Soybeans are harvested by direct harvesting in the phase of full ripeness at a grain moisture content of 16%. The speed of rotation of the threshing drum is up to 500 revolutions per minute. The cutting height of the plants should not exceed 6–7 cm, since about 6–7% of the beans are placed at a height of up to 5 cm, so the cutting device is set to the lowest cut.

Soybean seed losses increase if crops are thinned or weeded. The optimal speed of the combine when harvesting soybeans is 3–4 km/h. Immediately after harvesting, the grain heap is cleaned and, if necessary, dried in a soft mode. The optimal moisture content of seeds is 12–14%. Long-term storage of soybeans is possible at a humidity of 12% and below.

1.6.4 Beans *(Phaseolus)*

Beans are a valuable food leguminous crop. Its seeds contain 20–30% protein, about 2.5% fat, 50–60% starch and up to 4.5% sugar. Bean protein is similar in composition to meat proteins.

Beans are a good precursor for spring and, in the south, for winter crops. It can be grown in repeated crops, sowing after winter crops for green fodder, as well as in compacted crops with corn, potatoes, etc., in particular on homesteads.

Beans (large-seeded species) come from South America, and small-seeded beans (mung bean, adzuki) come from South Asia.

Beans were brought to Ukraine at the beginning of the 18th century. as an ornamental plant, and later it began to be grown as a vegetable crop. Already in the works of one of the first Russian agronomists, A.T. Bolotov highlighted the features of bean agrotechnics.

Beans are grown to obtain green seeds called "flagol" and green fruits - "scapula". Only the so-called asparagus or sugar varieties of beans are suitable for cultivation on a "shovel", in which there is no hard parchment layer in the pericarp. Varieties with a parchment layer are called peeling and are grown only for green or ripe seeds.

The world area of beans is more than 25 million hectares. Its largest areas are in India, Brazil, Mexico, the USA, Hungary, Bulgaria, Romania. In Ukraine, beans have long been grown in the southern and forest-steppe regions on an area of 25,000 hectares.

Biological features, varieties. Bean phenology is characterized by the dates of emergence of seedlings, primordial and first trifoliate leaves, the beginning of budding, flowering, formation of beans, and seed maturation (by periods of milky, waxy, and full maturity). The indicated phenophases are technological guidelines for timely sowing, application of fertilizers, carrying out agro-measures for plant care, determination of the best terms for harvesting.

Temperature requirements. Beans are one of the most heat-loving crops among legumes. Its seeds begin to germinate at +8...10°C. When the temperature drops to -1...2°C, plants die. Depending on the phase of development, beans need different temperatures. So, the optimal temperature for germination is +18...22°C, and for budding +20...25°C. At a temperature above +30°C, especially during a drought, drying and shedding of flowers and ovaries is observed. A sharp fluctuation in temperature during the day is quite harmful for beans.

Requirements to moisture. Beans are moisture-loving plants. Seeds need 106–114% of their own weight of water to germinate. The best conditions for growth are created at a soil moisture of 70% RH. High yields are obtained in regions where the annual amount of precipitation is at least 450–500 mm. It is a more drought-resistant crop than peas and lentils. The critical period for her during the drought is the phases of flowering and pouring of grain. Overmoistening harms beans, especially when it is accompanied by a drop in temperature.

Light requirements. Beans are a light-loving culture, but they develop well even in the shade. This biological feature makes it possible to grow it in compacted crops, in particular varieties with a twisted stem.

Soil requirements. The best soils for beans are chernozems and gray podzolized soils, light in mechanical composition, with a sufficient amount of lime. On heavy soils, acidic, swampy and sandy, beans grow poorly. Soils with a high level of groundwater are completely unsuitable for it.

A lack of nitrogen causes yellowing of seedlings, and a lack of phosphorus delays the growth of plants. Lack of potassium causes chlorosis, leaves and stems turn yellow.

According to the duration of the vegetation period, varieties of common beans are divided into 5 groups: very early ripening - 60–75 days; early ripening - 76–90 days; medium-ripe - 91–105 days; late ripening - 106-115 days and very late ripening - more than 115 days.

The main requirement for varieties is plant resistance to the most common and dangerous types of harmful organisms. The Register of varieties includes 12 high-yielding standard bean varieties suitable for mechanized harvesting: Bukovinka, Veselka, Dnipryanka, Dokuchaevska, Dvadesyatitsa, Zlatko, Mavka, Nadiya, Pervomaiska, Perlyna, Yarynka, Shchedra.

Cultivation technology. *Predecessors.* The best precursors for beans are winter and spring cereals, sugar beets, and corn. In the south-western regions of Ukraine, it can be grown in post-autumn crops after winter crops for green fodder. The term of its return to the previous place of cultivation is at least 4–5 years.

Fertilization. Beans are picky about feeding conditions. For the formation of 1 ton 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% of the necessary amount of elements is assimilated in the period from germination to the formation of green beans, that is, during the first 50–60 days.

The yield of beans is significantly increased by the application of fertilizers, especially organic ones. However, it is more expedient to apply manure under the previous crop.

Since beans meet only up to 50% of their nitrogen needs due to symbiotic nitrogen fixation, the amount of mineral nitrogen should be at least half of the full calculated dose.

The following rates of application of mineral fertilizers are recommended: on sod-podzolic and gray forest soils - $N_{45-60}P_{45-60}K_{45-60}$, on black soils - $N_{30–45}P_{45–60}K_{45–60}$ kg/ha of active substance.

Microelements - molybdenum, boron, manganese, magnesium, zinc, copper - have a positive effect on bean yield and grain quality.

Pre-sowing inoculation of seeds with preparations based on active strains of nodule and phosphorus-mobilizing bacteria is a mandatory element of cultivation technology.

Tillage. Field tillage for beans is no different from tillage for spring crops. Tillage from the beginning of spring work until the sowing of beans is aimed at preserving moisture, protecting against weeds, leveling the field and loosening the soil. With the onset of physical maturity of cultivation on light soils start with harrowing or cultivation with harrowing, on loamy and clay soils only cultivation is carried out.

As weeds appear, two or three cultivations are carried out before sowing the crop to a depth of 10–12 cm to 6–8 cm. The number of cultivations depends on weed contamination and soil moisture. In case of insufficient moisture level, the depth of cultivations and their number are reduced. Cultivation with harrowing or cultivation with modern combined units is carried out immediately before sowing.

Sowing. For sowing, it is necessary to use selected, high-quality seeds, with germination not lower than 95% and humidity - 14%. Two weeks before sowing, the seeds are treated with the drug Fundazol (3 kg/t) simultaneously with treatment with bacterial fertilizer and trace elements - molybdenum, boron, magnesium, zinc, manganese, 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^{0}C. The best method of sowing is wide-row with a row spacing of 45 cm. The sowing rate for small-seeded varieties is 400–500 thousand pieces/ha, for large-seeded tall varieties – 300–350 thousand pieces/ha of similar seeds at a depth of 4–5 cm, on on cohesive and moist soils – 3–4 cm, on light sandy soils and with late sowing – 6–7 cm.

Crop care. After sowing, the crops are rolled with ring or scarred rollers. The soil crust and weeds in the pre-emergence period are destroyed with the help of rotary hoes or by harrowing, when the weed seedlings are in the "white thread" phase, and the length of the bean seedlings does not exceed 1 cm.

The most effective method of weed control remains the combined one, in which the harrowing system is combined with herbicide treatment. For the destruction of one-year dicotyledonous and cereal weeds, it is recommended to apply the herbicide Gezagard (3 kg/ha) before sowing, and Bazagran (1.5–2.0 l/ha) is used in the phase of 3–6 leaves.

In the seedling phase - the first trifoliate leaf is interrowed 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 are closed. If necessary, inter-row cultivation is combined with crop fertilization.

Germinating seeds and seedlings of beans can be damaged by the larvae of sawflies, seedling fly, sand copperhead, gray weevil, black beet weevil, etc. Alfalfa aphids and spider mites damage vegetative plants. The seeds are damaged by bean weevil during storage. Among them, the most dangerous are the sprout fly and the bean weevil.

A number of agrotechnical measures are used in the fight against the sprout fly: high-quality pre-sowing soil cultivation, sowing at the optimal time.

In order to prevent the appearance of bean granuloid, it is necessary to spray bean crops during the budding period with the insecticide Bi-58 new, k.e. and other drugs approved for use in culture. If necessary, spraying is repeated after flowering. For the appearance of thrips or aphids on plants, spraying is carried out with the above-mentioned drug.

If signs of damage to plants by anthracnose, white rot or rust appear, the crops are treated with drugs approved for use on the crop.

Harvest begins when 70-80% of the beans turn brown and harden, and the leaves begin to dry and fall off. To prevent losses, it is better to harvest in the morning. The combine harvester is adjusted to the lowest possible cut (6–8 cm), since about 10% of the beans are placed at a height of up to 5 cm. To reduce grain injury, the frequency of rotation of the drum of the threshing machine is reduced to 400–500 rpm.

After threshing, the grain is cleaned of soil and impurities, if necessary, dried to a moisture content of 14–15% at a coolant temperature of +40...45^{0}C. The food bean grain is dried at a temperature of +65^{0}C for an hour, which leads to the death of the bean grain.

1.6.5 Lentil*(Ervum)*

Lentils are a valuable food and fodder

crop. It is grown mainly for grain, which ranks first among legumes in terms of protein and nutrition. Lentil seeds contain protein - about 32%, fat - 2% and non-nitrogenous compounds - 54%.

Lentil seeds are used in the food industry for the production of canned goods, various cookies and other products. In its nutritional value, straw is not inferior to hay of leguminous-cereal mixtures.

Lentils are a valuable precursor for many grain crops, including winter wheat, corn, and millet.

The homeland of large-seeded lentils is considered to be the regions of the Mediterranean Sea, and the countries of the Middle East are considered to be the homeland of small-seeded lentils. The world area is about 3.5 million hectares. The main reason for the insufficient spread of the culture is its short growth, which creates problems during harvesting.

The production of lentils in the world over the last 10 years ranged from 3.3 million tons to 4.55 million tons in 20120. Most of them are grown in such countries as: Canada, India, Turkey, Bangladesh, Australia, Nepal, the USA , China, Syria, Iran. Canada and Australia grow lentils almost exclusively for export. Approximately 75% of gross production is red lentils, 20% green, 5% brown and other types. The main producers of green lentils are the USA and Canada, while the rest of the world grows mainly red lentils. Green lentils are traditionally more common in Ukraine, all varieties of which in the State Register belong to this type. On average, 70% of cultivated lentils are consumed in the growing regions.

Biological features, varieties. The phenological phases of lentils are the same as those of lentil, with the difference that before the beginning of flowering, the stem grows slowly and branches weakly, and with the onset of the flowering phase, growth and branching increase. The main shoot and branches are in the second stage of organogenesis almost until the end of the growing season.

Temperature requirements. The minimum temperature for the germination of lentil seeds is +4...5°C, the optimal temperature is +15...18°C. Seedlings easily tolerate frosts down to -2...3°C. At a temperature of -6°C, the tips of the leaves freeze, but the crops do not die. During the growing season, the optimal temperature for growth and development is +17...20°C.

Moisture requirements. Lentils are an undemanding crop to moisture, so it is common in arid conditions. For germination, 80% of moisture from the weight of the seed is needed. Lentils tolerate drought better than peas, but during droughts, especially during flowering and bean formation, there is ovary drop and leaf and bean tip burning.

Light requirements. It is a long daylight plant. Flowering is long-lasting, especially in rainy and cloudy weather. This explains the uneven ripening of the beans. The duration of the growing season is 85–110 days.

Soil requirements. Sandy and light loamy soils are most suitable for lentils. Acidic, heavy, waterlogged soils are not suitable for it. On fertilized soils, it develops excessive vegetative mass, while reducing grain productivity.

The zoned lentil varieties include: Krasnogradska 100, Krasnogradska 49, Luhanchanka, Svitanok, Dniprovska 3.

Cultivation technology. *Predecessors.* Lentils grow very slowly at first and are therefore suppressed by weeds. The best predecessors for it are winter wheat, corn, potatoes, and sugar beets. Lentils are a good precursor for all spring cereals, in particular for corn.

It is necessary to return lentils to their previous place no earlier than after 5-6 years. It is not advisable to place it close to crops of perennial legumes.

Tillage. Hulling is used after stubble predecessors. Plowing is carried out to a depth of 25–27 cm as the weeds germinate. After potatoes and sugar beets, field plowing is carried out without preliminary peeling.

Spring tillage involves closing moisture with heavy harrows and pre-sowing cultivation with harrowing, under which it is mandatory to apply soil herbicides Gezagard (3.0 kg/ha) or Dual gold (1.2 l/ha).

Fertilization. Lentils are demanding on nutrients, in particular phosphorus and potassium. Phosphorous-potassium fertilizers are recommended to be applied under plowing at the rate of 40–60 kg/ha of active substance.

Applying nitrogen fertilizers is less effective than creating optimal conditions for symbiotic nitrogen fixation. In particular, this is seed treatment with rhizorthorphin, soil moisture within 60–80% RH, soil temperature +20...24°C, access to oxygen, neutral or slightly alkaline reaction of the soil solution, sufficient content of 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 recommended only for non-browning varieties. Seed contamination by pathogens is allowed no more than 10%. To prevent the development of fungal diseases that are transmitted with seed material, two to three weeks before sowing, 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) simultaneously with inoculation of seeds with nodule bacteria. The technique of inoculation of lentil seeds is the same as that of other legumes.

Since seedlings withstand spring frosts, lentils should be sown at the same time as early spring crops. Even a slight delay in sowing leads to a sharp decrease in yield. The experiments of the Kharkiv Research Station established that the most effective is the narrow-row method of sowing, in which lentils, like peas, lay down less and form a higher yield. Sowing rates are set depending on growing conditions. In the southern forest-steppe and steppe areas, it is recommended to sow 2–2.5 million grains per 1 ha, which for large-seeded varieties is 120–130 kg/ha. The seeds are wrapped to a depth of 4–5 cm, and if the soil moisture is insufficient, they are increased to 8 cm. The crops must be rolled.

Caring for lentil crops consists in destroying the soil crust and hunting flat-seeded vetch. To destroy weeds and bark, the seedlings are harrowed across the direction of the rows. During the growing season, when lentil plants are in the phase of two to five nodes, herbicides Pulsar (0.5–0.7 l/ha), Zenkor (0.6 l/ha) or Select (0.8–1.2 l/ha).

Harvesting. Lentils for green fodder are collected at the beginning of flowering, for hay - during the period of full flowering. To preserve the characteristic color of the seeds and prevent crop losses, separate harvesting should begin when 65-70% of the beans have reached full maturity. Since lentil seeds lose their characteristic color from rain and sun, the mown mass is threshed as it dries.

1.6.6 Chinnas*(Lathyrus)*

Sowing is used in our country mainly as a fodder crop: it is sown on grain, green fodder and hay. Plantain seeds contain 29–34% protein, 45–47% starch, 1% fat, 4–5% fiber and 2.5–3% ash. In terms of taste, it is inferior to peas, lentils and beans. Since the long-term feeding of chinnas can cause a disease of the animal's nervous system - lathyrism, it is recommended to feed it simultaneously with other concentrated feeds, in particular corn, and in limited quantities. A valuable feed is straw: 100 kg of it corresponds to 39 fodder units with a high content of digestible protein.

1 t of green mass of plantain contains up to 2.8 kg of digestible protein and 21.5 fodder units. In addition, 1 kg of green mass contains 76 mg of carotene and all necessary mineral salts for animals. The green mass does not become rough for a long time and remains tender and juicy, so its shelf life is longer than that of other spring fodder crops.

Chinna is a good honey bearer and is one of the best predecessors for other crops. It is also grown as a sidereal culture. The economic value is also determined by the resistance of the species to diseases and damage by pests. Crops are not treated with pesticides against grains, and the grown seeds are not gassed, because there are no pests in them.

Chinna belongs to ancient cultures. It was grown in Egypt, India, and the Roman Empire even before our era. Small-seeded forms come from South-West Asia, large-seeded ones - from the basin of the Mediterranean countries. It is grown in India, Iran, and Turkey. At the sorting offices of the Kharkiv region, 4.5 t/ha of rye grain are collected, and according to the data of the Pavlograd and Synelnyk sorting offices of the Dnipropetrovsk region - 4.6 t/ha. In arid regions, plantain is more productive (2.5–3.0 t/ha) than other leguminous crops, so it has the greatest prospects in the South-East of Ukraine. When grown for green fodder, the yield of sorghum reaches 25.0–35.0 t/ha, in arid areas it decreases to 12.0–15.0 t/ha.

It easily tolerates a significant drop in temperature in the spring and forms fairly stable crops in dry years. In steppe areas, it is not inferior to peas in terms of yield.

Biological features, varieties. The phenological phases of the plant have some features related to the nature of branching of the stem. The rudiments of lateral branches are formed in the axils of the two lower and two true leaves during the formation of the embryo. In the seedling phase, the growth of the main and side shoots begins almost simultaneously in plants with lower and mixed types of branching, that is, the stemming and branching phases coincide.

Temperature requirements. Chinna is a fairly cold-resistant culture.

Its seeds germinate at a temperature of +2...3°C, the optimal germination temperature is +20°C. The stairs of the plant can withstand a short-term drop in temperature down to -8°C. Thanks to the regenerative ability, frost-damaged seedlings grow back and are able to form a crop. During the flowering phase, plants are damaged by frosts of -1...3°C. The sum of the active temperatures required for ripening is 1500–1800°C.

Moisture requirements. For germination, the seed absorbs 100% of its mass of water. The transpiration coefficient is 400. It can withstand drought for a long time, and if it is followed by rains, it can form a high yield. During the period of flowering and budding, it is demanding on soil moisture.

In terms of drought resistance, peas, lentils and vetches prevail, second only to chickpeas. In wet and cool years, the plant is affected by rust, forms a large green mass and forms small seeds. In dry years, the growing season is shortened to 70 days.

Soil requirements. Chinna is undemanding to soils. Different types of soils are suitable, except for overmoistened and saline ones. It grows better on black soils and gray forest soils. Requires a neutral or slightly alkaline soil reaction (pH 7–8).

The following grades are common in Ukraine: Krasnogradska 4, Krasnogradska 5, Krasnogradska 7, Krasnogradska 8.

Cultivation technology. *Predecessors.* Field crops are placed after winter and row crops. The field must be free from weeds, as the plant grows slowly at the beginning of the growing season and is suppressed by weeds. It is a good precursor for grain and industrial crops.

Tillage. The system of main and pre-sowing tillage is the same as for other early spring crops.

Fertilization. The species is not demanding on soil fertility. It reacts poorly to the introduction of nitrogen fertilizers. China takes the most phosphorus and potassium from the soil. Phosphorus-potassium fertilizers should be applied under plowing at the rate of 50-60 kg/ha of active substance. Before sowing, the seeds must be treated with rhizorthorphin.

Sowing. Before sowing, the seeds are treated with Fundazol (2 kg/t). Since the seedlings of sorghum can withstand a significant drop in temperature, it is sown at the same time as early grain crops. The delay in sowing leads to a sharp decrease in the yield.

The method of sowing is conventional row sowing with a row spacing of 15 cm. With wide row sowing, the yield is lower. The seed sowing rate is 0.8–1.0 million similar grains per 1 ha, which for varieties with medium seed size is 160–220 kg/ha. The seeds are wrapped to a depth of 7–8 cm.

Crop care. The crops are rolled, which contributes to the friendly emergence of seedlings, especially with insufficient soil moisture. To protect against weeds and to destroy the crust, the steps are harrowed across the direction of the rows with medium harrows.

Harvesting. The main method of collection is separate. They start mowing in swaths when 50–70% of the beans are reached. They mow on a low cut, because the lower beans of the plants are placed at a height of 18–20 cm. Buckwheat beans crack much less than peas, but they should not be allowed to dry out.

Under favorable conditions, the pods can be harvested by direct harvesting when 90–95% of the beans are reached. Grain is stored at a moisture content of 14%.

1.6.7 Chickpeas*(Cicir*)

Chickpea is a valuable food and fodder crop. Its seeds contain up to 30% of protein, which is similar in quality to egg, and 7% of fat, it has good taste, so it is widely used as a food product. Varieties with dark colored seeds are used for livestock feed.

Its protein amino acid composition is very close to ideal - according to FAO criteria, its nutritional value is not inferior to other types of legumes, including soy. Due to 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 protein is 52–78%, the digestibility ratio is 80–83%. The seeds are a good addition to various products, especially baby food. Flour is used to make cookies and other sweets. It does not contain anti-nutritive compounds, so there is no need to heat it before feeding to animals.

The stems and leaves of chickpeas contain a lot of oxalic, malic and citric acids, so the green mass of this crop is unsuitable for cattle feed (straw is willingly eaten only by sheep).

Chickpea in symbiosis with nitrogen-fixing bacteria assimilates a significant amount of atmospheric nitrogen (100–120 kg/ha), uses difficult-to-dissolve mineral compounds from both the arable horizon and deeper soil layers that are difficult to access for grain crops. After harvesting, as much post-harvest organic matter as 15-20 tons of humus remains on each hectare with post-harvest residues.

Chickpea seeds contain a large amount of potassium and calcium, which are involved in the regulation of blood circulation, as well as selenium, which prevents the appearance of many diseases, especially such as endocrine, anemia, heart arrhythmia, nervous, etc.

Chickpea belongs to the most ancient crops in the world. It has long been cultivated in the republics of Central Asia. The world sown area is 10.5 million hectares, gross production is 8 million tons. The largest areas of chickpeas are in India (83% of the world area), Pakistan, they are sown in Italy, Spain, Turkey, Brazil, etc.

In Ukraine, favorable conditions for growing chickpeas are provided in the Zaporizhia, Mykolaiv, Odesa and Kherson regions.

Biological features, varieties.*Requirements to temperature.* Chickpea is a heat-loving and at the same time cold-resistant crop. The minimum temperature for seed germination is +2...4^{0}C, friendly seedlings appear at +6...8^{0}C. In terms of frost resistance, it ranks first among legumes. During a mild winter, crops, even in late autumn, overwinter well in the seedling phase under snow cover, withstanding a short-term drop in air temperature to -25°C. In the spring, after the snow melts, seedlings withstand frosts down to -16°C, adult plants do not die at -8°C.

The optimal temperature during the flowering period is +23..25^{0}C. Chickpea is a fairly heat-resistant crop, because at an air temperature of +40^{0}C, its leaves do not sag or lose turgor for 7-9 days.

Moisture requirements. Chickpea is a drought-resistant crop, has a developed tap root system that is able to transport water from a great depth and uses it economically. During germination, seeds absorb 120–140% of water relative to their weight. The transpiration coefficient is 350. Chickpea tolerates drought better than other grain legumes. Better tolerates a lack of water than overmoistening. Excessively wet weather during flowering reduces seed setting, side shoots are formed. In wet years, plants are damaged by ascochitosis, which often leads to the death of crops.

Soil requirements. The culture is medium-demanding to the soil. It grows well on saline soils. Black soil and chestnut soils are best for him.

Since chickpeas tolerate drought better than other legumes and grow on saline soils, its culture deserves to be widely spread in the southern regions of Ukraine. The growing season lasts from 80 to 170 days.

The following varieties of chickpeas are regionalized in Ukraine: Alexandrite, Dobrobut, Colorit, Ornament, Memory, Rozanna, Smachny, Stoik.

Cultivation technology. *Predecessors.* In the southern regions, chickpeas are mostly sown after winter cereals and row crops. Good precursors for it are corn and potatoes. Chickpea is a valuable precursor for winter wheat and corn. It is necessary to return to the previous place no earlier than after 4-5 years.

Tillage. After stubble precursors, the field is husked to a depth of 6–8 cm. After 10–14 days, a second husking is carried out to a depth of 10–12 cm. Plowing is carried out at the end of September to a depth of 20–22 cm in clean fields and 25–27 cm in weedy fields .

Fertilization. At a yield of 2.0 t/ha, chickpeas take 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 features make it possible to make good use of the after-effects of mineral and organic fertilizers, to fix molecular nitrogen in the air in symbiosis with nitrogen-fixing bacteria, and to absorb hard-to-reach forms of phosphorus at the expense of mycorrhizal fungi. Chickpea plants enter into a symbiosis with Rhizobium sisegi bacteria and, through biological nitrogen fixation, absorb up to 150 kg/ha of nitrogen from the atmosphere during the growing season, ensuring a seed yield of 2.0–2.5 t/ha without nitrogen fertilizers. After harvesting, up to 30% of biologically fixed nitrogen remains in post-harvest and root residues and is used by subsequent crops. Organic fertilizers in the amount of 30–50 t/ha should be applied only to the previous crop.

Chickpeas respond well to the after-effect of fertilizers applied under the predecessor. Therefore, when placing it after the rows, you can not apply mineral fertilizers. Chickpea plants need more phosphorus than cereal crops, 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 $P_{60}K_{60}$ under the plowing. The introduction of starting doses of nitrogen delays or inhibits the development of nodule bacteria and reduces their nitrogenase activity.

Sowing. Legume-rhizobial symbiosis is very sensitive to pesticides, the use of which is undesirable when growing chickpeas. All poisons to one degree or another have a negative effect on the formation of nodules and reduce their nitrogen-fixing activity. The least toxic include Fundazol, Vitavax and Bavistin.

An effective agricultural measure is the treatment of seeds immediately before sowing with chickpea rhizorthorphin, combined with poisoning with Fundazol (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 grain crops. Of the methods of sowing, the best is the usual row method, and in dry years - the wide-row one with a row spacing of 45 cm. The norm of sowing chickpea seeds in the wide-row method is 300-500 thousand, in the continuous row method - 600-800 thousand grains per hectare. The seeds are wrapped to a depth of 6–7 cm. If the soil is not sufficiently moist, it is increased to 10 cm. Since chickpeas, like peas, do not carry cotyledons to the surface of the soil during germination, deep wrapping during sowing does not negatively affect the yield.

Crop care. Chickpea plants are severely suppressed by the presence of weeds in crops, especially in the initial phases of the growing season. As soil herbicides, it is recommended to use preparations with the active substance acetochlor, a concentration of 90% (Harnes novy, Trophy, Etalon application rate of 2.0 l/ha), which destroy annual cereals and some dicotyledonous weeds. These preparations are applied before sowing or immediately after it without wrapping or with shallow wrapping when the soil is dry. The disadvantages of drugs of this class are a short duration of action, a weak effect on dicotyledonous weeds and a negative effect on the development of nodule bacteria.

The most effective drugs against dicotyledonous weeds are herbicides with the active substance imazethapir (Pivot, 10% r.c., Captain, 10% r.c.), which are suitable for application directly under leguminous crops. Herbicides of this group have an enhanced effect on annual grass and dicot weeds. They can be applied both before sowing and after, but before the emergence of seedlings in doses of 0.5–0.7 l/ha (preferably with shallow wrapping). The maximum dose of these drugs almost completely destroys all weeds. The active substance has a long-lasting effect; yes, wheat and barley can be sown no earlier than four months after application, corn - after a year, all other crops - after two. However, there is also an aftereffect on the main crop - chickpeas, especially in conditions of increased humidity. Chickpea plants may show yellowing, retardation in development and growth, various types of chlorosis. With the onset of normal weather conditions, all negative signs of herbicide action on chickpea plants, as a rule, disappear.

In recent years, experience has been accumulated in the use of Fabian herbicide for chickpeas, which includes two active components, imazethapyr and chlorimuronetyl. The herbicide destroys a wide range of annual and perennial grass and broadleaf weeds, including ragweed, ragwort and vetiver.

The active components 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 suppress 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.

On chickpeas, this herbicide is recommended to be applied before or after sowing, but necessarily before the emergence of crop seedlings. Its use on young plants leads to significant damage to them. Herbicide Fabian, thanks to two components and a lower concentration of imazethapir than Pivot and its analogues, causes less damage to subsequent crops. After harvesting chickpeas, it is possible to place winter wheat or barley on these fields, next year - spring cereals and corn.

During the growing season, against annual and perennial grass weeds, 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).

After sowing, the field is rolled with heavy scarred rollers followed by harrowing with light harrows. Kirku is destroyed with ordinary harrows, and during the appearance of seedlings - with rotary hoes. On wide-row crops, 2–3 cultivations are additionally carried out in the interrows. The first is carried out to a depth of 5–6 cm with a protective strip of 8–10 cm, the second – after 8–10 days to a depth of 6–8 cm and, if necessary, the third – before closing the rows. Inter-row cultivation, in addition to destroying weeds and soil crust after rains, helps loosen the soil, improves air exchange in it, which has a positive effect on the development of nodules.

There are no specific pests in chickpeas. However, in some years, especially when sowing after vegetable crops or in the fields next to them, severe damage by various types of scoops is observed. During the flight and laying of eggs, which coincides with the phases of flowering - the beginning of bean formation, one- or two-time treatments of crops with insecticides are effective. The preparations Connect 112.5 BS, k.s. have proven themselves well. (0.4–0.5 l/ha), Aktelik 500 EC, k.e. (1.0 l/ha), Arrivo, 25% k.e. (0.3–0.4 l/ha), Volaton 500, 50% k.e. (0.8–1.0 l/ha), Decis, 25% k.e. (0.3 l/ha), Sumition, 50% k.e. (0.6–1.2 l/ha), Fury, 10% (0.07–0.10 l/ha), Sherpa, 25% of (0.2–0.3 l/ha) and others.

More than forty diseases are found on chickpeas. However, in the conditions of southern Ukraine, only two diseases are widespread: ascochitosis and, especially, fusariosis. The latter causes wilting of seedlings, adult plants and rotting of seeds. Fusarium wilt is most common in wet and cool spring. The disease is, as a rule, of a fiery character.

When the plants are affected, yellowing of the leaves and their wilting is observed. In them, when the roots are broken, black dots or stripes of vessels clogged with mycelium of the fungus are visible. The infection persists in the soil, on plant residues and is transmitted through seeds. At the onset of conditions favorable for the development of the disease and the first symptoms of damage, it is recommended to treat the crops with a drug produced by Bayer Coronet (0.5–0.6 l/ha with the addition of Mero adhesive (0.4 l/ha) or, in the absence of this drug , others with the active substance *tebuconazole*.

Harvesting. The chickpeas ripen quite amicably, the beans do not crack, the grain does not fall off, the plants do not lay down. Harvesting begins in the period of yellowing of most beans. Chickpea varieties, in which the fruits are placed high, can be harvested by direct harvesting. Threshing is carried out with grain combines, reducing the number of revolutions of the drum to 400-500 per minute and lowering the drumming.

When standing on the stump, harvesting should be done in the morning so that the beans do not fall off.

1.6.8 Fodder beans *(Faba vulgarus)*

Forage beans are characterized by high fodder qualities: 100 kg of seeds correspond to 129 fodder units, and each fodder unit accounts for 220 g of digestible protein, and the same amount of green mass corresponds to 16 fodder units and 2.1 kg of digestible protein. Grain contains 25–35% protein, 50–55% starch, 3–6% fiber, 2.6–4.1% ash. Beans are also grown as a food crop, but in our country they are mostly used for livestock feed, mainly for the production of compound feed.

Forage beans in the yield of grain and green mass in the western regions of Ukraine in rainy years exceed other leguminous crops.

In areas with sufficient moisture, high yields of green mass with an increased content of digestible protein are collected from combined crops of forage beans and corn, which are used for green fodder and for making silage.

Beans are a good predecessor of winter and spring grain crops. They are used as a ball crop when growing vegetable crops, and in horticulture - for green manure. Beans are grown as a siderable crop and on heavy clay soils.

Beans belong to the most ancient crops that were grown in Egypt, Greece, and the Roman Empire. Beans have been cultivated in our country for a long time: even during the time of Prince Volodymyr in Kyivan Rus, they were grown as a vegetable crop. Now their largest areas are in Spain, Italy, Egypt, Morocco, and Brazil. The world area of fodder beans is about 8 million hectares, the gross harvest is 3.5 million tons with a yield of 1.5 tons/ha. In Ukraine, beans cover about 12,000 hectares.

Biological characteristics, varieties. The phenophases of fodder beans are the same as those of other leguminous plants with unlimited growth, with the exception of the tillering (branching) phase, which does not occur at optimal plant density.

Temperature requirements. Fodder beans are undemanding to heat, their seeds germinate at a temperature of +4...6°C. Seedlings tolerate short-term frosts down to -4°C. The most favorable 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 culture is most promising for areas with sufficient moisture. For seed germination, 110–120% of its weight is water. The seeds germinate more slowly than the seeds of peas, beans and lentils, which is explained by the presence of a thick seed coat on them, which does not allow water and air to pass through. The transpiration coefficient is 800.

When there is a moisture deficit in the soil, the beans grow slowly, drop their leaves, and the yield drops sharply. Plants almost do not tolerate waterlogging.

Forage beans - the plant is quite sensitive to long-term drought. Despite the fact that they have a well-developed root system, they do not tolerate dry and hot weather well, the plants wither quickly, and they produce fewer beans with a small number of grains.

Light requirements. They belong to long-day plants, and when grown in northern regions, the vegetation period is shortened. The duration of vegetation, depending on growing conditions, is from 90 to 130 days.

Soil requirements. Forage beans are characterized by increased requirements for easily soluble compounds of nutrients in the soil. The best for them are deep bound soils with a large amount of organic matter, capable of retaining water well. Thanks to a well-developed root system (root length 80–120 cm), beans are able to assimilate difficult-to-dissolve 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 more phosphorus than barley and winter wheat, and 2.5 times more potassium than peas and grain crops.

Soils unsuitable for beans are acidic, overmoistened and with stagnant groundwater at a depth of 50–60 cm. On such soils, the activity of nodule bacteria is inhibited, the root system dies, plant growth stops, which leads to a decrease in yield.

The following varieties of fodder beans are regionalized in Ukraine: Bilum, Visit, Orion, Prykarpatskyi 4, Yantarni. All these varieties are small-seeded and belong to the medium-ripening group.

Cultivation technology. The best predecessors for forage beans are potatoes, beets, corn and other row crops that keep the field clear of weeds. At the same time, beans are a good precursor for spring grain crops.

Fodder beans should not be grown after legumes and grasses, legumes. They can be re-sown on the same field no earlier than after 4-5 years, otherwise they will be damaged by root rot and other diseases and pests.

Tillage. Sparrow tillage for fodder beans is no different from tillage for peas and other legumes. Pre-sowing cultivation is carried out in one or two furrows to the depth of seed wrapping (6–8 cm) with simultaneous harrowing. It should be taken into account that forage beans respond positively to deep plowing - 25-27 cm.

In early spring, harrowing is carried out with heavy harrows. If it is planned to sow the field as soon as possible, harrowing is not carried out, but pre-sowing cultivation is immediately carried out to a depth of 10-12 cm. On heavy soils, two cultivations are carried out: the first - to a depth of 6-8 cm, the second - to a depth of 10-12 cm.

Fertilization. Forage beans use 60–70 kg of nitrogen, 15–21 kg of phosphorus, 25–28 kg of potassium, and 22–28 kg of calcium to form 1 ton of grain and the corresponding amount of straw. The largest amount of nutrients enters the plant in the phases of intensive growth of the stem - the formation of beans.

The yield of fodder beans increases significantly after applying organic and mineral fertilizers. It is recommended to apply manure under plowing (20–30 t/ha), and phosphorus-potassium fertilizers under plowing or in the spring for cultivation at the rate of 45–60 kg/ha of active substance. Nitrogen fertilizers applied under cultivation (15–20 kg/ha of the active substance) have a positive effect on the bean crop.

Sowing. Forage beans should be sown at the same time as early grain crops. The delay in sowing leads to a sharp decrease in the yield.

Early crops are less damaged by aphids and mature faster. To protect against bacterial and fungal diseases, the seeds are treated with Fundazol 15-20 days before sowing at the rate of 2-3 kg of the drug per 1 ton of seeds.

Forage beans are sown in wide-row and conventional row ways.

With the wide-row method of sowing, the width of the rows is 45 cm, and the distance between plants in a row is 10–12 cm. The seeds are wrapped to a depth of 5–8 cm. 450–500 thousand ha. The sowing rate for small-seeded varieties in the wide-row sowing method is 150 kg/ha, and in the row sowing method - 250 kg/ha. When growing beans with corn, they are sown in separate rows - after two rows of beans, four corn.

Crop care consists in loosening the soil and destroying weeds. Mandatory two-time harrowing of crops: the first - before the emergence of sprouts and the second - after sprouting in the phase of 3-4 leaves.

On wide-row crops, 2–3 inter-row treatments are carried out to a depth of 4–6 cm. During the last loosening, the plants are turned over. Interrow processing must be stopped before the onset of the budding phase.

In weedy fields, against annual dicotyledonous and grass weeds, soil herbicides Dual gold (1.3 l/ha) or Gezagard (3.0 l/ha) are applied to pre-sowing cultivation.

To protect against bruchus and aphids, crops are sprayed twice with the same preparations as peas (the first time during the flowering period and the second time after a week). To protect crops from diseases, the fungicide Ronilan (1.5 l/ha) is recommended.

Harvesting. The seeds of fodder beans ripen unevenly, so they are harvested separately when 25% of the lower beans are browned. They start mowing in swaths when the lower beans turn black and the seeds become hard.

To ensure simultaneous ripening of seed crops, Reglon super desiccant (4 l/ha) is used. Crops are sprayed when the lower beans turn yellow 8–10 days before harvesting.

1.6.9 Lupine *(Lupinus)*

Lupine is a valuable forage crop. Its seeds contain 38–52% protein, 25–40% carbohydrates, 5–20% fat. For fodder purposes, lupines began to be used in the 1930s. - after breeding non-alkaloid varieties. They include varieties whose seeds contain no more than 0.0025% of alkaloids. Protein concentrates are used to make artificial wool. Technologies for using lupine as a food product are being developed. So, some types of lupine (for example, variable) contain up to 20% of fats, which can be used both for technical purposes and in the food industry. There are trial technologies for baking confectionery products from it, production of candies, etc.

By the content of digestible protein in grain, it exceeds peas by 1.6–1.7 times, corn by almost 4.5 times (341 versus 195 and 78 g/kg, respectively); carotene in the green mass of lupine is 10 times more than in fodder beans (200 vs. 20 mg/kg); in 1 kg of straw - 0.32 k.o. and 23 g of digestible protein, while in wheat straw - 0.20 k.o. and 8 g of protein.

Lupine, as one of the most nitrogen-fixing crops, is a valuable sidereal crop. Up to 300 kg or more of nitrogen is fixed from the air on 1 ha of lupine sowing, which is equivalent to the action of 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 the poor soils of Polissia (yellow and narrow-leaved lupine). White lupine is grown in Lisostepa and Polissia. The total sown area of lupine in Ukraine is about 60,000 ha, and the average yield is 1.0–1.4 t/ha.

Fodder lupine in Ukraine is represented by yellow, capable of forming a grain yield of 2.0–2.5 t/ha, green weight of 60–80 t/ha, white with indicators of 4.0–5.0 and 55–70 t/ha, respectively ha and narrow-leaved species - 2.5–3.5 and 60–70 t/ha.

Among the fodder lupine varieties, there are alkaloid-free, or so-called "sweet" ones, whose alkaloid content in the seeds does not exceed 0.0025% (it can even be eaten), and low-alkaloid ones with an alkaloid content of 0.1 to 0.2%. In the seeds of sideral or "bitter" lupins, the alkaloid content reaches 1–2% or more. However, as purely sideral crops, "bitter" lupins have lost their importance and have been replaced by fodder lupins, which are both high-protein fodder for livestock (ripened grain or green mass) and improve soil fertility.

Collecting protein from 1 ton of fodder lupine grain is equivalent to 4.5 ton of barley grain or 5–6 ton of corn.

Lupine originates from the Mediterranean basin, where it was cultivated more than 2-3 thousand years BC. White lupine was known in Egypt, Greece, and ancient Rome. The perennial lupine comes from North America. In Ukraine, lupine began to be grown at the beginning of the 20th century for green manure.

Biological features, varieties. The lupine genus unites more than 250 species. Narrow-leaved, yellow, white, variable and perennial lupins are grown in Ukraine.

Lupine phenophases are slightly different from other grain legumes. Lupine forms a rosette of leaves, and branching of the stem precedes flowering (blue lupine) or begins after the flowering of the apical tassel (white lupine). In its development, lupine goes through the following phases of growth and development: seed germination, seedlings, formation of the first finger leaf, branching, budding, flowering, formation of beans, pouring and ripening of seeds.

Temperature requirements. Lupine is an undemanding to heat culture. The optimal temperature for the germination of narrow-leaved lupine seeds is +9...12°C (minimum +2...4°C), yellow +10...14°C (minimum +3...5°C), white +15...16°C (minimum +4...6°C). Seedlings of yellow lupine withstand frosts up to -2...3°C, narrow-leaved - up to -5°C. White lupine dies at sub-zero temperatures.

Moisture requirements. All varieties of lupine are demanding on moisture and are plants of long daylight. The period of seed germination and the period of formation of generative organs (from the budding phase to the formation of shiny beans) are critical periods in relation to providing moisture for the culture. 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 wheat, and the ability to maintain a high temperature in the tissues allows it to carry out photosynthesis even in the cold.

Soil requirements. Compared to other leguminous crops, lupine is not picky about soil fertility, but the most suitable are light and permeable soils. White lupine is the most demanding of soil fertility, yellow lupine is the least demanding. It grows on acidic soils, but it is better at pH 5–6. Carbonate, swampy and saline soils are unsuitable for lupine.

Varieties of lupine are divided into fodder, food, and cider varieties according to their use. The Register of varieties includes 10 varieties of white lupine (Volodymyr, Veresnevy, Garant, Diet, Kozeletsky, Lybid, Makarivsky, Serpnevy, Tuman, Shchedry 50), 6 varieties of yellow (Burshtyn, Kruglyk, Obry, Pripyatsky, Progressive, Chernihiv) and 3 varieties narrow-leaved (Zirkovy - sidereal, Pelikan and Flamingo - universal use).

Modern varieties of lupine are divided into three groups according to the content of alkaloids: alkaloid-free - the content of alkaloids does not exceed 0.025%; low alkaloid - 0.025–0.1%; alkaloids - more than 0.1%. Varieties of the first two groups are considered fodder (sweet), their vegetative mass and seeds can be fed to animals unconditionally. Alkaloid (bitter) lupins are fed in small quantities only in a mixture with other feeds.

Cultivation technology. *Predecessors.* Lupine is grown as the main crop in crop rotations, as well as post-harvest, post-harvest and in mixtures. As the main crop, it is grown for grain, green fodder and silage. For green fodder and silage, lupines are placed in steam fields before sowing winter crops. Lupine seeds should be sown on weed-free fields after winter and spring cereals, potatoes, corn, sugar beets and other non-legume row crops. It can be sown on the same field no earlier than after 4-5 years. It should be noted that on very poor soils only 2-3 crops are forced to alternate: for example, lupine - rye - oats.

Fodder lupine is one of the best siderates, so it can be grown in post-harvest, post-harvest crops, as well as in mixtures with other crops. During the growing season, it assimilates 130–230 kg/ha of nitrogen from the air and can leave 50–150 kg/ha in the soil for the next crop rotation. Lupine can be grown in mixed crops with wheat and rye. By winter, they form 6.0–7.0 t/ha of green mass, which in winter acts as a backdrop, and in spring it decomposes and is a fertilizer.

It is not desirable to place it after cereals, the cultivation technologies of which involved the use of herbicides with a long-lasting effect and can have a negative effect on lupine plants, as well as after legumes, perennial cereal grasses and next to cruciferous and perennial leguminous grasses in connection with the threat of migration of pathogens and pests. Return to the field in crop rotation - no earlier than after 2-3 years, for varieties resistant to fusarium - after 5-6 years.

Tillage. The main purpose of pre-sowing treatment is to loosen the soil to a fine clod state and create a dense bed at the depth of seed wrapping. Pre-sowing treatment of light sandy and loamy soils includes one or two harrowing with heavy harrows, on more cohesive soils - closing of moisture by harrowing and pre-sowing cultivation to a depth of 6-8 cm with harrowing. If the amount of moisture in the arable layer is insufficient, spring leveling of the soil should be avoided, which causes mixing of the parched upper layer with the lower, wetter one. In this case, it is advisable to sow as soon as possible immediately after performing the generally accepted spring cultivation, which is cultivation to the depth of seed wrapping.

Fertilization. 60 kg of nitrogen, 17 kg of phosphorus and 33 kg of K_2O are needed to form 1 ton of grain and the corresponding amount of by-products. 65–70% of the nitrogen requirement of fodder lupine is satisfied due to symbiotic nitrogen fixation of plants, the rest – due to soil nitrogen. Lupine has a deeply penetrating root system, which makes it possible to use nutrients not only from the arable, but also from the subsoil layer. In addition, with the help of root secretions, plants are able to transform poorly soluble compounds of phosphorus and potassium into an accessible form, therefore, 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) it is impractical to apply phosphorus and potassium fertilizers. At a very low, low, medium and high content of these elements, it is effective to apply phosphorus and potassium fertilizers in a ratio of 1:2 ($P_{30–45}K_{60–90}$ kg/ha per year). Nitrogen fertilizers in a dose of 20–30 kg/ha is advisable to apply only under white lupine. Necessary trace elements that activate the process of symbiotic nitrogen fixation are molybdenum and boron. If their content in the soil is low (less than 0.3 mg/kg of soil), it is advisable to use fertilizers containing these elements.

Sowing. High-quality seeds with a germination rate of 90–95% are used for sowing. 2 weeks before sowing against ascochitosis, fusariosis, anthracnose, seeds are treated with Fundazol, Vitavax or Tygam (3–4 kg/t of seeds). On the day of sowing, the seeds are inoculated with preparations based on active strains of nodule bacteria. If necessary, treat with trace elements at the same time, using their 0.1% solution instead of water to dilute nitrogen.

The sowing of narrow-leaved lupine for grain is started simultaneously with the sowing of early spring crops. The main requirement is that the soil must be ripe, and its temperature at a depth of

10 cm must exceed +5^{0}C. Under the specified conditions, flower buds are laid earlier, the stem is formed shorter, but with a more productive central tuft, plants mature more amicably, crops are less damaged by pests and diseases. In years with early spring, the best time to sow lupine for grain is the period after early spring crops, in years with late spring – simultaneously with early spring crops.

On weed-free fields, lupins are sown in the usual row method with a sowing rate of yellow and narrow-leaved 1.2–1.4 (160–180 kg/ha), white – 1.0–1.2 (230–260 kg/ha) million/ha of similar seeds. On seed crops, weedy fields, as well as on more cohesive, flooded soils, it is more expedient to sow lupins in a wide-row method with a row width of 45 cm and a sowing rate of yellow and narrow-leaved 1.0–1.2, white – 0.8–1 .0 million/ha of similar seeds. The depth of wrapping of yellow and narrow-leaved lupine seeds on light soils is 3–4 cm, on more cohesive ones – 2–3 cm, white – 4–5 and 3–4 cm, respectively.

Crop care. Caring for crops is reduced to protection from weeds, pests, diseases and inter-row cultivation.

Along with the insignificant competitiveness of lupine plants to weeds, it is characterized by significant sensitivity to herbicides. This biological feature is the main reason why the list of drugs approved for use on lupine crops does not include herbicides for the destruction of weeds during the plant's growing season. To date, only two soil herbicides recommended for application under pre-sowing cultivation are permitted - Treflan and Triflurex (1.5–3.0 l/ha).

To control weediness and improve the air-water properties of the soil in wide-row crops, inter-row loosening is recommended: 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.

Obtaining high-quality seed material is impossible without protection from pests. In case of exceeding the ecological threshold of harmfulness by lupine weevil, stem fly, aphid (15 pcs./m2) of sowing in the phase of the end of budding - the beginning of flowering, treat with insecticides Bi-58 new (0.5–1.0 l/ha) or Shtefesin (0 .2 l/ha).

The spread of such diseases as anthracnose, brown spot, fomosis and others in lupine crops is prevented by pre-sowing spraying with chemical poisons approved for use on the culture, biofungicides (Mikosan, Agat 25-K), treatment with which does not suppress the development of nodule bacteria, and spraying crops with Rovral FLO , (3 l/ha) during the period of budding - binding of beans.

Harvesting. The lupine ripens unevenly on the grain. Beans often crack when ripening, so it is advisable to collect them separately when 3/4 of the beans turn brown on the plants. In order to accelerate the ripening and drying of plants, 2 weeks before physiological maturity, which is determined by the light yellow color of the root of the seed embryo, desiccation or defoliation of crops is used with a solution of Reglon (2.5 l/ha), ammonium nitrate (100–120 kg /Ha). Such crops are harvested by direct combining.

After threshing, the grains are cleaned of impurities, weeds, chaff and, if necessary, dried. The grain is dried at a moisture content of more than 14%, but the temperature of the heat carrier should not exceed 35–45^{o}C, and the moisture loss in one pass should not exceed 4%. During intense heating, an excessive amount of water vapor accumulates in the seed, under the pressure of which the seed coat breaks, which contributes to the penetration of infection under the coat and leads to a decrease in the sowing qualities of the seed.

2 TECHNICAL CULTURES

Industrial crops – agricultural crops grown for the purpose of obtaining raw materials for various industries (food, textile, soap, paint, pharmaceutical, chemical, etc.). This is a large group of field crops that includes many families, so there is no common botanical, biological and ecological characteristic. According to the intended purpose, technical crops are divided into groups (in parentheses are some representatives of the group that are cultivated in Ukraine): starch-bearing (potatoes, which are usually not included in technical crops, but are considered in the group of tuberous plants), sugar-bearing (sugar beets, stevia), oleaginous (sunflower, rapeseed, curly flax or oleaginous, ginger, castor oil), essential oil (coriander, essential rose, peppermint, clary sage), spinning (flax, hemp, cotton), medicinal (valerian , purple echinacea, common ginseng), aromatic and narcotic (hops, tobacco, shag).

Some technical plants have been cultivated in Ukraine for centuries (e.g. flax, hemp), some since the 19th century. – sugar beets, sunflower, hops, some (cotton, typhoon) just from the most recent times. A new direction in the use of technical crops is the production of various types of biofuel: biodiesel, bioethanol, biogas and solid fuel.

2.1 POTATOES

Potatoes are the most important and widespread among tuberous crops in world crop production, including in our country. Earthen pear (topinambur) is grown on small areas. Sweet potatoes, cassava, yams, taro and other crops are common in other countries of the world.

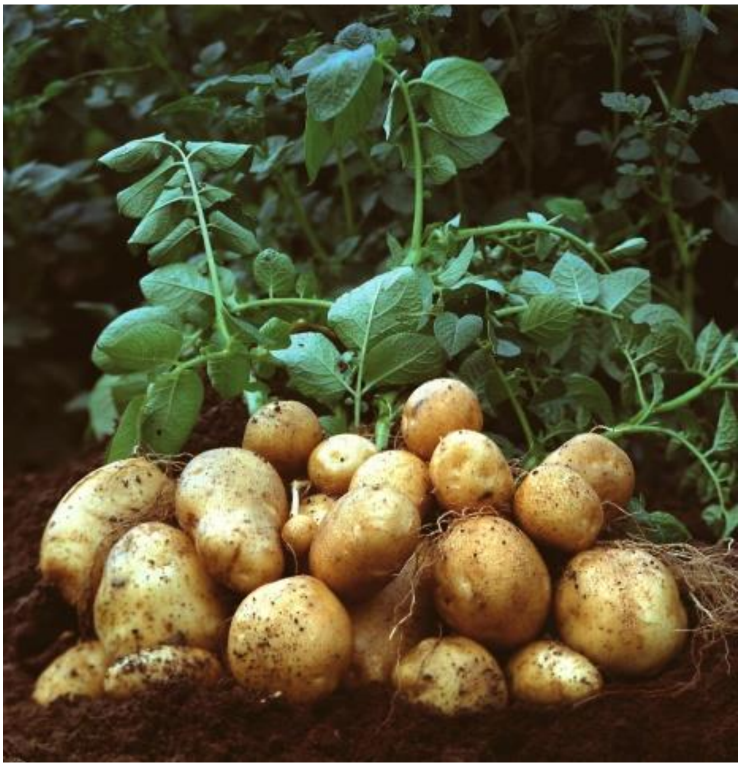
Sweet potato is common in Africa, India, China, Japan, the USA, South America, Central Asia, and the Caucasus. Belongs to perennial plants with creeping stems 5 m long. Forms tubers with white flesh weighing from 0.5 to 5 kg or more. It is used as a food and fodder crop. The yield of tubers is 9.0–10.0 t/ha.

Cassava is grown in India, Africa, Central and South America, and Indonesia. It is a perennial shrub plant belonging to the milkweed family. Spindle-shaped tubers weighing up to 1.5 kg are formed as thickenings of 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 Dioscoreaceae family. Tubers weighing up to 5.0 kg are formed in the form of root thickenings. It tastes like potato tubers. They are used boiled like potatoes. Flour is made from dried tubers.

Tarot is widespread in Africa, Asia, and Indonesia. It is a perennial herbaceous plant from the Aroid family. Tubers weighing up to 4 kg are formed at the ends of rhizomes. They are used boiled, fried, they are used to make waffles, cookies, and cakes.

2.1.1 Potatoes*(Solanom tuberosum L.)*



Potatoes are among the most important agricultural crops. In world agriculture, it occupies one of the first places along with rice, wheat and corn. It is a culture of universal use. Potato is an important food, fodder and technical crop.

Potato tubers are a real chemical laboratory and contain 25% dry matter, including 14–22% starch, 1.4–3.1% protein, 1% gluten, 0.2–0.3% fat and 0.8–1 % ash elements.

Potatoes are an important source of anti-scurvy vitamin C and vitamins A, B1, B2, B, D, which increase the body's resistance to diseases of the nervous and circulatory systems. The tubers contain a number of important enzymes of organic acids (citric, oxalic, malic), 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. Silage from green tops and waste from industrial processing are also important as fodder. In terms of digestibility of organic matter (83–97%), ittakes one of the first places among vegetable fodder, like fodder root crops. The fodder nutritional value of 100 kg of raw tubers is estimated at 29.5 fodder. unit and 2 kg of digestible protein, silage - 8.5, dried zhmaks - 95.5, dried bard - 52 fodder. unit With a yield of 12.0–15.0 t/ha of tubers, the yield of fodder units can exceed 5.5–6 thousand.

In medicine, the potato diet is recommended as a diuretic, fresh potato juice is used for scurvy, jaundice, 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 boiled potatoes helps with catarrh of the upper respiratory tract.

Potatoes are a valuable raw material for the processing industry. Alcohol, starch, molasses, glucose, dextrin and other products are made from tubers. From 1 ton of tubers, which contain 17.6% starch, 170 kg of starch and 1000 kg of pulp or 112 liters of alcohol and 1500 liters of liquor are obtained.

Due to the content of starch, high-quality protein and vitamins in potato tubers, as well as high taste properties, it is a very useful product for human nutrition. Potatoes are rightfully called the second bread. In European cuisine, there are more than 200 dishes made from potatoes and their processing products. Modern methods of processing potatoes into food products and semi-finished products open up new opportunities for their use.

It should be remembered: the skin and pulp of green potato tubers contain a poisonous substance - solanine (0.005-0.01%), which partially decomposes during cooking. Therefore, green and sprouted tubers under daylight or artificial lighting are unsuitable for food and animal feeding without thorough cooking.

Recently, a special substance - glycoalkaloids, which are structurally similar to digitalis glycosides - has been discovered in potato skin, flowers, leaves and stems. In moderate doses, these compounds cause a steady and long-term decrease in blood pressure, increase the amplitude and decrease the frequency of heart contractions, have anti-inflammatory, pain-relieving and anti-allergic effects, and have a positive effect on the course of burn shock.

As a row crop, potatoes with high agricultural technology contribute to the reduction of weediness in fields and are a good precursor for grain and other crops, and early varieties for winter crops as well.

South America (Chile, Peru, Bolivia) is considered the homeland of the potato, where it was grown 2 thousand years BC. It was brought to Europe (Spain) in 1565, from where it gradually spread to Italy, France, Holland and other European countries. Potatoes were brought to Russia by Peter I from Holland (1710–1725). It began to be intensively grown in Russia since 1765.

Now potatoes are grown on all continents in most countries of the world on an area of more than 20 million hectares. The largest cultivated areas in European countries are up to 13 million hectares. In the CIS, potatoes occupy 6.0–6.5 million hectares. The world production of potatoes is 300 million tons. The main producers on the American continent are the USA and Canada, in Asia - China and India, and in Europe - Russia, Belarus, Poland, Germany.

Per capita consumption of potatoes in different countries varies from 40 to 175 kg per year, including 175 kg in Belarus, 138 in Ukraine, 127 in Russia, 99 in Great Britain, 105 in Japan, 80 in France, and 60 in the United States. , Canada - 65 kg.

In Ukraine, potatoes are grown on an area of 1.5–1.6 million hectares. The largest massifs are concentrated in Polissia - about 60% and in the Forest Steppe - up to 30%. The average yield of potatoes in favorable years is 12.0–13.0 t/ha of tubers. In the advanced farms of the Chernihiv region, 25.0–30.0 t/ha of tubers and more are obtained. 35–40 t/ha are harvested annually at the Vlada farm in the Mlyniv district of the Rivne region, using modern zonal cultivation technologies.

Biological features, varieties. In the development of potatoes, four phases are determined: germination, budding, flowering and ripening. The duration of each phase depends on the characteristics of the variety and growing conditions. Thus, seedlings of medium-ripe varieties of potatoes appear after 15–20 days, 17–24 days pass from seedlings to the beginning of budding, 14–18 days from budding to full flowering, and 45–48 days from flowering to the death of the tops. Each period is shorter in early-ripening varieties, and several days longer in late-ripening varieties.

Temperature requirements. Potatoes belong to heat-loving crops. Tubers begin to germinate when the soil temperature at a depth of 10–12 cm is not lower than +3...50C. However, the appearance of seedlings at such a temperature is delayed for 30–35 days and they are affected by diseases. Normal germination of tubers occurs at a temperature of +7...8^{0}C. The higher the soil temperature, the earlier the seedlings appear. The optimal temperature for tuber germination is +18...20^{0}C, at which seedlings appear 10–12 days after planting. Potatoes ensure maximum crop growth at an average daily temperature of +17...18^{0}C. With sufficient lighting and soil moisture, the formation and growth of tubers and the accumulation of starch in them occurs better at a soil temperature of +16...17^{0}C, and above-ground mass (stems, leaves) - at +18...22^{0}C. The most favorable temperature for photosynthesis is +22...25^{0}C. At a temperature above +30^{0}C, the assimilation processes stop, the growth of tubers and the accumulation of starch in them. High temperatures not only retard the growth of tubers, but also cause potato degeneration, which is the main reason for the limited cultivation of potatoes in the southern arid regions.

Potatoes are sensitive to minor frosts. Seedlings die when the temperature drops to -2...3^{0}C. At the same time, tubers in the soil remain viable and have the ability to germinate and form new shoots. During autumn frosts, when the soil temperature drops to -2^{0}C, the tubers freeze and lose their ability to germinate.

The sum of temperatures during the growing season above +10^{0}C, necessary for the full development of potatoes, is 1000–1400^{0}C for early and mid-early varieties, and 1400–1600^{0}C for late-ripening ones.

Moisture requirements. Potatoes are very demanding on moisture, as they form a powerful aerial mass due to an underdeveloped root system. The transpiration coefficient of potatoes is 400–550, but can vary from 170 to 660, which indicates its considerable plasticity and adaptability to environmental conditions. On fertile soils, with a sufficient supply of nutrients, potatoes use water sparingly. The best conditions for the growth and formation of a high yield of tubers are created at a soil humidity of 70–80% RH in the area of the root system during flowering and tuber formation and 60–65% during the accumulation of starch in the tubers.

As the plants grow, the potato's need for moisture increases. The critical period for it is the flowering phase, when the leaf surface reaches its maximum size. The lack of moisture in the soil at this time causes a decrease in the yield of tubers by 17–20%. The lowest requirements for moisture are observed in the initial period, when seedlings and seedlings are formed due to the water of the mother tuber.

Potatoes are better than other crops able to use water from the air with the help of leaves, thanks to which plants suffer less from short-term droughts. However, a guaranteed high yield of potatoes can be obtained only if at least 300 mm of precipitation falls during the growing season. Therefore, in areas of insufficient moisture, special care should be taken to preserve and accumulate moisture in the soil. In these conditions, the moisture deficit can be compensated only by irrigation.

Potatoes, at the same time, do not tolerate excessive soil moisture, which negatively affects its growth and development. In conditions of excessive moisture, when soil moisture exceeds 85% RH, premature death of plants is observed, the growth of tubers stops, they rot, and their yield and quality deteriorate sharply.

Light requirements. According to the modern classification, cultivated varieties of potatoes belong to short-day plants. And although a short day is not mandatory for her, under the conditions of a short day in potatoes, the period of tuber formation is shortened. However, when potatoes are grown in areas with long daylight, more intense flowering, better development of vegetative organs and a higher yield of tubers are observed.

Like any row crop, potatoes are picky about light. In case of shading, excessive thickening or significant weeding, plants turn yellow, stretch out, almost do not bloom, photosynthesis, exchange processes and soil nutrition are disrupted in them, which leads to late formation of tubers and a decrease in yield.

The direction of the rows significantly affects the yield and quality of tubers. According to research, potato plants are better lit during the day if the rows are placed in the southeast, northeast, or northwest directions compared to the west-east.

Requirements for power cells. Potatoes consume the largest amount of nutrients during the intensive growth of above-ground mass and at the beginning of tuber formation (flowering phase). At the end of the growing season, the use of nutrients by plants gradually decreases and completely stops at the beginning of drying of the leaves. During the flowering period, potatoes use about 60% of nitrogen, 45–50% of phosphorus and more than 50% of potassium.

With an average yield of 18.0 t/ha of tubers and 8.0 t/ha 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 ton of tubers, this amounts to 5.6 kg of nitrogen, 2.2 kg of phosphorus and 6.4 kg of potassium.

Soil requirements. The potato root system is characterized by an increased intensity of respiration, especially during the period of tuber formation. For the formation of 1 g of dry matter, 7–12 mg of oxygen is consumed within one hour. In order to ensure a sufficient amount of oxygen, the soil must be in a sufficiently loose state. On loose soil with a volumetric mass of 1.1–1.2 g/cm^3, 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 due to oxygen starvation. On compacted soils, in addition, stolons do not develop well, and small, often deformed tubers are formed.

For the normal development of tubers, the soil must be loose, fertile, aerated with a water-permeable subsoil. Sufficiently fertilized sandy and loamy soils, light chernozems are most suitable for potatoes. When organic fertilizers are used, potatoes are also grown on light sandy soils. Heavy clay soils are not suitable for potatoes. On such soils, potatoes suffer from diseases, small tubers with reduced starch content are formed. Potatoes will grow poorly even on saline soils. Potatoes grow and develop better under the condition of a slightly acidic reaction of the soil solution (pH 5–6). It grows poorly on acidic and alkaline soils (pH below 4.5 and above 8).

Potato degeneration. Long-term vegetative reproduction of potatoes leads to its degeneration, the signs of which are the premature awakening of buds in the cells, the formation of long sprouts, the development of small tubers affected by viral and other diseases, and a decrease in plant productivity. Degeneration is caused by unfavorable environmental conditions during the growth and development of potatoes and viral diseases.

Environmental causes of degeneration include high temperatures and lack of moisture in the soil during the formation of tubers, unfavorable plant nutrition. At a temperature above $+25^0C$, the composition of plant protein substances changes, the buds germinate prematurely with the formation of long and thin sprouts. Under such conditions, potato plants have low productivity and form small tubers. Ecological degeneration most often occurs in the southern regions.

Viral degeneration of potatoes is observed in different climatic conditions. This degeneration is caused by viruses X, S, Y, M, L, R and others. External signs of a viral disease are twisting, wrinkling and speckling 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, agricultural technology.

Degeneration of potatoes can also be the result of planting physiologically old tubers, late planting, low level of agricultural technology. In the southern regions, there is a cumulative effect on plants of unfavorable environmental conditions and viral diseases, as a result of which the degeneration of potatoes increases.

The main measures to prevent potato degeneration are the cultivation of varieties resistant to viruses and other causes of degeneration, the cultivation of the elite not affected by viruses by the method of meristem culture, 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% of the sown areas are occupied by table varieties, which are characterized by high taste qualities, a favorable ratio of protein and starch, and a high content of vitamin C in the tubers, and have a rounded and oval shape with superficial placement of cells. These are usually early and mid-ripening varieties.

Technical varieties are often late-ripening, contain the most starch (18–25%) in the tubers and are characterized by good shelf life. Forage varieties are characterized by a high protein content (up to 2% or more) and a high yield.

Potatoes of universal varieties have good taste and high starch content. Depending on the needs, they are used as table, technical or fodder.

By ripening time, 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).

In Ukraine, the following varieties of potatoes are zoned: early-ripening - Asterix, Borodyanska rozova, Bonsedar, Vesta, Vineta, Vitara, Hart, Dnipryanka, Zov, Impala, Kobza, Cardena, Karatop, Mriya, Melody, Nemishaevska 100, Povin, Presto, Porom, Roza , Rosalidn, Serpanok, Tiras, Chernihiv Ranya, etc.; mid-early - Caesar, Fantasia, Solara, Slavyanska, Satina, Sante, Secura, Polyana, Pekurovska, Malinska bila, Malych, Kupava, Zabava, Delicat, Goldila, Vodogray, etc.; medium-ripe - Crimson, Virinea, Vera, Volya, Hirska, Dara, Zolushka, Zahidnyi, Zoryana, Karalina, Courage, Leleka, Lybid, Olvia, Slava, Santana, Ukrainian rose, Yavir, etc.; mid-late - Chervona ruta, Teteriv, Saturna, Oksamit 99, Dubravka, Dzvin, etc.; late ripening - Drevlyanka, Bernadette.

Cultivation technology.*Their place in crop rotation.* The best predecessors of potatoes are winter grain crops after perennial grasses and busy pairs, leguminous crops, corn for silage, flax-dovgunets, annual and perennial grasses. In Polissia, potatoes are grown after lupine for green manure of post-harvest sowing, in Lisostepa - after winter wheat in a chain with grain legumes, corn and sugar beets, provided there is sufficient moisture. In arid areas of the Steppe, high yields of potatoes are obtained in irrigated vegetable crop rotations, in river floodplains, in low-lying areas. In vegetable rotations, potatoes are grown after many crops, except nightshades, which share many common pests and diseases.

Potatoes are one of the few crops that, with a high agricultural culture, are able to produce high yields when re-cultivated on last year's field. In this regard, in specialized crop rotations, where 35–50% of the area is devoted to potatoes, they are re-grown while maintaining a high agrotechnical level.

Potatoes, in turn, are a good precursor for early spring crops (wheat, barley, oats), legumes, oilseeds, and fiber crops. Potatoes are often grown as a steam crop, using early varieties for this purpose.

Tillage. Soil cultivation methods depend on soil and climatic conditions, soil type, precursor, fertilization system, etc. After grain and leguminous crops, the main cultivation involves husking the stubble and deep furrow plowing. Peeling is carried out with disk peelers to a depth of 6–8 cm at the same time or after harvesting the predecessor. Plowing is carried out 2–3 weeks after peeling. In the fields after non-stubble precursors, plowing is carried out immediately after their harvesting. On sandy soils, where fertilizers are applied in the spring, instead of autumn plowing, two huskings of stubble are carried out: the first - immediately after harvesting the predecessor to a depth of 5–6 cm, the second - after 20–30 days to a depth of 10–12 cm with plow huskers. Deep plowing is carried out in the spring with the simultaneous application of organic fertilizers.

According to the data of scientific institutions and best practices in Polissia and the Northern Forest Steppe, the replacement of spring plowing with spring plowing practically does not affect the potato harvest, if spring plowing is carried out without delay and in a short time.

The depth of plowing for potatoes depends on the depth of the plow layer. On light sod-podzolic soils with a shallow arable layer, it should be deepened by 3–5 cm with the obligatory application of fertilizers. In the spring, harrowing is carried out in 1–2 furrows. To create a loose layer - cultivation to a depth of 14-16 cm. On soils that flood, spring plowing is practiced, and in years with a small amount of precipitation - plowing with plows without front plows. With high humidity and a prolonged spring, in addition to plowing, before planting the tubers, the soil is loosened with chisel cultivators or plows without shelves by 16–18 cm.

A new, progressive method of soil preparation is planting potatoes in pre-cut ridges. As a result of faster warming of the soil in the ridges, potatoes can be planted earlier. Due to ridges, the root layer of the soil increases, which contributes to better nutrition and development of plants.

Fertilization. Numerous studies show that on almost all types of soils common in potato-growing areas, it absorbs the most nitrogen from the soil (phosphorus on deep and ordinary chernozems). Plants are the most picky about nutrients during budding and flowering.

Organic fertilizers are applied under potatoes. The largest increases are provided by organic fertilizers on sod-podzolic soils, which are light in terms of mechanical composition. The best organic fertilizer for potatoes is semi-rotted manure. 50–60 t/ha of half-rotted manure or peat compost are applied directly under potatoes in Polissia, 40 t/ha in Lisostepa - under the predecessor. When applying liquid manure, its rate is increased by 1.5–2 times. The best time is to apply organic fertilizers in the fall under plowing. As organic, green fertilizers are also used - lupine, rapeseed, winter rye, which are plowed into the soil together with the applied phosphorus-potassium fertilizers in the fall.

The effectiveness of mineral fertilizers depends on the type and degree of cultivation of the soil, weather conditions, and the characteristics of cultivation. Increasing the doses of nitrogen and phosphorus fertilizers to 60–90 kg/ha and potash to 90–135 kg/ha (active substance) in the non-chernozem strip ensures significant yield increases. The maximum yield increases from mineral fertilizers are on sod-podzolic and gray podzolic soils.

More effective and economical combined use of organic and mineral fertilizers. Mineral fertilizers provide potatoes with nutrients in the first half of the growing season, and organic fertilizers in the second, when they are mineralized. Against the background of organic fertilizers, depending on the fertility of the soil, complete mineral fertilizer is applied according to the calculation: on chernozems - $N_{60–90}P_{60–90}K_{60–90}$; on sod-podzolic, gray forest, light chestnut soils - $N_{90–120}P_{60–90}K_{90–120}$. Only phosphorus-potassium fertilizers in the norm $P_{60–90}K_{90–120}$are used on drained peat soils. Phosphorus-potassium fertilizers are applied during fallow plowing, nitrogen fertilizers are applied in the spring for cultivation. Fertilizers are also applied to the rows when planting potatoes with potato planters.

The best phosphorus fertilizers for potatoes are superphosphate, and on acidic sod-podzolic soils - phosphorite flour. Nitrogen fertilizers for potatoes include ammonium nitrate, ammonium sulfate, urea and ammonia water. Potassium fertilizers must be chlorine-free or concentrated with a small chlorine content. These are fertilizers such as: potassium sulfate, potassium magnesia, wood ash, potassium salt. It is better not to use potassium chloride and raw potassium fertilizers under potatoes.

Microfertilizers (manganese, boron, copper) for potatoes are effective on sandy and sandy sod-podzolic soils. It should be noted that the greatest yield increases occur on soils poor in trace elements. Microfertilizers are applied in different ways: together with mineral fertilizers during plowing or foliar feeding, spraying planting material with a solution of appropriate microfertilizers at the rate of 50 liters of solution per 2.5–3 tons of tubers.

As already mentioned, liming of soils helps to increase the yield and improve the quality of the tubers. It is necessary to apply limestone fertilizers under the previous crop. Application of high rates of lime directly under potatoes causes the development of actinomycetes, as a result of which the tubers are affected by scab, and potassium nutrition of plants deteriorates. If limestone fertilizers were applied under the previous crop, then they can not be applied directly under the potatoes, or 0.5 doses are applied according to hydrolytic acidity under plowing in the fall, in the winter after snow, in the spring during pre-sowing tillage.

Terms and methods of applying fertilizers to potatoes depend on soil and climatic conditions, types and forms of fertilizers. On chernozem soils, complete mineral fertilizer applied in autumn provides the same yield as when applied in spring. In the western regions and on sod-podzolic sandy soils of the non-black soils zone, phosphorus and potassium fertilizers can be applied in autumn or spring, and nitrogen fertilizers can be applied in spring. On light soils, as well as on soils with a high level of groundwater, where deep freezing of the soil is possible, it is advisable to apply not only nitrogen, but also phosphorus-potassium fertilizers in the autumn-winter period and spring.

Preparation of tubers for planting. Healthy, non-degenerate tubers are used for planting. Diseased and damaged tubers are removed before storage. In the spring, the tubers are again reviewed and sorted. Planting material should be typical for this variety, without mechanical damage and diseases. It is not recommended to plant spindle-shaped tubers, with pale color and thread-like sprouts, that is, with signs of degeneration. For planting, it is more appropriate to use medium-sized tubers (60–80 g), but small (30–50 g) and large (more than 90 g) are also planted. Potatoes of different sizes should be planted separately. Large tubers are cut into parts weighing 20–30 g with 3–4 cells. The tubers should be cut the day before or on the day of planting. Before planting, cut tubers are treated with Fundazol (0.5–1.0 kg/t), Vitavax (2 kg/t).

Germination of tubers before planting accelerates the appearance of seedlings, promotes better growth and development of above-ground mass, roots, stolons and tubers. Effective pre-planting germination in areas with a short frost-free period, with late planting periods on peat soils. Tubers are germinated in the light or in the dark, on racks or in boxes in special rooms (springers) adapted for this purpose, sometimes covered with polyethylene film. Potatoes for sprouting are placed in 2–3 layers, and boxes are stacked in stacks of 10 pcs. Blocks of fluorescent lamps are placed on the racks between the stacks of boxes. In the room, the temperature is maintained at +12...15°C and the air humidity is 80–90%. For uniform illumination, the tubers are periodically turned over. In addition, tubers are germinated in a moist environment (in sawdust, peat, humus), in polyethylene bags or sleeves, in storages and sides with the use of generators for heating, etc. Potatoes of early-ripening varieties germinate 35-45, and medium-ripening varieties - 45-60 days before planting.

*Planting.*When planted too early in unheated soil, the tubers do not germinate for a long time, they are damaged by diseases, which leads to thinning of the plants and a decrease in the yield. It has a negative effect on the potato harvest and late planting.

Potatoes are planted when the soil at a depth of 10–12 cm warms up to a temperature of +6...7°C. On light soils, where the soil warms up faster, potatoes are planted early - simultaneously with the sowing of early grain crops. First of all, germinated tubers of early ripening varieties are planted, then seed and commercial potatoes of later ripening varieties.

In areas where there is a lot of precipitation and stagnant water, ridge planting of potatoes is used. The most common comb method of planting potatoes, in which the tubers are dug into the soil to a depth of 4–6 cm, and then the comb is poured. The distance from the top of the ridge to the surface of the tubers is 15–16 cm. On ridge crops, potato care can be carried out before the emergence of seedlings.

The width of the rows when planting potatoes is 70 cm, with tubers placed in a row at a distance of 25–35 cm. Planting with a row spacing of 90 cm is sometimes used.

The depth of planting on light soils is 12–14 cm, on heavy moist clay and loamy soils, as well as on lowlands - 7–8°C, in areas with sufficient moisture on black soils - 10–12°C, in areas with insufficient moisture and in the south and southeast areas - 12–15 cm.

The average planting density of tubers weighing 50–80 g in areas with sufficient moisture (Polyssia, Northern Forest Steppe) is 55–60 thousand/ha, seed planting – 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; with irrigation - 55 and 60 thousand/ha. Potatoes are planted more densely (by 10%) on more fertile soils, when growing early varieties and when using small tubers. Depending on the size of the tubers, 3.5–4.5 tons are planted per hectare.

Caring for potato plantations begins with harrowing, which is carried out 2–3 times before and 1–2 times after the emergence of seedlings. Profile, rotary and net harrows, cultivators with arrow paws and razor paws are used on ridge and semi-ridge crops on the 6th–8th day after planting.

After the emergence of seedlings, inter-row loosening is carried out: the first - to a depth of 12-14, and the following ones - 10-12 cm. In case of insufficient soil moisture, the loosening depth is reduced to 6-8 cm.

During budding, the potato plants are rolled up by 8–10 cm. Under conditions of insufficient moisture, shallow loosening is performed instead of rolling up. The most effective raking is immediately after the rain.

Protection against weeds is of great importance in the potato care system. Preparations of continuous action (Roundup, etc.) are used after harvesting the predecessor on stubble, when weeds are growing intensively. Before the emergence of seedlings on potato crops, the following herbicides are applied: Gezagard (3.0–4.0 kg/ha), Dominator (2 l/ha), Zenkor (0.5–1.5 kg/ha), Stomp (5 l /ha), Hurricane forte (1.5 l/ha). During the growing season of potatoes, when the weeds are in the phase of 3–4 leaves, apply insurance herbicides Panthera (1.5–2.0 l/ha), Targa (2.0–4.0 l/ha), Titus (50g/ha), Shogun (0.6–1.2 l/ha), Fusilade super (1.0–3.0 l/ha).

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). Crops are processed twice: the first time – after the appearance of early potato seedlings during the period of mass emergence from the soil and the settlement of beetles, the second time – after 10–15 days, with the mass appearance of larvae of the second generation.

Against phytophthora, the first spraying of crops is carried out during the period of budding - at the beginning of flowering (according to the data of the section on the forecast of the development of diseases and pests or plant protection station). Re-seeding is done when black spots appear on the plants. Fields are then sprayed every 8-10 days if the disease spreads. Acrobat (2.0 kg/ha), Ridomil (0.8–1.0 kg/ha), Tattu (3.0 l/ha), Champion (2.5–3.0 kg/ha) are used.

Harvesting. Signs of the complete maturation of potato tubers are the drying of the tops, the drying of the stolons and the easy tearing of the tubers from them. 3–4 days before harvesting on heavy soils, loosen the interrows to a depth of 14–16 cm to improve the operation of potato harvesters.

Depending on the variety and use of tubers, potatoes are harvested at different times. Early varieties, which are used for food needs, are harvested before the onset of full ripeness.

It is necessary to start harvesting potatoes during the period of the dying off of potatoes with the calculation to finish it at an air temperature of +7...10°C. First, seed potatoes are harvested, and then food potatoes.

On food crops, 3–4 days, on seed crops 10–12 days before the start of harvesting, the tops of potatoes are mowed with a KIR-1.5B harvester. Potatoes are collected by harvesters and potato diggers in a direct, separate, streaming or combined way.

Separate harvesting is used on heavy wet soils. With this method, the tubers are first dug up by diggers-rollers and placed in rolls of two, four or six rows. After drying, the tubers are picked from the rolls by harvesters. The remaining rows are dug up with a combine harvester.

When collecting directly, the tubers dug by the harvester are separated from the soil, husks and piled up in a bunker. During separate harvesting, tubers dug from several rows (2, 4, 6) are placed in a roll for subsequent harvesting by combines. With the combined method, tubers from 2 or 4 rows are placed with diggers in the interrows of two unexcavated rows, after which these rows are removed by direct harvesting.

The most effective method of harvesting is the flow method, which uses a system of machines for cutting tops, a potato harvester, and a sorting station of the KSP-15B type. To improve the work of harvesters, 2–3 days before the start of harvesting, the rows are loosened to a depth of 14–16 cm. 2–3 harvesters work in each field. Potatoes are unloaded from the bunkers into vehicles and transported to the sorting station, where the tubers are dried and sorted. With the flow-transshipment method of harvesting, the tubers are stored for some time in the sides on the field under a layer of straw.

After removing diseased tubers, seed potatoes should be kept in the light for 10-12 days until they turn slightly green. The alkaloid solanine (0.3–0.4%) accumulates in the green tubers, which protects the tubers from damage by diseases.

Potatoes are stored in specialized potato warehouses and warehouses. In potato warehouses, a favorable mode of storage of tubers is created with the help of active ventilation. The temperature should be +2...4^{0}C, and the relative humidity should be 85-90%.

Ways of improving seed potatoes. When growing seed potatoes, the same complex of agrotechnical measures is used as when growing high yields of commercial potatoes. However, specialized measures are also used for this purpose. To obtain high-quality seed material, summer planting of potatoes, growing them on peatlands, harvesting unripe tubers is used.

With summer planting, the formation of tubers occurs in more favorable conditions than with spring planting. When planting potatoes in late June - early July, the formation of tubers occurs in mild weather, when it rains and the daylight hours shorten. For summer planting, seed material imported from closed northern regions is used. Freshly harvested tubers from spring plantings are also used for planting. Planting density is 60–65 thousand/ha. During the summer-autumn growing season, potatoes are watered 4–5 times after the emergence of seedlings with an irrigation rate of 450–500 m^3/ha, and diseased plants are removed. Potatoes are harvested in the second decade of October. Summer landings are especially effective in the Steppe of Ukraine.

Features of growing potatoes under irrigation. Irrigation of potatoes is especially effective in arid southern regions. Under irrigation conditions, the yield of tubers increases almost twice.

Potatoes are planted with ridge irrigation, the planting density is increased to 55–60 thousand bushes per 1 ha. The rate of organic and mineral fertilizers is increased by 30–40%. Potatoes are wrapped to a depth of 8–10 cm.

The need for watering is determined by the condition of the plants (withering 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% RH. Potatoes are watered 3–5 times with an irrigation rate of 450–500 m^3/ha of water. Stop watering when the main mass of tubers is formed. After each watering, inter-row processing is carried out. During the period of budding, potatoes are turned over. Irrigation is more effective if it is combined with vegetative fertilization with mineral fertilizers, especially during the period of tuber formation.

2.2 ROOT FRUITS

Fodder root crops include fodder beets, carrots, rutabagas and turnips. They are grown to obtain juicy fodder. Juicy fodder contains a lot of carbohydrates, vitamins, and minerals that are easily absorbed by the animal's body.

Fodder root crops are, first of all, an important source of easily digestible carbohydrates, the content of which in the root crops of fodder beets, carrots and rutabagas is about 9%, turnips - up to 7%, and the digestibility ratio reaches 96-98%. The protein content is small - about 1.1-1.5%, but it is characterized by a rich amino acid composition and good digestibility. Root crops also contain a significant amount of minerals (1–1.5%) and vitamins. Carrot roots are especially rich in vitamins. It contains all the vitamins known to date. Of all root vegetables, carrots have the most carotene (provitamin A). For 1 feed. unit accounts for 700–1400 mg of carotene.

In addition to root crops, buckwheat is also used for feed, thanks to which, with a root crop yield of 500–600 t/ha, 20–25 t/ha of fodder units are obtained.

Fodder root crops form a high yield and output of fodder units. Thus, fodder beets with a root crop yield of 800 t/ha and 150 t/ha of swedes yield 120–130 t/ha of fodder units. The nutritional value of fodder root crops is characterized by the data given in Table 10.

As row crops, root crops leave behind fields free of weeds and are good precursors in crop rotation for the following crops.

Fodder beets and carrots are grown in all zones, rutabagas and turnips, as moisture-loving and undemanding to heat, are most common in the Northern Forest Steppe and Polissia.

Table 10 – Number of fodder units and digestible protein in 100 kg of plants

Crops	Root Fruits		Hychka	
	fodder units	digestible protein, kg	fodder units	digestible protein, kg
Fodder beets	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
Turnip	9,0	0,4	11,3	0,9

2.2.1 Sugar beets (*Beta vulgaris L.*)

Sugar beets are the main source of large-scale sugar production both in Ukraine and in many other countries of the world with a temperate climate. Sugar is of extremely important economic importance as a food product and as a raw material for industry. Sugar is produced in 116 countries of the world: in 71 - from sugar cane, in 34 - from sugar beet, in 11 - from sugar cane and beet. If at the beginning of the 20th century more than half of the total amount of sugar was produced from sugar beets, then after the Second World War, its production from sugar beets and sugar cane acquired a ratio of 30:70. In recent years, the share of sugar obtained from beets has decreased to 23–25%. Sugar beets are also an important factor in strengthening the fodder base and improving agricultural culture. Thanks to favorable soil and climatic conditions, Ukraine has always taken a leading place in terms of the area of sugar beet crops and sugar production. The state needs almost 2 million tons of sugar annually to meet domestic needs alone.

Root crops contain 17–19% sugar, and under favorable growing conditions, high-sugar varieties and hybrids contain up to 20%. Sugar is mainly represented by the carbohydrate sucrose. ($C_{12}H_{22}O_{11}$) It crystallizes from the juice of plants and is found in nature in its pure form. Sucrose consists of glucose and fructose molecules and is hydrolyzed to these components under the action of enzymes in the human body.

The chemical composition of root crops can be characterized by the following indicators: water content 75%, dry matter 25%, of which sugars 17.5%, non-sugars - 7.5%. The content of individual substances depends on soil and climatic conditions, technology. So, dry matter can be from 16% to 26%, sugar - from 8% to 23%. Root crops also contain 2% fiber, 1.5% nitrogenous substances and 0.7% ash.

The importance of sugar beets is not limited to the production of sugar from them. They are also used as fodder crops. 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 buckwheat silage are obtained, which can be equated to a winter wheat yield of 8.3 t/ha .

In terms of nutritional properties, sugar beet root crops significantly exceed other root crops: 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 beets are digested by cattle only by 40%, and fodder beets by 100%. Therefore, it is impractical to feed them to animals. The mass of buckwheat is 35–50% or more of the mass of root crops, it is used for green fodder, for ensiling. It contains 26.5% dry matter, in particular 2.5–3.5% protein, 0.8% fat, many vitamins. 100 kg of cottage cheese corresponds to 18–20 fodder units. Although the fodder properties of sugar beet pulp are not bad, its use as livestock feed is increasingly losing its economic value. For example, currently less than 10% of farms in Germany use it for this purpose. Beet pulp is a valuable organic fertilizer. Plowed buckwheat is a good slow-acting fertilizer for subsequent crops, especially cereals. 10 t contains about 31 kg of N, 57 kg of K_2O and 9 kg of Mg with a fluctuation of up to 50%. Buckwheat yield of 40.0–50.0 t/ha equals 30 t/ha of manure.

When processing beets, many other products are obtained: pulp, molasses (or molasses), feces. Molasses contains up to 60% sugar and is close to grain in nutritional value: 100 kg of it corresponds to 77 fodder units and 4.5 kg of digestible protein. It is used for the production of animal feed, processing into alcohol, bioethanol, production of glycerin, yeast, citric acid and other substances for the chemical, perfumery and food industries. The yield of raw pulp is 80%, squeezed - 40%, molasses - 4.5-5.5% of processed root crops. 100 kg of fresh pulp contains 8 feeds. unit and 0.9 kg of digestible protein, and 100 kg of dry pulp contains 85 fodder. unit and 3.9 kg of digestible protein. Waste from sugar beet processing - feces - is used to reduce soil acidity. Manure is a limestone fertilizer containing 60–75% $CaCO_3$, 10–15% organic matter, 0.2–0.7% N, 0.2–0.9% P_2O_5 and 0.3–1.1% K_2O. Application of feces increases the yield of sugar beets by 2.0–4.0 t/ha and the yield of sugar by 0.2–0.4%.

Sugar beets are of great agrotechnical importance. Under this culture, deep tillage of the soil is carried out, fertilizers are applied, careful care of crops is carried out, so they are a valuable precursor for many agricultural crops.

The history of sugar beet culture is not so ancient. The homeland of beets is the Mediterranean (Anterior Asia), where they began to be grown approximately 2000-2500 years BC. e. According to scientists, it is probably the only culture created by man. It is believed that the cultivated two-year plant of sugar beet comes from a wild one-year form, which is still found on the coast of the Mediterranean, Caspian and Black seas, in Transcaucasia and in Asia Minor. Leaf forms of beets were grown 1500–2000 years BC. e., and root crops in Eastern Asia were known 500–800 years before BC. e. In Kievan Rus, root beets began to be grown in the 10th–11th centuries, in Western Europe in the 13th–14th centuries.

Leaf forms (chard) were the first to be introduced into the culture, and later - root forms. The appearance of root-fruited sugar beets dates back to the beginning of the 18th century; its original form was white garden ones.

The broad development of beet sugar production in Ukraine was initiated since 1840, when in the village of A powerful sugar factory was built in Smila. Sugar beets were first grown by the seedling method, and seed sowing was introduced from the middle of the 19th century.

Among sugar-bearing plants, sugar beet is inferior only to sugar cane in terms of the area of cultivation. During the last 14 years, its area has been decreasing. The world area of sugar beet crops is more than 9 million hectares. The main crops are concentrated in Europe (37.1% of the world), Asia (17.4%) and North America (7.7%). Among the countries, the largest areas of sugar beet are in Russia - 1.25 million ha, Germany - 0.57 million ha, the USA - 0.56 million ha, France - 0.46 million ha.

The gross harvest of sugar beets in the world is 264 million tons. The most sugar beet root crops are produced in Russia - 31.1 million tons, France - 29.9, Germany - 23.8, the USA - 24.6 million tons. In Ukraine the current production of root crops is 12.3 million tons.

Beet crops in Ukraine at the end of the 20th century were in the range of 1.6–1.7 million ha. In recent years, they have decreased significantly. For 2013, the projected sown area is 450,000 hectares, the gross harvest of root crops is 12.0–14.0 million tons, and the production of sugar is 1.5–1.7 million tons. The largest areas of sugar beet are concentrated in Poltava, Cherkasy, Kyiv, Vinnytsia, Khmelnytskyi, Kharkiv and Ternopil regions.

Sugar beets are a high-yield crop. The average yield of root crops in the world is about 36.0 t/ha. Among the countries, the highest productivity is in France - 65.0 t/ha, Italy - 49.7, Great Britain - 54.8, the United States - 44.0, 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 features, hybrids. The relationship of sugar beets to the main factors of life - moisture, heat, light, soil, the content of nutrients in the soil - is determined by their biological characteristics. The formation of a large mass of organic matter, including sugar, is possible with a sufficiently long vegetation period, good lighting and a favorable temperature regime, sufficient moisture content in the soil.

Requirements to moisture. Sugar beets were formed in regions with sufficiently high relative humidity, so they are negatively affected by a sharply continental climate. Plants develop poorly in the absence of precipitation in March and April. The germination period should be warm with moderate rain, the first half of the 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 beets. It is necessary for seed germination (160–170% of its mass), cooling of plant tissues as a result of transpiration, ensuring the turgid state of plants, opening of stomata, photosynthesis and other biological processes.

Sugar beets belong to crops that use water sparingly and are 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 in dry periods at high temperatures, when depression occurs in other cultures. However, sugar beets use a lot of water and dry out the soil deeply. With a root crop weight of 400–500 g, one plant consumes 30–35 liters of water per growing season, with 1–2 liters of water on one hot July day. 70–80 cm3 of water is used for the formation of 1 g of raw root mass from the soil, and 450–500 cm^3 of water is used for 1 g of sugar. Only to ensure transpiration at a yield of 40–50 t/ha of root crops, plants absorb 4000–5000 m^3 of water from the soil.

The optimal soil moisture for the growth and development of sugar beets ranges from 50 to 90% RH.

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 part of solar radiation in the wavelength range of 0.38–0.71 μm, which is used in the process of photosynthesis by plants. The amount of PAR is approximately 52% of the total (direct and scattered) radiation that reaches the Earth's surface. Beetroot leaves most intensively use blue-violet (0.40–0.48 μm) rays, and orange-red (0.65–0.69 μm) rays for the growth of vegetative mass.

Solar radiation resources for sugar beets are estimated by the average multi-year sums of total solar radiation during the growing season with a temperature above $+5^0$C. The provision of heat should be at least 80%.

According to the value for the accumulation of sugar in root crops in the second half of the growing season, in areas with sufficient moisture, the first place should be lighting, the second - air temperature. In areas of unstable and, especially, insufficient moisture, the first place is occupied by moisture.

Seed germination, plant growth and productivity of sugar beets directly depend on the thermal regime. The heat requirement of sugar beets for the period from sowing to technical ripeness is determined by the sum of active temperatures of 2340^0C. In the beet-growing regions of Ukraine, the sum of average daily air temperatures above 5^0C from the beginning of the growing season to the mass harvesting of sugar beets is 2400–2800^0C.

The most favorable temperature for the germination of sugar beet seeds is about 200C. The length of the germination period depends on the temperature of the soil. So, at a soil temperature of $+1...2^0$C, seeds germinate within 45–60 days, $+3...4^0$C - 25–30, $+6...7^0$C - 10–15,

+9...10^{0}C - 8–10 and +11...12^{0}C - 3 - 4 days.

Beet seedlings can tolerate short-term frosts on the soil surface - 3...5^{0}C, and sometimes up to -6...7^{0}C. Root crops dug up in autumn are damaged by frosts of -2^{0}C.

The life activity of sugar beets is most productive when the temperature of the root layer of the soil is around +30^{0}C during the day and +10^{0}C at night.

Requirements to soils. The soils on which sugar beets are grown must have a sufficiently high absorption capacity. The soil absorption complex of such soils is saturated with calcium, which determines the favorable physical, chemical and biological properties of the soil. The optimal amount of exchangeable calcium in the soil for sugar beets is 60–70% of the absorption capacity, exchangeable magnesium and potassium – 10–15 and 3.5, respectively. The most favorable water, air and heat regimes are created on such soils. Humic substances retain plant nutrients in the soil, contribute to their rational use, reduce unproductive losses and prevent environmental pollution.

Humus provides a continuous flow of soil carbon dioxide into the surface layer of the air, which improves photosynthesis and the accumulation of sugar in root crops. In fertile, well-structured soil, the solid phase occupies 50% 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 beets. It is determined by the volumetric 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 favorable conditions are created when the total porosity of the soil is 53–58%, the density is 1.1–1.2 g/cm^3, and the air capacity is about 15%.

Requirements to power elements. Beets are characterized by increased requirements for the content of nutrients in the soil. For the formation of 10.0 tons of crops (root crops and sedges) on chernozems in areas with sufficient moisture, they remove 50–60 kg of nitrogen, 15–20 kg of phosphorus, and 55–75 kg of potassium from the soil. Sugar beets also remove a lot of calcium, magnesium, sulfur, manganese, boron and other elements from the soil. The optimal amount of exchangeable calcium in the soil for sugar beets is 60–70% of the absorption capacity, exchangeable magnesium and potassium – 10–15 and 3.5%, respectively.

To obtain high yields of sugar beet root crops with high sugar content and good technological qualities, it is necessary to ensure moderate nitrogen nutrition during the period of seed germination and in the early phases 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 supply at the end of the growing season. At the end of the growing season, the need for nitrogen can be met by recycling it from older leaves.

The maximum amount of nutrients beets consume in July - August (the period of the highest increase in dry matter).

More than 160 varieties and hybrids of sugar beet have been entered into the State Register of plant varieties suitable for distribution in Ukraine. The share of varieties-populations is insignificant, and in production they occupy smaller and smaller areas every year.

The selection of sugar beets is aimed at creating hybrids that ensure high yield and high sugar harvesting. At the same time, we offer varieties with the following classification:

E – harvest type, sugar output is ensured due to a high yield of root crops.

N – normal type, sugar output is realized both by productivity and sugar content.

Z – sugary type, sugar output is realized due to high sugar content.

ZZ – the most sugary type, which ensures high sugar collection due to its especially high content in root crops

*Z*and*ZZ* – types are more profitable in regions with significant distances to sugar factories, which is associated with a decrease in transport costs. In addition, they require less nutrients per unit of sugar crop and are much more profitable than early harvesting.

Hybrids, compared to varieties, are more demanding in terms of environmental conditions, need increased care, optimally high supply of nutrients, moisture and other factors of life.

For sowing, encrusted or coated seeds are mainly used for hybrids of the new generation of the domestic hybrids (Ukrainian ChS 70, Yaltushkivskiy ChS 72, Ivanivskyi ChS 33, Bilotserkivskiy ChS 57, KV Ros, KV Bar, KV Zbruch, KV Roy, KV Yaltushkiv, Bilotserkivskii ChS 90, Shevchenkivskyi , Ivanivsko-Veselopodilsky ChS 84, Slavyansky ChS 94, Vesto, Vorskla, Umansky ChS 97) and foreign selection - Krokodyl, Alyona, Boruta, Silenta, Vincent, Mozaik, Libero, Nastya, Corrida, Bakara, Slatka, etc.

Cultivation technology. *Predecessors.* Sugar beets are very picky about placement in crop rotation.

In the zone of sufficient moisture, 10-field crop rotations with the following rotation of crops were widespread in beet farms: 1) annual crops for green fodder and silage; 2) winter wheat; 3) sugar beets; 4) spring cereals with subsowing of perennial grasses; 5) perennial herbs; 6) winter wheat; 7) sugar beets, 8) peas; 9) winter wheat; 10) sugar beets, corn for grain.

In the zone of unstable moisture, the highest yields of sugar beets are obtained after winter wheat, peas and perennial grasses.

In the zone of insufficient moisture, the correct alternation of crops in crop rotation acquires special importance as a factor in regulating the water regime of the soil.

Re-sowing of sugar beets is especially undesirable. Repeated sowing of beets on the same field causes "beet-like" soil, which is caused by the accumulation of specific pests and diseases (nematodes, aphids, rot, cercosporosis, transfersporosis, etc.). Unchanged cultivation leads to a decrease in yield and sugar content, even with the introduction of manure and complete mineral fertilization. In crop rotation, sugar beets can be grown on the same field no earlier than in the 4th year. When the soil is infected with a nematode - after 5 years, and when it is heavily infected - after 6-7 years.

Tillage. Sugar beet forms the main part 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 make good use of plant residues, straw, applied fertilizers. The two most common methods of basic tillage are improved and semi-steam.

Improved processing involves double husking of the stubble. The first is carried out with disc huskers (LDH-10) in two tracks at an angle of 30–45° to a depth of 5–6 cm. If straw is used as an organic fertilizer and when the soil dries out, it is better to use heavy disc harrows (BDT-3, BDT -7, BDV-6,3). This accelerates the decomposition of straw, reduces evaporation of moisture, provokes the germination of weed seeds, destroys or suppresses growing weeds.

10–12 days after the first, the second peeling is carried out with plow peelers (PPL-5-25, PPL-10-25) to a depth of 12–14 cm in a unit with heavy harrows.

When weeds appear after peeling, they are destroyed by surface treatment with the help of harrowing, cultivation, etc. After applying organic and mineral (phosphorus and potash) fertilizers, plowing is carried out to a depth of 28–30 cm in late September - early October with PLN-5-35 and PLP-6-35 plows. To improve the quality of tillage, it is better to use PYA-3-35 two-tier plows; MON-4-40, MON-4-40.

Sugar beet reacts very negatively to spring plowing. Under no circumstances should the soil be plowed if it is overmoistened. At the same time, a plow sole is formed, the soil is flooded, compacted, and plants can absorb nutrients and moisture only from the plowed layer. The root system almost does not assimilate them from the subsoil layer.

On heavy soils, the arable layer is cultivated to a depth of 37–40 cm with the help of soil deepeners.

The improved method of soil cultivation is most effective in areas of unstable and insufficient moisture.

Semi-steam tillage is recommended to be used in areas of sufficient moisture with higher weediness of the fields. It consists of husking the stubble to a depth of 5–6 cm with disc huskers in 2 tracks. After applying organic and mineral fertilizers, the field is plowed to a depth of 28-30 cm with plows with front plows in a unit with heavy harrows (BZTS-1.0), and in dry conditions - with rollers ZKKSH-6, no later than the first decade of August.

In the case of weeding with rhizome weeds (wheatgrass, sedge, sedge), they are first peeled with plow tools to a depth of 12–14 cm in order to turn the rhizomes of the weeds to the surface, later they are cut with disc peelers, which are processed in 2–3 tracks. Plowing is carried out when weeds are growing.

As weed seedlings appear, the plowed field is worked several times with harrows or cultivators to destroy new waves of sprouted weeds.

In the second half of October, the field must be loosened to a depth of 16–20 cm with plows without shelves or flat cutters. Ammonia water can be added at the same time. Semi-steam treatment reduces weediness by 30–50%, increases moisture reserves in the soil by 20–30 mm.

It is important to carry out loosening to a depth of 45–50 cm in late autumn with the help of ShP-3-70 loosener.

With late plowing, weed seeds do not have time to germinate and sprout only in spring, weeding beet crops.

Spring tillage. The quality of sugar beet sowing and seed germination largely depend on timely and high-quality spring cultivation. It consists of loosening the top layer of the soil, leveling it, and in the zone of sufficient moisture, additional layer-by-layer deep loosening. The need for such loosening also occurs in fields with soils prone to flooding. The spring tillage system also includes pre-sowing cultivation.

On the fields, well prepared and leveled in the fall, only pre-sowing cultivation is carried out in the spring.

Early spring loosening and leveling of the soil. The purpose of early spring loosening and leveling is to loosen the surface layer of the soil to a fine-grained state, prevent moisture loss, level the field surface and create favorable conditions for pre-sowing tillage, sowing and crop care.

Early spring loosening must be carried out during the period of physical maturity of the soil, when its moisture is 3-4% higher than the lower limit of plasticity and the soil is not smeared and crushed without sticking of the working bodies of tillage tools. The duration of this state of the top layer of the soil is no more than one to two days. A one-day delay in closing moisture leads to unproductive losses of 60–120 t/ha of water. The thickness of the loosened soil layer should be 2.5–3 cm. In the loosened layer, the content of clods with a diameter of more than 20 mm should not exceed 20%, including those with a diameter of 50 mm - no more than 5% of the mass of the sample.

Early spring loosening is carried out with wide-grip units, equipped with toothed harrows on the traction of tracked tractors, which do not form deep ruts. Depending on the type of soil, the density of the upper layer, two rows of harrows are attached to the hitch: heavy or medium harrows are placed in the first row; in the second - medium crops or row crops. Mechanically heavy soils, including those that have become flooded and excessively compacted, are processed with a unit in which heavy toothed harrows are placed in the first row, and medium harrows in the second. For the cultivation of moderately compacted soils, medium harrows are placed in the first row, and sowing harrows are placed in the second row. For the cultivation of loose soils, sowing harrows are placed in the first row, and row harrows are placed in the second row.

Leveling of 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, with a unit from the hitch of plumes and harrows. In the first row, trailing harrows are used, and in the second - row harrows. Under conditions of low humidity and high air temperature, the field is leveled without preliminary loosening it with tooth harrows. Early spring loosening and leveling of the soil are effective only when they are carried out in a complex and without delay. In the system of technological measures of intensive technology, early spring loosening and soil leveling are combined into one complex operation. To carry out these works and apply soil herbicides, complex units are used, which perform all operations in one pass.

In Germany, in most cases, after the autumn leveling of the fields, no special leveling is carried out in the spring. Usually, they are limited to one pre-sowing treatment with combined units, for example, of the "Compactor" type from the "Lemken" company.

Pre-sowing tillage of the soil. The task of pre-sowing soil cultivation is loosening the surface layer to a fine-grained state at a given depth, creating a solid seed bed, destroying seedlings and weed seedlings (Table 11).

Table 11 - Agrotechnical requirements for pre-sowing soil treatment

Indicator	Requirements and permissions
Terms of work	Processing begins when the average daily temperature of the soil at a depth of 8–10 cm reaches +5–6 ^{0}C and is carried out simultaneously with sowing
Duration of work in one field	One to two calendar days, for which the group method of operation of machines is used
The depth of the loosened soil layer after the passage of the unit	To the depth of seed wrapping (2,5–4,0±0,5cm)
Looseness of the soil	In the processed layer, the content of lumps over 20 mm in size should not exceed 10% of the total weight of the sample
Weed cutting	The working bodies of the tools must cut at least 98% of the weeds

Time gap between pre-sowing treatment and sowing of sugar beets	The time required for 2–3 passes of the sowing unit

Pre-sowing tillage is an integral part of a single technological process - sowing of sugar beets and should be carried out without any gap in time, only the first one precedes sowing by two or three passes of the sowing unit.

Failure to comply with agrotechnical requirements for pre-sowing soil preparation leads to drying out of the loosened layer, which worsens the conditions for beet seed germination (Fig. 11).

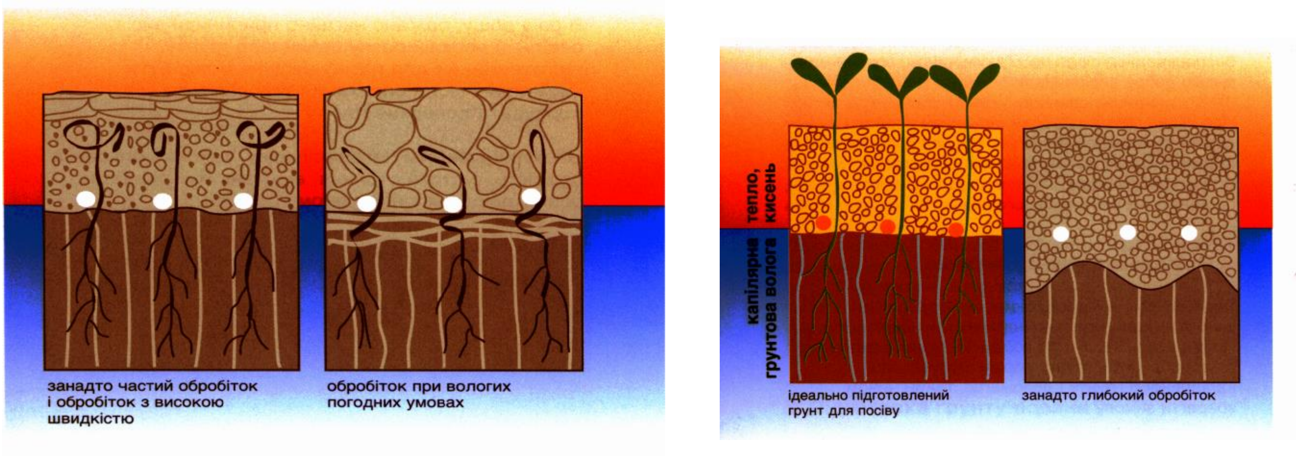


Fig. 11 – The effect of pre-sowing tillage on the field germination of sugar beet seeds

Simultaneous implementation of early spring and pre-sowing operations is carried out using multi-operational units, for pre-sowing processing a harrow-cultivator is also used.

Modern tillage tools make it possible to prepare the soil for sowing sugar beets in 1–2 passes. Pre-sowing treatment with the help of combined units of the "Europak" type prevents over-compaction of the soil, which is caused by multiple passes of single-function units. The combined units perform more than four operations in one pass – leveling, crushing lumps, loosening, compacting the seed bed. This is an important element of energy saving and a prerequisite for high-quality sowing.

Fertilization. Fertilizers in combination with other agrotechnical measures are the most effective factor for intensification of sugar beet cultivation. The yield increase of root crops for the introduction of 1 kg of nitrogen is, on average, 35.7 kg, 1 kg of phosphorus - 37.5 kg, 1 kg of potassium - 18.8 kg.

The system of fertilizing sugar beets provides the main fertilizer, which is applied in the fall under deep cultivation of the soil; row, which is introduced during sowing in the zone close to the germinating seeds; fertilization during the growing season (fertilization). The main fertilization includes organic and mineral fertilizers, mineral micro- and macro-fertilizers are added to the rows during sowing, and they are fertilized with mineral and liquid organic fertilizers.

The highest productivity of sugar beets is provided by the introduction of organic and mineral fertilizers. Of the organic fertilizers for beets, half-rotted litter manure is mainly used, which is obtained after 4-5 months of storage in manure storages or bunds. From 1 ton of such manure, 5 kg of nitrogen, 2.5 kg of phosphorus and 6 kg of potassium are introduced into the soil. Manure is recommended to be applied in autumn directly under sugar beets or under the predecessor (under deep plowing without a gap between spreading and plowing) at the rate of: in the zone of sufficient moisture 40–50 t/ha, unstable moisture – 30–40 t/ha and insufficient – 30– 35 t/ha. When growing beets using the Ukrainian intensive technology, manure rates are increased to 30–60 t/ha, depending on moisture conditions.

The rates of mineral fertilizers are based on the planned yield. Approximate rates of mineral fertilizers recommended by the Sugar Beet Institute and its network of research and breeding stations for different moisture zones and soil types are calculated to obtain a root crop yield of 35.0–50.0 t/ha. In the zone of sufficient moisture on typical, leached chernozems, mineral fertilizers should be applied at the rate of $N_{160}P_{170}K_{160}$, on dark gray forest soils and podzolized chernozems - $N_{170}P_{160}K_{200}$, on gray forest soils - $N_{180}P_{150}K_{200}$; in the zone of unstable moisture - $N_{120}P_{150}K_{150}$, $N_{140}P_{140}K_{190}$, $N_{160}P_{130}K_{170}$, respectively; in the zone of insufficient moisture - $N_{160}P_{130}K_{170}$, $N_{130}P_{120}K_{150}$, $N_{140}P_{120}K_{150}$, respectively.

Most of the recommended or estimated rate of mineral fertilizers (70–90%) is added to the main fertilizer. Mineral fertilizers are applied to the rows in all zones in a dose of $N_{10}P_{15–20}K_{10–15}$. In the zone of sufficient moisture, it is advisable to feed sugar beets in the phase of 2–4 leaves with a dose of $N_{30}P_{30}K_{40}$ fertilizers. In this zone, a part of mineral fertilizers, especially nitrogen fertilizers, can also be applied under pre-sowing cultivation, provided that the fertilizers are not applied under deep plowing. However, it should be borne in mind that spring application of fertilizers is less effective compared to using them in the main fertilizer.

Foliar feeding is also effective on sugar beet crops, which is used in all zones. For foliar fertilization, urea (25–30 kg/ha) or a combination of urea (25 kg/ha) and potassium chloride (20 kg/ha) is used. Fertilization increases the yield of root crops by 4.0–6.0 t/ha, and the sugar content by 0.5–0.8%. It is most effective to carry out this feeding before closing the leaves of sugar beets in the rows.

Boron, copper, manganese, zinc, molybdenum and cobalt microfertilizers are also used for sugar beets. Boric fertilizers in the form of boric acid or magnesium borate are applied to the rows at the rate of 0.4–0.6 kg per year. boron per ha. They are especially effective on sod-podzolic and gray forest soils. Copper microfertilizers are used mainly on drained peat bog soils in the form of copper sulfate or pyritic nitrites. Manganese fertilizers increase the yield of sugar beets on carbonate chernozems, leached and saline soils. 100–170 kg/ha of manganese slag is applied under deep plowing, or 250–300 l/ha of a 0.1% solution of manganese sulfate in foliar fertilization.

Acidic soils must be limed. Liming increases the vital activity of microorganisms, which accelerate the mineralization of organic substances and improve the nutrient regime of the soil. On acidic soils, sugar beets are planted with limestone meliorants in the form of feces, raw limestone, dolomites, chalk, etc. The dose of lime (t/ha), depending on the content of calcium carbonate in it, is determined by multiplying the hydrolytic acidity of the soil by a factor of 0.5. In beet crop rotation, lime fertilizers are applied under winter crops (precursor of sugar beets) or directly under sugar beets - once per crop rotation rotation.

In order to improve the conditions for the development of sugar beet plants, plastering should be carried out on saline soils that occur in the beet cutting zone. The average doses of gypsum on the salt-rich soils of the left bank are 3–4 t/ha, on salt marsh patches – 6–10, and in the south – 2–3 and 5–6 t/ha, respectively.

Sowing. Currently, seeds are sold in sowing units. One sowing unit contains 100,000 ± 2% seeds. At seed factories, seeds are calibrated according to 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 uniformity of not less than 90%, humidity - not more than 14.5%.

In order to prepare high-quality seeds (and this is an indispensable requirement of modern intensive technologies of factory sugar beet cultivation), it must be ground during the factory preparation process. This especially applies to the seeds of emergency hybrids, as well as to all seeds grown without planting. At the same time, the sowing 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, passes into a smaller fraction or into the waste as multigerminal. Improvement and mastering of modern technologies of post-harvest and factory processing and preparation of seeds to a large extent solves the problem of its alignment within each sowing fraction.

The last stage of seed preparation at seed factories is its etching or more modern methods - encrusting, coating or encapsulation.

Seed treatment involves applying a layer of insecticides and fungicides to its surface in order to protect seedlings 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 poisoning - inlaying, i.e. applying a thin film on it, the composition of which, in addition to the film-forming agent, includes fungicides, insecticides, and sometimes substances that stimulate its germination. In addition, various dyes are used for branding. Except for a certain increase in flowability, encrustation does not change the physical properties of the seeds. Its main effect is reduced to a stimulating and protective function. Seed germination is stimulated, therefore its field germination is increased, emergence is accelerated and seedling friendliness is optimized. Due to the addition of effective pesticides to the inlay film, which protect seedlings and seedlings from diseases and pests, the preservation of the given density of plants in the initial period of their life is ensured, which is difficult to overestimate from the point of view of the effectiveness of the entire intensive technology of growing sugar beets as a whole.

Compared to coated seeds, such seeds require less moisture for germination, so it is advisable to use them in farms where in the spring the moisture reserves in the upper layer of the soil are limited and insufficient for the germination of coated seeds.

When growing sugar beets by sowing reduced seed rates, or sowing at the final density of plant standing, the most effective is the use of coated or encapsulated seeds. The seed coating and encapsulation technology is more complex and energy-intensive, but it makes it possible to obtain better quality seeds, mainly due to high uniformity in size, more reliable layer-by-layer fixing of components of protective and stimulating substances.

The spherical shape of the coated seed best allows it to be sown at a given interval for the final density of the plants. Reliable and safe fixation of chemical protective-stimulating drugs around the seeds in separate shells improves the nutrition of seedlings and the protection of seedlings from pests and diseases. Dragee is hydrophilic and does not require high soil moisture (Fig. 12). However, in arid conditions, or with a low agricultural culture, it is not worth using coated seeds. Here it is better to sow "bare" encrusted seeds.

Fig. 12 – The structure of sugar beet seed dragee:

1. Fungicide on seeds with embryo;2. Special dredging mass; 3. Fungicide and insecticide;4. Protective colored shell

Encapsulated seeds differ from coated seeds in that a shell (capsule) is created near the seed, which contains nutrients, stimulating substances and a composition of insectofungicides. Compared to coated seeds, it requires less moisture for germination, which allows its use in conditions of lower moisture of the upper soil layer.

Dredging as a special measure to increase the evenness of sowing fractions of sugar beet seeds, improve the entire complex of its physical properties (size, shape, flowability, ballistics) and, what is most important, first the accuracy and fixity of its sowing, and then the friendliness of seedlings, stimulation of initial growth and protection seedlings from pests and diseases became widespread in global beet growing.

High-quality material is used for dredging, which contributes to fast and friendly climbing without negative consequences. In order to disinfect seeds from pathogens, to ensure a protective effect against soil and terrestrial pests in the early phases of plant development (from sowing to the appearance of the first pair of true leaves), the seeds are treated with protective and stimulating compositions, which include, as preparations of fungicidal action (TMTD (8 l /t) and Tachigaren (6-15 kg/t), as well as such preparations as Gaucho (128.6 g/1 p.o.), Poncho Beta FS 453.3 (0.075-0.15 l/1 p.o. o.), Force 200 SS (35 ml/1 p.o.) and Cruiser 350 FS (10.0-15.0 l/t), which effectively protect seeds and seedlings from a complex of underground and terrestrial pests in the initial periods of growth sugar beets.

Sowing dates are determined by the biological properties of sugar beets (the need for heat, moisture, the length of the growing season), as well as soil-climatic and agrotechnical conditions, features of meteorological phenomena.

Given that modern sugar beet hybrids are resistant to the manifestation of "flowering" and can withstand relatively low temperatures during seed germination and at the beginning of the growing season, they should be sown in early spring - immediately after the sowing of early spring crops.

It is necessary to start sowing sugar beets when the soil moisture is 22-23% of the LV and the soil is well crushed, and its average daily temperature at a depth of 8-10 cm reaches 5-6^{0}C. The delay in sowing by only 5–6 days, against the optimal terms, leads to a shortage of 3.0–4.0 t/ha of root crops.

On cultivated fields in areas with sufficient moisture, the depth of seed wrapping is 2–3 cm, unstable and insufficient – 3–4 cm. On heavy flooded soils, the depth of seed wrapping should be no more than 2–3 cm.

The main condition for the established seed wrapping depth is the need to dig it into the moist soil layer. Coated seeds, which need more moisture for germination, are also sown a little deeper. The best depth of covering coated seeds with normal moisture is 2.5–3 cm. When water reserves are limited, the depth of covering seeds increases to 4 cm.

The optimal plant density for the harvesting period on high agrophones for the zone of sufficient moisture is 100–110 thousand/ha, unstable – 95–100, and insufficient – 90–95 thousand/ha. The mass rate of sowing 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 coefficient of plant loss from seedlings to harvesting (1.2–1.3) and the expected field germination, taking into account laboratory germination, soil characteristics, its condition in the spring, the forecast of species and the number of pests, pathogenic microflora, etc.

Under the intensive technology of growing sugar beets, two methods of forming the density of plants are used: sowing to the final density and forming by mechanical methods. When sowing at the final density of plants, 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 beets when sowing at the final density of plants is most effective when using coated seeds.

Mechanical and pneumatic planters of domestic and foreign production are used for sowing sugar beets with row spacings of 45 cm. Due to regulation and sowing control during sowing, the necessary width of the main row spacings is provided - 45±1 cm.

Crop care. The crop care system includes: continuous tillage of the soil before the emergence of seedlings, loosening of the soil between the rows and in the zone of the rows (layering), continuous loosening of the soil between the rows, protection against weeds, pests and diseases, feeding of plants.

When sowing at the final density, pre-, post-emergence and inter-row loosening is carried out only if necessary, as they can lead to a significant decrease in the optimal density of plant standing. It is worth remembering that coated seeds need more water and better air access than normal ones for germination.

Pre-seedlings care. Under optimal conditions for seed germination, sugar beet seedlings appear 8–10 days after sowing, and at a low temperature of the surface layer of the soil - after 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 layer of the soil is carried out once or even several times. The purpose of complete pre-emergence loosening of the soil is to destroy weed seedlings, prevent the formation of a soil crust and disease of seedlings by rootworms, and improve the conditions for the germination of sugar beet seeds.

For pre-emergence loosening, mainly wide-grip units equipped with tooth harrows are used, as well as cultivators equipped with rotary working bodies with rod rotors without loops.

If it has rained after sowing and the formation of a soil crust is possible, pre-sowing loosening of the soil should be carried out as soon as it is possible to operate the units in the field. On very loose soils, in order to ensure the required depth of cultivation, the field is pre-rolled with smooth rollers, the movement of which is directed at an angle of 5–10? to the direction of the lines. Continuous loosening of the soil before emergence is not allowed if the height of the seedlings exceeds 10 mm.

Post-seedlings care for crops consists of the first loosening of the soil in the interrows and in the zone of the rows (layering), adjustment (at low seeding rates) or formation (at increased sowing rates) of plant density, continuous loosening of the soil in the interrows, protection against weeds, pests and diseases, plant nutrition.

The first loosening of the soil between the rows and in the zone of the rows (layering) is carried out, if necessary, in the period when the rows of beet seedlings appear. For this, cultivators equipped with one-sided flat-cutting paws with a grip width of 150 mm are used for this, two are installed on each inter-row and at a cultivation depth of 3-4 cm, as well as rotary batteries that move in the inter-row and zone areas of the rows.

In very weedy fields and with a sufficient number of seedlings (at least 10 plants per 1 ha. m), continuous post-emergence loosening of the soil is used. The optimal period for its implementation is the first pair of real leaves.

If the equilibrium density of the soil is high on the sugar beet crops, a dense crust forms on the soil, or the soil floods after prolonged and heavy rains, then there is a need for inter-row loosening. Loosening of the soil between the rows is carried out after the formation of the density of the standing plants, combining it with top dressing. For this, cultivators are equipped with appropriate working bodies. The first ones equipped with rotary working bodies allow to reduce the protective zone of the rows to 6–8 cm and to loosen the soil in the zone of the rows 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 lumps are formed due to increased soil density, the soil is first loosened to a depth of 5–6 cm with one-sided razor blades, installing two of them for each row interval and rotary working bodies.

Then loosen the soil by 10–12 cm and simultaneously feed the plants with mineral fertilizers. A chisel, feeding knife and rotary working bodies are installed for processing each row.

After 10–15 days, depending on the amount and intensity of precipitation, the appearance of weeds, and the condition of the soil, it is advisable to carry out another loosening of the rows to a depth of 12–14 cm, and even deeper on heavy soils.

Protection of crops from weeds. Due to their morphological features, sugar beet plants are unable to resist weeds by themselves.

The amount of sugar beet yield reduction significantly depends on the period of their joint vegetation with weeds in the crops, the species composition of the weeds. Perennial weed species (thistles, creeping heather, field birch) and one-year dicotyledonous weeds (species of quinoa, scotchwort, bitter gorse, and others) are characterized by a particularly high level of harmfulness. An important factor of harmfulness is their competition for energy supply, water, and mineral substances. During 80 days of joint vegetation, the weed complex absorbs from the soil such a volume of the most available forms of macroelements (N, P_2O_5, K_2O), which is sufficient for the formation of a crop of root crops of 45–55 t/ha with the corresponding above-ground mass. Research has established that with a mixed type of weeding, the permissible mass of weeds on crops in the second half of the growing season should not exceed 100–200 g/m2.

Crop weediness is influenced by many factors, namely, the amount of potential field clogging, crop rotation in crop rotation, methods of main tillage for predecessors and sugar beets, species composition of weeds. In general, the basis for obtaining high yields of agricultural crops and, in particular, sugar beets, are agrotechnical measures

Herbicides are an important and effective tool for protecting crops from weeds, the use of which requires strict compliance with regulations.

Perennial weed species are a serious problem in the fields, the number of which must be controlled in the crops of sugar beet predecessors, or after their harvesting. On the stubble, when perennial plants grow back, continuous-acting herbicides are used against them. Against creeping wheatgrass (phase 4–6 leaves), it is sufficient to spray Roundup herbicide (3–4 l/ha), against various 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 a generative shoot in thistle). If the fields are weeded with thistles and dicotyledonous annual species before Roundup, to enhance its effect, it is recommended to add 2,4-D amine salt (2.5 l/ha), Dialen super (1.5 l/ha) or Dicamba forte (1.2 l/ha).

Annual weeds, especially dicots, cause great damage to sugar beet crops. These weeds are characterized by a large species diversity, belong to different botanical families, and seed reserves in the plowed soil layer reach 2.0–2.5 billion pieces/ha. A reliable system of protection against weeds is an important part of the intensive technology of growing sugar beets.

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 mechanized operators, the financial capabilities of the farm and the peculiarities of soil and climatic conditions. Today, two main systems of protection of sugar beet crops against weeds are recommended for production: combined and post-seedlings.

The combined system of protection against weeds is used in fields with a high level of potential clogging of the arable layer, as well as in farms with an insufficient level of technical support. The combined system involves mandatory application of soil herbicides that act in moist 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 number of seeds of annual weed species in the soil, the pH value, the mechanical composition of the soil, the humus content, the level of moistening of the upper layer of the soil in the spring period, the spectrum of action of the drugs.

It is most difficult to control a complex of dicotyledonous weed species. In the zone of sufficient moisture, it is most appropriate to apply Goltix and Pyramin Turbo to the soil. In the zone of unstable hydration, use the above-mentioned preparations or Dual Gold. In the zone of insufficient moisture, use Dual Gold or Frontier Optima from soil preparations. The action of Frontier on sugar beet plants is relatively "harsh", therefore it requires an accurate and correct choice of application rates. When the content of humus in the soil is up to 3.0%, the application rate of Frontier Optima for sowing beets can be 0.8–1.0 l/ha. If the soil contains more than 3.5% humus, the dose of Frontier Optima can be increased to 1.2 l/ha.

The time of applying soil herbicides to the soil is of great importance. If the spring is cold and prolonged, it is better to apply soil preparations before the emergence of seedlings, then the active germination of weed seeds coincides with the period of active action of the preparations. In the conditions of late and friendly spring, when the temperature rises rapidly, pre-sowing application of herbicides to the soil will be more rational.

In the zone of sufficient moisture, soil herbicides may not be applied to the soil. In the zone of unstable moisture, in a dry spring, it is desirable to apply herbicides to the soil, if the spring is rainy, then this measure is optional. In the zone of insufficient moisture, wrapping soil preparations is mandatory, as it increases the effectiveness of herbicides by 15–30%.

Most soil herbicides are able to effectively suppress the emergence of weeds for 3-4 weeks from the time of their application, provided there is moisture in the soil. In the future, the protective effect is significantly reduced. As a result of the decrease in the protective effect of soil herbicides, weed seedlings appear on sugar beet crops already in the second half of May.

Under the combined weed pest control system, before the emergence of sugar beet seedlings (in dry conditions, it is better to wrap them in the soil), apply the following herbicides or their compositions: 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 + Lenatsil 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 to 1.2 l/ha (only on soils with a humus content of more than 3.5%).

Soil herbicides can significantly reduce weediness, but as mentioned above, their duration of action is limited (30–35 days).

During the emergence of beets (weeds in the cotyledon phase), one or two sprayings with one of the herbicide compositions should be carried out: Betanal Expert (or Betanes) + Caribu, 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; Symbetan Duo, 2.0–2.5 l/ha.

When a new wave of weed seedlings appears (after 7–10 days), spraying is repeated using one of the compositions: 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; Symbetan Duo, 3.0–3.5 l/ha;

The use of soil preparations reduces the tension in carrying out protective measures at the emergence of sugar beet seedlings, but cannot replace post-seedlings herbicides. Most types of weeds, especially dicots, have a long period of seed germination, so it is very difficult to completely control their appearance with soil herbicides. To successfully protect sugar beet crops from weeds, the action of soil herbicides is enhanced with post-seedlings preparations.

The post-seedlings system of protection against weeds is advisable in fields with a low and medium level of potential clogging of the arable layer in farms with a high culture of agriculture, with sufficient technical support (there should be enough sprayers to process all areas of sugar beets no longer than in 3 days) , the availability of qualified specialists and herbicides in the required quantity in the farm. The post-seedlings system requires high technological discipline, timeliness and high quality of protective measures, taking into account the species composition of weeds, phases of plant development, peculiarities of the action of drugs, and weather conditions. The post-seedlings system is the most modern and promising and can be used in all soil and climatic zones of beet sowing.

Almost simultaneously with the appearance of sugar beet seedlings, the seedlings of white quinoa, hybrid quinoa, multi-seeded quinoa, birch mustard, spreading mustard, wild radish, field mustard appear on the crops. At the same time, or 7–15 days later, late blooming types of weeds sprout en masse: common sedum, white sedum, chicken millet, black solanum, mouse gray and others. For the correct selection of herbicides, the sensitivity of weeds of different species to the action of specific drugs should be taken into account (Table 1.4).

Dicotyledonous weed species must be treated with herbicides in the cotyledon phase, when weeds are most sensitive to their action. When choosing herbicide compositions, it is necessary to take into account the characteristics of weeds and the structure of weeding of crops.

The rates of application of herbicides at the first spraying of seedlings are minimal. The most selective and "soft" sugar preparations for beet plants are used: Goltix, Pyramin turbo, Caribu, Bethanal expert, Bethanal progress OF, Viktor and others. Do not spray crops heavily damaged by pests or after frost.

If soil herbicides were not applied, then two or three successive sprayings are carried out in the phase of developed cotyledons in sugar beet and weed plants.

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; Symbetan Duo + Caribu, 2.6 + 0.03 l/ha; Bethanal Progress Am + PyraminTurbo, 1.5–2.0 + 1.5 l/ha

When a second wave of weed seedlings 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) + Caribu, 1.0 + 0.03 l/ha; Burefen FD-11 + Caribu, 3.0 + 0.03 l/ha; Symbetan Duo + Caribu, 3.0 + 0.03 l/ha.

Spraying seedlings or using them in tank compositions with other herbicides when a new wave of weeds appears (after 10–14 days), applying Bethanal Expert is carried out according to the same norms, 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 after 10–14 days with the same rates of herbicides as during the second treatment.

As a rule, during the period of the third, and sometimes the second spraying, massive sprouts 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 and others) or in combination with the introduction of drugs against dicotyledons.

When using herbicides on sugar beets, it should be remembered that the main task of an agronomist-technologist is not 100% destruction of weeds in crops, but obtaining a high yield of high-quality raw materials of sugar beets. Therefore, the regulations and deadlines for the use of herbicides should be strictly followed, since these drugs in high doses and when used in the cotyledon phase of sugar beets are quite phytotoxic for the culture. Therefore, they can significantly suppress sugar beet plants, which leads to a decrease in yield and product quality.

The complex of protection of beet fields from weeds with strict adherence to the regulations for working with herbicides does not produce side effects and is therefore acceptable. Mechanized work can be carried out on the 4th day after applying herbicides. Manual work can be started on the 8th day after spraying.

The optimal consumption rate of the working fluid 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, with a wind speed of up to 5 m/s and a temperature not higher than $+24^0$C.

Pests of sugar beets and measures to protect against them. Sugar beets in Ukraine are damaged by many types of pests. Among them, the most harmful are: common and gray beet weevils, beet fleas, scale insects, beet mealybugs, wireworms, beet fly and beet leaf aphid.

In some years, sugar beets are harmed by leaf-gnawing and nibbling caterpillars, meadow moth, root beet aphid, mealybug larvae, carrion eaters, passing moth and others.

If there is a strong threat of the appearance of soil and terrestrial pests, both in the winter and in the spring-summer period, a set of measures should be implemented. In particular, for sowing, it is necessary to use seeds treated with protective and stimulating substances with the inclusion of insecticides and fungicides in their composition, or their compositions in accordance with the recommendations of scientific institutions for a specific zone of beet sowing, the species composition of phytophages and pathogens and their regional abundance.

So, application of a composition of systemic insecticides: Poncho Beta, Cruiser 350 FS, Force Magna and fungicides: Tachigaren 70%,Apron XL, 35%, Royal flo 48%, TMTD, Tachigaren + Royalflo, in the recommended rates, provide adequate protection of sugar beet seedlings from harmful organisms for 30–40 days from the beginning of the vegetation of the crop under optimal weather. With increased air temperature in the period after sowing sugar beets (above $+20^0$C) and the absence of precipitation, the term of the toxic effect of insecticides will be significantly shortened.

To avoid the loss of plants from damage by wireworms, it is desirable to determine the location and condition of these pests. The best time for sowing is when wireworms are in the soil layer of 0-5 cm, the toxicity of the poisoned seeds ensures almost 100% of their death.

When the number of beet fleas, gray and common beet weevils is above the economic threshold of harmfulness (fleas 5–7 individuals, weevils 1.5–2 individuals per 1 m.p.) and the seedlings are threatened by them, sugar beet crops should be sprayed with insecticides, giving this gives preference to organophosphorus compounds or their mixtures with pyrethroid drugs in half the rates. For this, it is necessary to have a reserve of insecticides of at least 30% of the total volume of crops of this crop (Bazudin, 60% + Phozalon, 35% - 0.8 + 1.5 kg/ha by preparations or Decis 5% + Phozalon, 35%, - 0.2 + 1.5 kg/ha per preparation).

In the summer period, when an increased threat to developed beet plants is expected from the main specialized (leaf and root aphids, midge fly, nematode) and omnivorous (leaf-gnawing and nibbling caterpillars, meadow butterfly, etc.) pests, careful monitoring of the appearance and growth of these pests is necessary insects When they reach the level of the economic threshold of harmfulness, protective measures must be taken.

The leaf aphid and the passing fly first inhabit the edges of the plantations. Therefore, in June, when 10% of the plants are inhabited by aphids and 30% by the passing fly (3 larvae per plant), the marginal strips 45–60 m wide are sprayed and, only if necessary, the entire field is treated with insecticides: Aktelik or Lebaitsid, 50% , Dursban 48% k.e., Buzudin, Diamet 60% – 0.8 l/ha, Sumition, 50% of – 0.6–12 l/ha, Sherpa, 25% – 0.48 l/ha (seeds).

Sugar beet diseases and protection measures. Sugar beets are affected by many diseases, the causative agents of which are fungi, bacteria, viruses, flowering plants - parasites, as well as unfavorable soil and climatic conditions and other factors of the external environment. The most common and harmful diseases of sugar beets are: seedling root rot, scab, dry fusarium, brown and other rots of root crops, powdery mildew, viral diseases, rots of root crops during the growing season, as well as black rot - during storage of beets. Diseases cause disturbances in the normal physiological functions of plants, which lead to suppression of their growth and even death.

Agrotechnical measures can prevent or significantly reduce seedling diseases. At the same time, a high general culture of agriculture, observance of scientifically based crop rotations with the introduction of optimal doses of organic and mineral fertilizers, high-quality main and pre-sowing soil cultivation, optimal sowing dates and depth of seed wrapping are of decisive importance.

An important element of protection against diseases is the treatment of seeds with compositions of protective and stimulating substances at seed factories. A mandatory component of these compositions is a fungicide, which allows you to completely destroy the activity of soil pathogens.

In the zone of constant threat of the appearance of correid, the most reliable protection is provided by Tachigaren mixed with Apron or Previkur, or Sulfocarbathion-K. Treatment of sugar beet seeds with protective and stimulating substances is carried out centrally at seed factories no earlier than six months before sowing, or immediately before sowing.

Taking into account the periods of active harmfulness of diseases according to the phases of development of sugar beets, a fungicide application program is developed, which indicates the drugs recommended for combating individual diseases or their complex, the dosages and the duration of toxic action.

The use of sugar beets for processing, for livestock feed, as well as seed production of this crop by the planting method, requires storage of root crops for 150–160 days. At the same time, as long-term experience shows, the storage of sugar beets is usually accompanied by losses of mass and sugar, often significant. One of the reasons for these losses is the vital activity of microorganisms - fungi and bacteria that cause rotting of root crops - kagat rot. Affected by this disease, individual parts or the entire root crop are covered with white, gray, red or pink mold, and the rotten tissue acquires a grayish, sometimes almost black color, loses its strength, and collapses. In some years, 15–20%, sometimes even 30–40% of sugar beet root crops die in the kagat fields of sugar factories. The following system of measures has been developed against the Kagat rot: the creation and introduction into production of disease-resistant varieties and hybrids of sugar beets; sowing of sugar beets after the best predecessors, introduction of scientifically based norms of organic and mineral fertilizers; timely protection of crops from a complex of pests and diseases; protection of root crops during harvesting, transportation, packing and storage from mechanical damage, wilting and freezing; creation of optimal conditions in root storages, trenches, trenches - temperature +1...3 ^{0}C, relative humidity – 90-98%.

Protection of the leaf apparatus from diseases, the main of which are cercosporosis, powdery mildew, ramulariosis, fomosis, peronosporosis and rust diseases, is of great importance when growing sugar beets. To protect crops from these diseases, modern single- and multi-component preparations have been created that protect against a complex of pathogens, and with one spraying, you can solve the problem not only with one of the pathogens, but also protect crops from other harmful diseases. Among them, we should note fungicides that contain the active substance of the strobilurin group: azoxystrobin (Amistar extra 280 sc, k.s.); pyraclostrobin (Abacus, m.c.e.), picoxystrobin (Acanto plus 28, c.e.); trifloxystrobin (Sphere max). The use of these drugs in the systems of protection of sugar beets from leaf diseases allows to protect sugar beets not only from diseases, but also, thanks to the so-called "vigor effect", to significantly prolong the active photosynthetic activity of sugar beet leaves in the late growing season (August - September). . This allows you to significantly increase the yield and sugar content of the roots.

It should be taken into account 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 the development of leaf diseases (the third decade of June - the first decade of July). In addition to the already mentioned drugs, the "List of pesticides and agrochemicals approved for use in Ukraine" includes a sufficient number of original and "generic" fungicidal drugs that successfully control leaf diseases. As shown by the experience of producers and scientific research, when planning a sugar beet protection system, in order to prevent negative side effects on plants, preference should be given to original drugs and very careful to replace them with "generic" ones.

The first signs of cercosporosis appear on the leaves in the form of single light brown: spots with a brown border in the phase of leaf closure in the interrows (end of June - beginning of July). In most cases, the disease manifests itself first in areas that border or are close to last year's crops.

Factors that accelerate the development of the disease are sudden changes from moderate and humid weather to hot and dry. Under their influence, sugar beet leaves quickly lose turgor and become vulnerable to the causative agent of cercosporosis.

Harvesting. In the fall, sugar beets continue to grow intensively and accumulate sugar. Thus, the weight gain of one root crop from August 20 to September 20 is an average of 96 g, and the sugar content during this time increases by 2.2%. Therefore, it is necessary to plan harvesting operations in such a way that there is a greater increase in the mass of root crops and timely completion of harvesting and removal of the crop.

Mass harvesting of sugar beets in the main beet cutting zone of Ukraine should be carried out from September 20 to October 25.

Today, foreign-made self-propelled beet harvesters - Holmer (Germany), Kleine (Germany), Verwat (Netherlands), Moreau (France) are used in harvesting operations, which allow harvesting both chard and root crops in one pass, and trailed beet harvesters - Kleine (Germany). , Stol (Germany) (Fig. 1.4).

When harvesting beets, cutting the heads of root crops into beets and contamination of the collected beet raw material with green mass should not exceed regulatory tolerances - 5.0 and 3.0%, respectively; the total loss of the green mass of the gorse is no more than 10%, and the mass of the land in the gorse is no more than 0.5%; the number of root crops knocked out of the soil and their parts remaining in the soil and on its surface should be no more than 1.5%, severely damaged root crops by mass - no more than 5%.

When loading root crops with harvesters from field kagats with beet loaders, the completeness of selection of root crops should be at least 99%, and the number of severely damaged root crops should be no more than 3%. The total contamination of the beet raw material after the beet loader should not exceed 5%, including scallions and other plant residues - no more than 10%.

Losses and the quality of the equipment are monitored during assembly. For this purpose, 10 m^2 are measured, i.e. 6 rows of 3.70 m each in a six-row harvesting machine. On the site, all root crops or their remains are collected from the soil, weighed and the result is divided by 100. This is how losses in quintals per 1 ha are obtained. In order to accurately determine the losses per 1 ha, it is necessary to carry out such control for each unit at least 5 times per shift. Losses occur due to surface losses of root crops, under-digging and breaking off of their tails (underground losses). Losses of beets when the tails of root crops are broken off are shown in Figure 13.

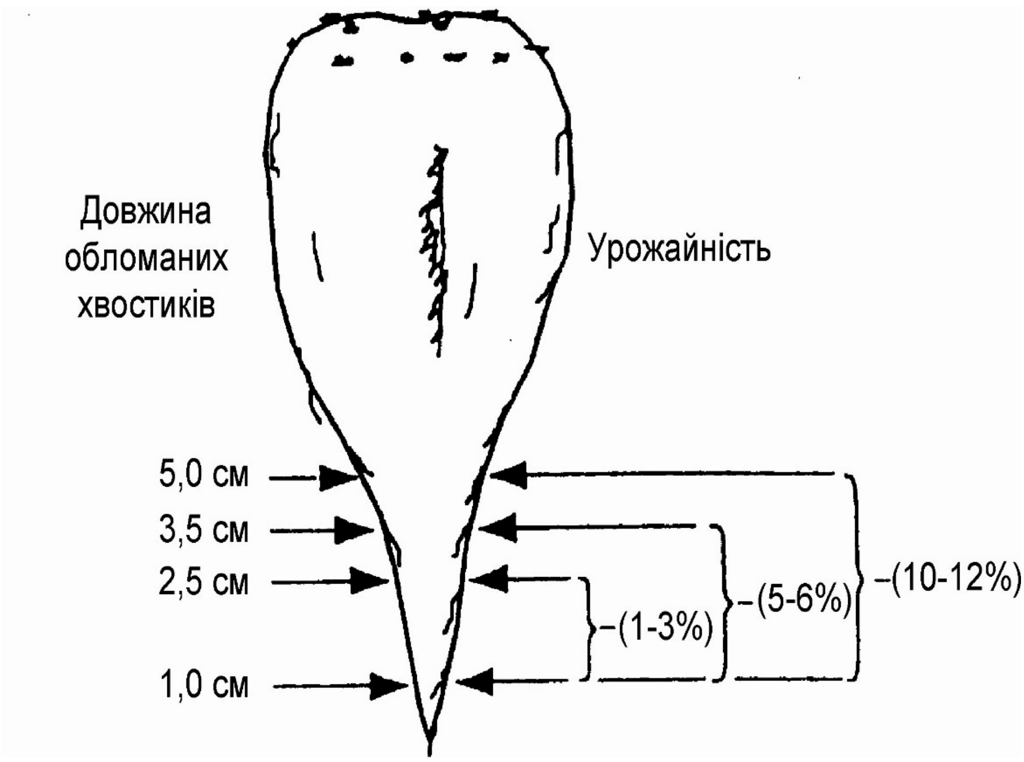


Fig. 13 – Losses of the sugar beet harvest depending on underground losses, %

Not only the yield and quality of the root crop depends on the cutting height of the gorse, but also, as a result, the refined yield of sugar. The optimal place for cutting the gorse is 1 cm below the lowest green petioles of the leaves. At the same time, the quality of the cutting edge of the knife-hitch cutter is of decisive importance.

Field uniformity also affects the cutting of sedges, since the height of the heads of sugar beet plants turns out to be different in thinned crops. As a result, the cut of the hem is either too high, or too low, or oblique. The distance between plants in a row also affects the quality. At a very short distance, a sharp knife can jump and not cut at all. Finally, the quality of the cut depends on the varietal properties of the hybrids. The quality of sugar beets depends on the correct cut, because the heads of the latter contain, compared to the whole root crop, a double content of substances harmful for processing (Fig. 14).

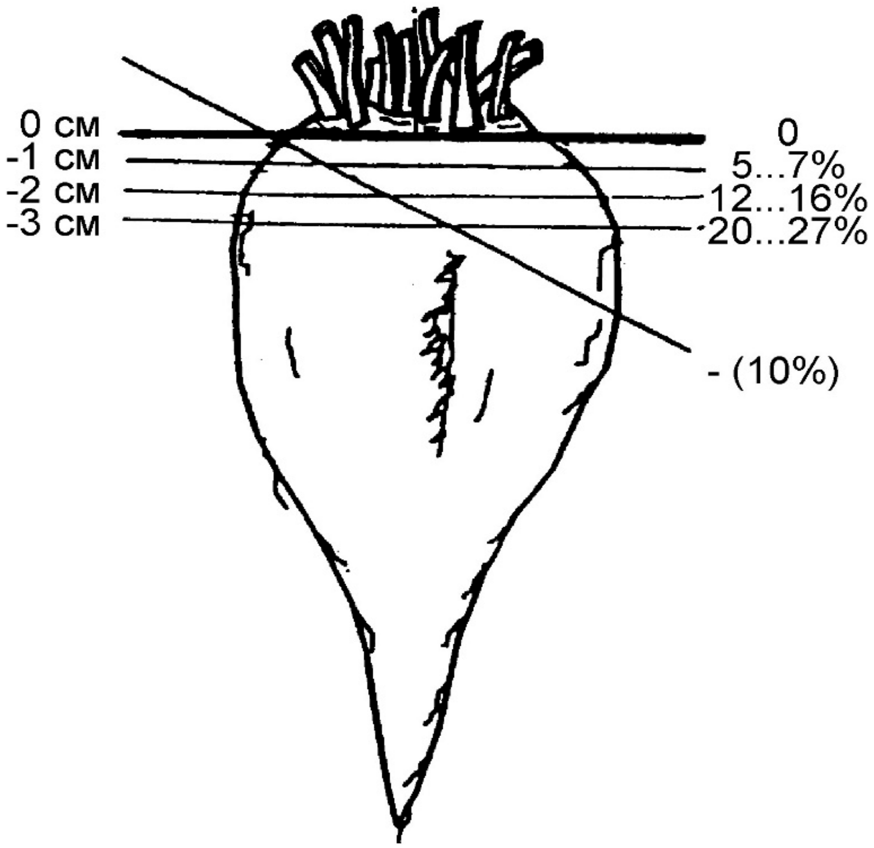


Fig. 14 – Sugar beet crop losses due to incorrect cutting of the sedge, %

The main method of harvesting sugar beets is streaming. It ensures minimal labor and money costs, high quality of beet raw materials and less loss and damage of root crops due to direct delivery to the sugar factory and avoidance of their temporary storage in field storage bins. Root crops collected by the flow method are better stored in the factory storage bins. Their mass loss from rotting is 1.5–3.0 times less than that of root crops collected by the transshipment method. However, the application of the flow method requires more vehicles, more fuel consumption and wear and tear of cars moving alongside root harvesting machines at low speed. In addition, at the same time, the efficiency of the use of heavy trucks and road trains decreases.

The transshipment method of harvesting should be used in case of insufficient supply of road transport equipment and in extreme conditions (very wet or dry, hard soil, increased weediness), when root crops are significantly contaminated with soil and plant residues. It should be applied only in an amount that allows the stock of root crops created during the day of harvesting to be taken to the sugar factory within a day. It should be noted that the transshipment method of harvesting increases the efficiency of the use of heavy-duty vehicles, reduces the contamination of raw materials with soil and plant tails, and increases the possibility of transporting beets in adverse weather conditions.

It should be remembered that with the transshipment method of harvesting, losses of raw materials increase, their quality deteriorates due to an increase in the number of damaged root crops during their stacking and temporary storage in field sacks.

On the eve of harvesting, an agrotechnical assessment of the plantations is carried out - the width of the main and adjacent rows, the density of plants, the yield of root crops and sprouts, their size and weight, the position of the heads of root crops relative to the soil surface, the deviation of the rows from the axial lines are determined.

It is advisable to start harvesting beets from fields far from paved roads, with an earlier sowing period, as well as from areas damaged by diseases and pests, with uneven placement of plants and the presence of large hollow root crops, which are most likely to be damaged during harvesting.

First, beets are collected from turning lanes, the width of which should be 21.6 m (4 passes of a 12-row seeder). After harvesting the beets on the turning lanes, the field is divided into corrals with the optimal number of rows of 240, i.e. multiples of the width of the working grip of the machines. The width of intercorral passages should be equal to 12 rows; the borders of the folds should pass along the joint spacing. For the passage of transport units, six lines are assembled on each side of the corral.

Harvesting sugar beets by a three-phase method (roller technology) and a complex of less metal-intensive trailed machines for its implementation requires an increase in the number of energy resources, which leads to an increase in labor costs, fuel, and crop losses.

2.3 OIL AND ESSENTIAL OIL CROPS

The oleaginous group includes crops whose seeds or fruits contain at least 15% fat (lipids). There are more than 340 such plants belonging to different botanical families and they unite more than 15 thousand varieties and hybrids. The content and quality of vegetable oil in the seeds of different oil crops are not the same. Oil crops are grown on all continents and in many countries of the world. The main producers of oil crops include the USA and Brazil. Argentina, China, India, Russia, Ukraine. Together, these countries provide more than two-thirds of the world production of oil raw materials. The production structure of oil crops is dominated by soy. They account for more than half of the world production of oil raw materials, while rapeseed - 14%, cottonseed - 11%, sunflower - 9%.

In the balance of the world's fat resources, vegetable fats predominate, particularly oil. Vegetable oil satisfies 60-70% of the world's need for fats. About 86% of its total production is used for food purposes and fodder, and only 14% - for technical purposes. According to the United States Department of Agriculture (USDA), the area under cultivation of oil crops has been constantly increasing over the past five years and in the 2011/12 marketing year was 227 million hectares. The total production of oilseeds in the world in the 2011/2012 marketing year was 441.39 million tons, and the world production of vegetable oil was about 100 million tons, of which sunflower oil was 10 million tons (world leadership belongs to soybeans - 25.8 %).

Vegetable oil is of great nutritional and technical importance. The direction of its use, first of all, depends on the composition of fatty acids, the ratio between saturated, monounsaturated and polyunsaturated fatty acids. Oil is used directly as a food product, used in the canning, food and confectionery industry, for the production of various types of margarine. It is a valuable raw material in the production of oil, varnishes, paints, stearin, linoleum, used in electrotechnical, leather, metalworking, chemical, soap making, textile and other industries. Vegetable oil is the main source for the production of biological fuel - biodiesel.

Regardless of the direction of use of oils, the first step in seed processing usually consists of two processes: pressing and extraction. During the production of oil, cake and meal appear as by-products. Cake and meal is a valuable concentrated feed for animals, which contains 35-40% protein with a high content of essential amino acids.

By its nature, vegetable oil is a complex ester of triatomic alcohol - glycerol and various fatty acids. Compared to proteins and carbohydrates, oil has a higher calorie content. 1 g of oil contains 9500 calories (1 g of protein - 4400-5500 cal, 1 g of carbohydrates - 4000-4200 cal). 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 the directions of their use. The oil used for food should contain few free fatty acids.

A large part of vegetable oils, adding air oxygen, dry out and turn into a solid elastic mass. The ability of the oil to dry is a valuable indicator of its quality and is determined by the iodine number, that is, the number of grams of iodine that are used to oxidize 100 g of oil. The higher the iodine number, the more drying the oil is. According to the ability to dry, vegetable oils are divided into three groups.

Linseed, safflower, and castor oils belong to the *drying* ones (unit number over 130). They are used mostly for technical purposes.

Semi-drying oils (iodine number from 85 to 130) - sunflower, rapeseed, mustard, safflower, etc. They are used mainly for food.

Non-drying oils (iodine number less than 85) - castor, peanut, olive. They are used in medicine and for technical needs.

High-quality food and technical oil should contain a minimum amount of free fatty acids. An indicator of the content of free fatty acids in oil is the acid value, which is determined by the number of milligrams of caustic potassium (KOH) needed to neutralize free fatty acids in 1 g of oil. Oil with an acid number of more than 2.25 is unsuitable for food purposes. The acidity of the oil largely depends on the growing conditions of the oil crop and the ripeness of the seeds, the harvesting period and the storage conditions.

An important indicator of the quality of the oil used to make soap is the number of saponification, which is determined by the number of milligrams of caustic potassium (KOH) used to neutralize free and glycerol-bound fatty acids. For most vegetable oils, the saponification number is 160–200.

Among the oil crops in Ukraine, the following are common: sunflower, soybean, rapeseed, mustard, curly flax (or oilseed), poppy, rye, safflower, castor, peanut, sesame, perilla, lalemantia.

Essential oil crops are cultivated to obtain volatile aromatic substances from them - essential oil. These are various mixtures of organic compounds: carbohydrates, alcohols, phenols, ethers, aldehydes, ketones and organic acids. Essential oils have a pleasant smell and are used in cosmetic, pharmaceutical, food, soap, tobacco and other industries. They accumulate in various plant organs: in fruits, seeds (coriander, cumin, anise, fennel); in leaves and stems (mint, lavender, sage), in flowers (rose);

rhizomes (iris) (Table 12).

Table 12 – The content of essential and fatty oils in various essential oils

Name of crop	Organ of accumulation of oil	Essential oil, %	Fatty oil, %
Anise	seeds	2,5–4,0	16–22
Coriander	too	1,5–2,7	17–28
Cumin	too	4,0–7,0	18–22
Mint	Leaves and stem	2,5–4,0	–
Sage nutmeg	inflorescence	0,2–0,35	–
Lavender	too	1,0–2,0	–

Such essential oil crops as coriander, cumin, anise, in addition to essential oil (from 1 to 7%), contain a significant amount of fatty oil - 14-28%. Essential oil is obtained by steam distillation, and fatty oil is obtained by extraction with organic solvents. Essential oil crops, unlike oil crops, contain volatile oil with a strong pleasant smell.

In Ukraine, the most common essential oil crops are coriander, cumin, mint, anise, fennel, rose, lavender, sage. In the late 80s of the XX century. the sown area of ether-bearing crops was almost 33,000 ha. In 1998, it decreased to 10,000 hectares. However, in recent years there has been a trend towards the expansion of sown areas.

There is a large number of rare essential oil crops that are suitable for cultivation in Ukraine. These are anise lofant, lavender, lemon wormwood, lemon catnip, medicinal rosemary, etc.

2.3.1 **Sunflower***(Helianthus)*

Sunflower is the main oil crop in our country. It accounts for about 65% of oil crops and 15% of all cultivated areas.

The seeds of modern varieties and hybrids contain 50–55% of fat (per completely dry weight of seeds) and 16% of protein, and the kernel – 65–67% and 22–24%, respectively. Compared to other oil crops, sunflower provides the highest yield of oil per unit area (750–1000 kg/ha on average in Ukraine). The oil belongs to the semi-drying group (iodine number 112–124), that is, it has high taste qualities and advantages over other vegetable fats in terms of nutrition and absorption.

The special value of sunflower oil is due to its high content of up to 90% of unsaturated fatty acids: linoleic (55–60%) and oleic (30–35%). The fatty acid composition of the oil in sunflower seeds changes due to the blocking of the desaturase enzyme, which converts oleic acid into linoleic acid. About 65% of the total amount of fatty acids is synthesized in ordinary sunflower oil, and no more than 15% in high-oleic sunflower oil. Biologically, the most 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 for the production of canned fish and vegetables, in the bakery and confectionery industries. After refining (cleaning from mixtures) and hydrogenation (the oil reacts with hydrogen, as a result of which hydrogenated fats are formed; hydrogenation makes fats less prone to bitterness, 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 potatoes.

Inferior quality varieties of sunflower oil are used in the paint and soap factory and other branches of industry, they are used for the production of stearin, linoleum, waterproof fabrics, electrical fittings, etc.

When processing seeds into oil, a cake is obtained during pressing, and during extraction - meal, which makes up 35% of the weight of the seeds. The cake contains 38–42% digestible protein, 20–22% nitrogen-free extractives, 6–7% fat, 14% fiber, 6–8% ash and mineral salts. In terms of nutrition, 1 kg of cake corresponds to 1.09 fodder. unit and contains 363 g of digestible protein. Meal contains about 33–34% digestible protein, 3% fat, 1 kg of it corresponds to 1.02 fodder. unit

The husk (yield 16–22% of the seed weight) is a valuable raw material for the production of hexose and pentose sugars. Ethyl alcohol and fodder yeast are produced from hexose sugar, and furfural is produced from pentose sugar, which is used in the manufacture of plastics, artificial fiber, durable glass and other products.

Sunflower baskets (yield 56–60% of the seed mass) are used for animal feed. They contain 6.2–9.9% protein, 3.5–6.9% fat, 43.9–54.7% BER, 13.0–17.7% fiber. 1 kg of flour made from dry baskets contains 0.8 feed. unit and 38–43 g of protein. Food pectin is produced from the baskets, which is used in the confectionery industry. Ash from dry sunflower stalks is a valuable phosphorus-potassium fertilizer (it contains up to 36% potassium oxide and 4% phosphorus). The stems can be used to make paper.

Sunflower is also grown as a fodder crop in pure sowing or in mixtures with other fodder crops. The yield of green mass when growing tall varieties of sunflower reaches 40.0–50.0 t/ha. Silage from sunflower, collected in the flowering phase, is not inferior in terms of nutrition to silage from corn. 1 kg of it contains 0.13–0.16 feed. unit, 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 crop. From 1 ha of his crops, the honey collection reaches 40 kg. Yellow petals of reed flowers have medicinal value.

Sunflowers are also sown to create scenes on steam fields for snow retention.

So, among field crops, sunflower is one of the most generous. From 1 ha with a yield of 2.5 t/ha, you can get 1200 kg of oil, 800 kg of cake (300 kg of protein), 500 kg of husks (70 kg of yeast), 1500 kg of baskets (equivalent to hay), 35–40 kg of honey. The production of 1 ton of sunflower oil requires 1 hectare, and 1 ton of animal fat requires 8–10 hectares of arable land.

The homeland of the sunflower is considered to be the southwestern part of North America, where wild species of the genus Nelianthus are still found, among which there are close relatives of the cultivated sunflower. The native population used its seeds for food purposes, and also made flour from it for baking bread. Currently, soy is the most common oilseed crop on the American continent. As an oil crop, sunflower has been grown for about 150 years, mainly in regions with a climate of moderate latitudes, with rich black earth soils, warm summers, and sufficient rainfall. However, a significant part of its crops is also concentrated in areas with a hot climate and insufficient moisture.

The Spanish brought the sunflower to Europe in 1510, calling it the Peruvian chrysanthemum. In Russia and Ukraine - in the 18th century. For a long time it was grown as an ornamental plant, only occasionally - for obtaining seeds. In the middle of the 19th century sunflower oil was obtained for the first time. Since then, it has been widely cultivated.

Sunflower occupies 8% or 27 million ha in the world production of oil crops. Its main crops are concentrated in Europe (60%) and Asia (20%), and among the countries: Russia - 6.5 million ha, Ukraine - 5.2 million ha, Argentina - 3.4 million ha, India - 2.2 million hectares, the USA - 1.4 million hectares.

According to forecasts of the US Department of Agriculture (USDA), the production of 36.5 million tons of sunflower seeds is expected in the 2012-2013 marketing year. The increase in production is a consequence of the increase in productivity and the expansion of cultivated areas. Thus, the yield is expected to be about 1.4 t/ha, and the sown area of this crop is about 25 million hectares, which is 2.2 million hectares or 10% more than the previous year.

In recent years, Ukraine has observed a tendency to increase the production of sunflower seeds. If in 2005 the harvest of this crop was 4.7 million tons, then in 2012 it increased to 8.4 million tons. This was facilitated by the expansion of the sown area in 2012 to 5.2 million hectares. Simultaneously with the expansion of the area, the productivity increases, which in 2011 amounted to 1.84 t/ha (compared to 1.28 t/ha in 2005). The share of Ukraine in the world trade of sunflower oil is estimated at 57%, which confirms the sole leadership in the external sale of this product. For comparison: oil exports from Russia amount to more than 1 million tons or 11% of world sales, Argentina - more than 1 million tons (17%). In general, Ukraine exports sunflower oil to 88 countries, including India, which buys up to 27% of the external commodity fund, EU countries – 22%, Turkey – 12%, Egypt – 8%, Russia – 6%.

Biological features, varieties and hybrids. Temperature requirements. In relation to heat, sunflower is a heat-loving culture. Its seeds begin to germinate at +4...6^{0}C, but seedlings appear at this temperature in 18-20 days. The optimal germination temperature is +20^{0}C. Seedlings at this temperature appear on the 6-7th day. The sum of active temperatures from sowing to germination is 140–160^{0}C. Sunflower seedlings can withstand frosts up to -8^{0}C, but the growth and development of plants is delayed and weakened. In the flowering phase and in the following period, the most favorable temperature is +25...27^{0}C. A temperature above +30 ^{0}C suppresses the growth of plants, and at +40^{0}C - the processes of photosynthesis stop. The sum of effective temperatures during the growing season is 1600–1800^{0}C for early-ripening varieties and 2000–2300^{0}C for late-ripening varieties.

Moisture requirements. Sunflower is a drought-resistant crop. However, the requirements for the presence of moisture in the soil are quite high. Water consumption per plant during the growing season exceeds 200 liters. The transpiration coefficient is higher than that of many other plants and is 450–570. However, having a well-developed root system that penetrates the soil to a depth of 3-3.5 m, sunflower satisfies the need for water from deep soil layers. The moisture supply of sunflowers in the phase of flowering - pouring of seeds is of decisive importance for the formation of a high yield. With a lack of moisture during this period, the yield is sharply reduced due to significant empty grains, incomplete seed maturity and a decrease in the number of seeds in the basket. Therefore, when growing sunflowers in arid conditions, the accumulation of moisture in the soil through snow retention, irrigation, etc. is of great importance.

Light requirements. Sunflower is very light-demanding. With shading and cloudy weather, the growth and development of plants is weakened, small leaves and small baskets are formed, which negatively affects the harvest. Sunflower is a short-day plant. In the north, the growing season is lengthening.

Soil requirements. Sunflower is very demanding on soil fertility. The best for it are sandy and loamy black soils and chestnut soils with a neutral or weakly acidic reaction of the soil solution (pH 6.0–6.8). Heavy, structureless, as well as light sandy, saline and very acidic soils are unsuitable for sunflower.

Requirements for power cells. Sunflower uses nutrients from the soil better than other crops, and produces more of them per unit of crop. Thus, 65 kg of nitrogen, 27 kg of phosphorus and 150 kg of potassium are absorbed by the formation of 1 ton of seeds. Nutrients are used unevenly by phase. The sunflower consumes the most nitrogen in the period from the beginning of the formation of the basket to the end of flowering, phosphorus - from seedlings to flowering, and potassium - from the formation of the basket to maturity.

During the growing season, the sunflower goes through the following phases: germination, the first pair of true leaves, the formation of a basket, flowering, maturation. The duration of interphase periods for the most common medium-ripening group of sunflower varieties is: from sowing to germination 14–16 days, from germination to the beginning of basket formation 37–43, from the beginning of basket formation to flowering 27–30, and from flowering to maturity 44–50 days. The total duration of the growing season of this group of varieties is 120–140 days. Interphase periods are shortened in early ripening varieties. The duration of the growing season of varieties and hybrids, depending on their precociousness, ranges from 80 to 140 days.

According to the duration of the growing season, sunflower varieties and hybrids are divided into pre-ripened or ultra-early (80–100 days), early-ripening (100–120), medium-early (110–130) and medium-ripening (120–140 days). Abroad, sunflower hybrids are divided into groups of maturity according to the duration of the period of flowering and ripening. More than 120 hybrids and varieties of domestic and foreign selection have been entered into the State Register of Varieties.

Precocious - Odessa 149, Kharkiv 49, Enei, Ranok, Chumak, Tisa, PR62A91; early ripening - EC Biba, EC Karamba, Danube, Zaporizhsky 26, Znahidka, Natil, NK Brio, Sanluka, Svitoch, Kharkivskyi 7, PR63A40, PR63A90, Kazio, Savinka; mid-early – Alamo, Arena, Krasotka, Odessa 123, Kharkiv 58, PR64A44, PR64A63, ES Bambina; medium-ripe - Kharkivskyi 3, Zaporizhia confectionery, PR64A58, PR64A83, PR64A89, PR64E83, ES Aramis, high-oleic - NK Ferti, Tutti, NK Kamen.

Cultivation technology. Place in crop rotation. When placing sunflower in the fields of crop rotation, it should be taken into account that it is affected by the parasitic weed sunflower wolfberry (Orobanche cumana Wallr.). Lupus seeds remain viable in the soil for 6–8 years, and under favorable conditions, for 10–13 years. In addition to sunflowers, safflower, perilla, tobacco, shag, and tomatoes are affected by safflower. Therefore, sunflower should be grown on the same field no earlier than after 7–8, or even after 8–10 years. In order to fight the wolfberry in the fields of crop rotation, it is necessary to systematically destroy weeds, and first of all those on which it can be a parasite (bletoka, wormwood, wild lettuce, nettle). The best precursors for sunflower are winter wheat, corn, and legumes. It is inappropriate to sow sunflower after perennial grasses, Sudan grass, sugar beets, peas, rapeseed, soybeans, and in the Steppe - after barley and oats.

Due to the fact that sunflower deeply dries the soil and leaves a lot of carrion, it is one of the worst predecessors in crop rotation. The fields on which sunflowers were grown are left under clean steam, which makes it possible to restore moisture reserves in the soil.

Tillage. The method and terms of soil preparation for sunflower are chosen differently, depending on the predecessor and the availability of appropriate technical means, using one of three known technologies: classic (traditional), minimal or zero (No-Till).

The best method of the main tillage of the soil in sunflower growing areas is improved tillage.

After grain crops littered with annual weeds, two huskings of stubble are carried out with LDH-10, LDH-15 disc huskers - the first to a depth of 6–8 cm, the second - after 10–12 days to a depth of 8–10 cm. In fields littered with thistles and other rhizome weeds, the first peeling is carried out with disc tools to a depth of 6–8 cm, and the second, as the weeds appear, with plow peelers PPL-10-25 or flat-cut cultivators KPSH-5, KPSH-9 on a depth of 10–12 cm. An effective method of controlling root weed infestation is a combination of tillage with the use of herbicides of the 2,4-D amine salt group mixed with ammonium nitrate (8–10 kg/ha). They are applied after the growth of weeds on the peeled field. This method ensures the death of 94% of thistle and 96% of field birch.

When placing sunflowers after corn before plowing, the soil is disked with disc harrows BDT-7, BDV-6.3 in two directions to grind up nutrient residues.

At the end of September - beginning of October, plowing 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 a depth of 22-25 cm.

Semi-steam treatment is used in the zone of sufficient moisture. With this method, peeling and plowing are first carried out with plows with front plows in the unit with harrows. In the future, as weeding and germination of weeds takes place, cultivation is carried out with simultaneous harrowing.

Against wind erosion, especially in the Steppe, where dust storms often occur, flat-cut tillage is recommended, which involves tilling the field of needles with a BIG-3 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 regrowth of weeds, the soil is loosened with a KPG-250 flat cutter to a depth of 25–27 cm.

Spring and pre-sowing soil cultivation consists in early closed moisture and carrying out 1–2 cultivations. Pre-sowing cultivation is carried out to the depth of seed wrapping.

The herbocritical period of sunflower is 40–50 days (it lasts from germination to the stage of basket formation). The biological basis of the long herbocritical period is the slow growth of the plant at the beginning of the growing season, and the technological basis is the wide-row method of sowing, which creates favorable conditions for the germination of weed seeds. The peculiarity of sunflower cultivation is that all the main actions to protect crops from weeds must be carried out before the crop sprouts, which involves the use of soil hybrids, and only in the case of cereal weeds, it is possible to use graminicides. For pre-sowing cultivation, soil herbicides Harness new (2–2.5 l/ha), Stomp 330 (3–5 l/ha), Treflan (2–5 l/ha), Trophy (2–2.5 l/ha) are applied), Frontier Optima (0.8–1.4 l/ha), Dual Gold (1.2–1.6 l/ha), Gezagrad (2–4 l/ha); against dicots - Goal (0.8–1.0 l/ha).

The effectiveness of soil herbicides largely depends on a number of factors. For example, the rate of use of herbicides depends on the absorptive properties of the soil and the number of weeds – the more there are, the higher the rate. Even if the herbicide is applied on light soils, and the level of contamination is several times higher than the harmfulness threshold, the maximum rate of consumption should be applied, and vice versa, the rate of the drug should be reduced if the level of contamination is not high. The soil on which the herbicide is applied must be fine-grained, so that the drug evenly covers the entire surface of the field with a protective screen, and does not fall on the lumps, from which weeds will safely sprout.

The choice of herbicide depends on the type of cultivation and the expected yield. For extensive cultivation technology, Trofi 90 EC, and Gezagard 500 FW, but it should be remembered that one should not allow exceeding the rate of consumption of Trophy, because this can lead to the occurrence of phytotoxicity. The main signs of phytotoxicity of acetochlors on sunflower are weak development of the lateral root system, deformation of culture plants, retardation in development.

Fertilization. Mineral fertilizers significantly affect the quality of seeds and the fatty acid composition of oil, especially high-oleic hybrids. Nitrogen fertilizers contribute to the growth of productivity, but its excess leads to a decrease in fat content and increases the content of linoleic acid to 10%, which is undesirable when growing high-oleic sunflower. Phosphorous and potassium fertilizers - increase the content of oil in 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.

Sunflower has a long period of assimilation of nutrients. The sunflower fertilization system consists of the main and row fertilization ($N_{15}P_{20}$). It is better to apply organic fertilizers under the predecessor at the rate of 30–40 t/ha. In the Steppe and Forest-Steppe of Ukraine, on black-earth and dark-chestnut soils, the highest yields are obtained when nitrogen-phosphorus fertilizers are applied. With low availability of nutrients in the soil (less than 5 mg per 100 g of soil), apply 60 kg of nitrogen and 90 kg of phosphorus/ha, with medium availability (5–10 mg per 100 g of soil) apply $N_{45\text{-}60}P_{90}$, and with high availability (more than 10 mg per 100 g of soil) – $N_{20\text{-}30}P_{30}$. Fertilizer rates should be specified in each specific field. On less fertile soils, it is recommended to apply complete mineral fertilizer at the rate of $N_{60}P_{40\text{-}60}K_{40\text{-}60}$.

Sunflower is sensitive to the lack of microelements such as boron and magnesium, and therefore microfertilizers must be applied to soils lacking these elements.

Sowing. Seeds are prepared for sowing immediately after harvesting seed crops. It is cleaned, dried, sorted and only then poured into storage. For sowing, seeds weighing 1,000 seeds are used for varieties of 80–90 g, and for hybrids - at least 50 g, purity 98.0–99.9%, shell quality - 96.0–99.0%, germination 87.0–92 .0%.

Full disclosure of the potential of any hybrid and obtaining uniform and healthy seedlings is impossible without reliable protection, the first step of which should be the protection of seeds and seedlings from diseases (seed mold, fusarium root rot, white rot, transferporosis) and pests. For this purpose, the seeds are treated with special preparations - protoxins, among which the basic one is Maxim XL 035 FS, t.c.s. (6 l/t). This preparation contains 25 g/l of fludioxonil and 10 g/l of metalaxyl-M, thanks to which it not only provides reliable protection against a complex of diseases (moulding of seeds, fusarium root rot, false powdery mildew, etc.), but also does not have a negative effect on the energy of germination seeds within a year after processing. In the case of a high threat of downy mildew damage to the seedlings during poisoning, the amount of metalaxyl-M should be increased by adding the poisoner Apron XL 350 ES, (3 l/t). In this mixture, the consumption rate of Maxim can be reduced to 3 l/t.

Sunflower seedlings can be damaged by a whole complex of pests (wireworms, weevils, aphids, mealybugs, etc.). Therefore, to protect against pests at the first stages of organogenesis, seeds must be treated with Cruiser 350 FS preparations, 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", that is, it has a stimulating effect on the root system, as a result of which plants develop more actively, seedlings are more uniform and tolerate drought better.

If the number of soil pests is too high, the drug Force 200 CS, s.k. should be added to the Cruiser. (2 l/t). The peculiarity of this poison is that thanks to its fumigating properties, a protective gas sphere is formed around the seeds and young roots, entering which the pests die without damaging the plants. Force can also be used in a special granular formulation. In this case, the drug must be applied to the soil during sowing, with a consumption rate of 6 kg/ha.

Sunflowers are sown in a dotted pattern with a row width of 70 cm, with precision seed drills to a depth of 6–8 cm for varieties and to a depth of 4–6 cm for hybrids.

Both early and late sowing times cause undesirable results. With early sowing, the period before the emergence of seedlings stretches for 3–4 weeks, the seedlings are unfriendly, thinned. With late sowing, the top layer of the soil is often dried, which also has a negative effect on germination. Preference is given to early sowing times (at the same time as early spring crops) in the Northern Forest Steppe. This is explained by the fact that at late sowing times in conditions of sufficient moisture, the development of the vegetative mass increases to the detriment of generative organs. The optimal time for sowing is when the soil warms up at a depth of 4–6 cm to +6...80C. Each individual sunflower field must be sown in 1–2 days, in the farm, sowing is completed within 4–6 days.

The seeding rate depends on the recommended plant density. The optimal preharvest density of plants is 30–35 in the southern Steppe, 45–50 in the central and northern Steppe, and 55–60 thousand/ha in the Forest Steppe. Early-ripening and short-growing varieties and hybrids do not reduce productivity when thickened up to 80,000/ha.

Crop care. During the care of crops, effective protection against weeds, pests and diseases should be ensured, the optimal density of plants should be maintained, favorable conditions should be created for their growth and development, which will ensure the formation of a high yield of sunflower seeds. If the sowing layer is loose and the weather is windy, it is necessary to roll the field after sowing. This will improve the germination of sunflower seeds and, 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 teeth do not go deeper into the soil by more than 3-4 cm and do not damage the sunflower seedlings. When sowing in colder soil and slow germination of sunflower, the seedlings are harrowed twice.

The optimal period for post-emergence harrowing is the period when the sunflower has 1–3 pairs of true leaves. The unit's speed is no more than 4 km/h. This operation should not be carried out earlier than 11 o'clock, because due to high turgor, the plants are severely damaged. If these conditions are observed, the damage to sunflower plants does not exceed 10%, and the destruction of weeds reaches 80–90%.

In sunflower crops, you can use post-emergence anti-grass 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).

During the growing season, two inter-row loosenings are usually carried out with KRN-4.2, KRN-5.6A, KRN-8.4 cultivators. Inter-row loosening is especially effective in fields overgrown 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, it is recommended to carry out the last loosening with chisel-shaped paws to a depth of 10–12 cm at an increased speed of the unit. A powerful mulching layer of the soil is created, which prevents the evaporation of moisture, and vegetative weeds are destroyed. Due to the increased speed, weeds are sprinkled in the protective zone of the row, in addition, the upper horizontal layer of the sunflower root system is cut, as a result of which the development of the root system in deeper horizons is stimulated. This reduces the risk of plant suppression in the event of drought.

The sunflower yield increases when apiaries are placed on its crops. In addition, pollination of plants by bees reduces self-pollination of flowers in baskets, empty grains, etc. The apiary is taken to crops at the rate of 1-2 bee colonies per hectare.

The introduction of the Clearfield system is an innovative direction in sunflower cultivation technology. Translated from English, clearfield means "clear field". This system fully justifies its name, because it allows you to get practically clean crops even on heavily littered fields. On sunflower, the Clearfield system was first used in 2003 in the USA and Turkey, and in recent years has been widely used in the world.

According to Clearfield, modern high-yielding hybrids used in the system have the opportunity to fully realize their yield potential. At the same time, one should focus, first of all, on the phase of weed development. It is desirable that dicotyledonous weeds do not outgrow the six-leaf phase, and grasses - four leaves. And in the presence of wolfberry, the herbicide Euro-Lightning (1.0–1.2 l/ha) should be applied in the phase of 8–10 leaves.

It should be noted that at high temperature, low air humidity, as well as other environmental factors unfavorable for sunflower, a slight manifestation of phytotoxicity is possible - yellowing of leaves. After the normalization of weather conditions, this phenomenon passes quickly, without having any negative impact on yield formation. After applying the herbicide Euro-Lightning, it is very important to consider crop rotation restrictions.

Clearfield hybrids: NK Fortimi, NK Neoma, Sanai, Tristan, ES Amis, ES Primis, ES Florimis, ES Artemis, ES Aramis, ES Bellamis, Mas 80, Mas 91, Mas 87, Mas 92, Mas 95.

The DuPont company offers the Express Sun system - a unique "hybrid-herbicide" sunflower cultivation 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 drug include, first of all, its high effectiveness against a wide range of dicotyledonous weeds, including malicious and hard-to-eradicate ones (species of thistles, ragweed, etc.). Among other advantages of using this drug, it is worth noting the flexibility and wide interval of herbicide application in time: from 2 to 8 leaves of the crop. For this technology, Pioner offers the following sunflower hybrids: PR64E83, PR64E71, P63LE10, P64LE19.

To control sunflower blight (especially with Clearfield and Express Sun technologies) in the following crops of the crop rotation, it is recommended to use Granstar Gold, Caliber, Ellai Super, Laren Pro herbicides in tank mixtures with herbicides based on fluroxypyr, dicamba, 2,4-D, 2M-4X. In corn crops, it is recommended to use the herbicide DuPont Task 307-385 g/ha + surfactant Trend 90, 200 ml/ha, as well as Titus, Basis, Harmony in tank mixtures with herbicides of the hormonal group (2,4-D, dicamba). Spatial isolation of 1,500 m must be provided for areas intended for seed crops or sunflower hybridization plots from sunflower crops tolerant to the action of Express and Euro-lightning.

Protection against diseases and pests. Significant crop losses (20-30% or more) can cause sunflower diseases. Therefore, it is recommended to use insecticides recommended for use on sunflower crops (Table 13).

Table 13 - Fungicides for the protection of sunflower plants from diseases

Name of the drug, active substance, company	Application rate l, kg/ha	Harmful organism against which it is treated	Method, processing time, limitations
Akanto Plus 28 hp. (picoxystrobin, 200 g/l, cyproconazole, 80 g/l), Dupont	0,5-1,0	white and gray rot, fomopsis, fomosis, rust, false powdery mildew, septoriosis, alternaria	spraying during the growing season no more than 2 times no later than 30 days before harvesting

Derosal, k.s. (carbendazim, 500 g/l), f. Bayer Crop Science	1,5	white and gray rot, fomosis, false powdery mildew	
KolfugoSuper, v.s. (carbendazim, 200 g/l), f. Agro-Kemi Kft	2,0	phomopsis	
Korbel, k.e. (fenpropimorph, 750 g/l), f. BASF	0,8	phomopsis	
Thanos, v.g., (cymoxanil, 250 g/kg, famaxadone, 250 g/kg), Dupont	0,4-0,6	Alternaria, phomopsis, fomosis, powdery mildew, septoriosis, white and gray rot	

To protect against pests, sunflower crops are treated (if the harmfulness threshold is exceeded) with recommended insecticides (Table 14).

Table 14 – Insecticides for the protection of sunflower plants from pests

Name of the drug, active substance, company	Application rate l, kg/ha	Harmful organism against which it is treated	Method, processing time, limitations

Decis f-Lux, k.e. (deltamethrin, 25 g/l), f. 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), f. Crompton	0,09	locust complex	spraying in the phase of 12-18 leaves in sunflower no more than 1 time no later than 25 days before harvesting.
Mospilan, r.p. (acetamiprid, 200 g/l), f. Nippon Soda Co. Ltd.	0,05-0,075	locusts	spraying crops no more than 1 time no later than 40 days before harvesting.
Koragen, k.s. (chloranthraniprole, 200 g/l), f. Dupont	0,15-0,175	a set of scoops, a sunflower fire, a meadow butterfly	spraying of crops no more than 2 treatments per season (consecutively, within one generation of the pest).
Fufanon 570, k.e. (malathion, 570 g/l), f. Keminova	0,6	bugs, aphids	spraying crops no more than 2 times no later than 20 days before harvesting.

Harvesting. 35–40 days after flowering, in the phase of yellow ripeness, the accumulation of fat in the seeds ends. Next, the physical evaporation of water from the seed occurs and the phase of full ripeness begins. Practically, three phases of ripeness are established by the change in the color of the baskets: yellow - leaves and baskets of a lemon yellow color, humidity of the basket 85–88%, seeds - 30–40%; brown - baskets are dark brown, their humidity is within 40–50%, seeds – 10–12%; full - moisture content of baskets is 18–20%, seeds – 7–10%.

Harvesting of sunflower begins at an average seed moisture content of 12–14%, when in 80–90% of the plants the baskets are yellow-brown,

brown and dry, and in 10–20% they are only yellow. Optimum conditions for harvesting are 9–11% seed moisture. Provided that the farm has drying equipment and a large area of sunflower sowing, it is possible to start harvesting when the moisture content of the seeds is 20–22%. It should be taken into account that seeds with a moisture content of no more than 7–8% are suitable for long-term storage. At high humidity, the seeds oxidize and the oil becomes unfit for food.

The optimal duration of sunflower harvesting is 5–6 days. If sunflowers are harvested in the phase of full ripeness, then on the fifth day losses from seed shedding increase by 2 times, and on the 15th day by 12 times. That is, harvesting early leads to an increase in energy costs for drying, and leaving sunflowers on the stump until the stage of full maturity is accompanied by seed losses. Therefore, to speed up harvesting and simultaneous ripening of crops, they 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), Glifogan (3 l/ha), Roundup (3 l/ha). Reglon Air is a contact desiccant with an increased content of the active substance and an optimized system of adjuvants. Specially designed for desiccation by air method, ensures harvesting with the least losses. Desiccation is an indispensable part of the technology of growing many agricultural crops, including sunflower. It must be carried out on sunflower crops in order to accelerate the ripening and drying of plants at the root, to obtain dry seeds that will allow harvesting to begin 8–10 days earlier. In production, there are four main cases when it is necessary to use desiccants: wet, cool weather; uneven ripening of crops; severe disease (especially gray and white rot); high weediness of crops. Also, desiccants should be used on high backgrounds and irrigation, when the length of the sunflower growing season can change significantly. They are applied at a seed moisture content of 25–30%. Desiccants work best at an average daily air temperature of 13-14 ^{0}C. At the same time, the plants stop vegetation, at the same time ripen, harvesting is accelerated by 7-8 days. Damage by diseases is reduced, the productivity of harvesters, the quality and yield of seeds is increased, the oil yield from 1 ha is increased, and the consumption of energy carriers is reduced. They begin to collect after treatment with Reglon after 5–6 days at a seed moisture content of 12–14%, when 75–85% of the baskets turn brown. When spraying with Roundup or Glifogan, harvest after 11 days.

The heap is immediately cleaned on grain cleaning units ZAV-20, ZAV-40. Sunflower seeds are dried to 12%, and what will be stored - to 6-7%. Commodity sunflower must meet the conditions of DSTU 4694-2006 "Sunflower. Oil raw materials. Specifications". Depending on the quality criteria, the grown products are divided into higher, first or second classes.

2.3.2 Winter rapeseed *(Brassicanapus)*

Winter rapeseed is the most common oil crop from the cabbage family. Among cabbage (cruciferous) crops, it is the most high-oil crop. Its seeds contain 45–50% semi-drying (iodine number 94–112) edible and technical oil. Rapeseed oil contains 60–70% oleic acid, and since the 1980s. it began to be widely used for the food industry, while until 1974 it was used mainly for technical purposes. This is explained by the high content of erucic acid in the oil, which is harmful to the body (up to 40-45%). However, at the end of the century, rapeseed varieties with a small content of erucic acid (0–5%) were created, which significantly increased its nutritional qualities and brought it closer to sunflower oil in terms of quality. According to the European standard, edible oil from modern erucic rapeseed varieties (00) should have only traces of unsaturated acids - erucic and eicosene, 5-8% of saturated acids, 60-65% of monounsaturated acids and 30-35% of polyunsaturated acids.

When processing rapeseed from 100 kg of seeds, in addition to 38–41 kg of oil, 55–57 kg of cake is obtained, which contains 32–34% of well-balanced protein in terms of amino acid composition and 10–18% of fat, or meal (34–38%) of protein and only 2-5% fat. The composition of protein includes amino acids that are irreplaceable and vitally necessary for animals - lysine, methionine, thiotin, tryptophan, threopine. 100 kg of cake contains 90 k.o. 1 kg of rapeseed meal contains 413 g of digestible protein. A ton of meal or cake allows you to balance 8–10 tons of grain fodder in terms of protein, while increasing the content of digestible protein by 1 k.o. from 80 to 110 g.

Up to 1.0 tons of oil and 0.5–0.6 tons of protein feed are obtained from 1 hectare of rapeseed crops. For comparison, only 0.2 tons of oil and 0.7 tons of protein feed are obtained from 1 ha of crops of such a valuable crop as soy.

Winter rapeseed as a fodder crop is also valued for the fact that it is grown for green mass, for the production of silage and hay. 100 kg of its green mass corresponds to 16 fodder units, and one fodder unit accounts for 190 g of digestible protein, or 2 times more compared to the green mass of corn. The green mass contains vitamins A and C, it is highly digestible.

Rape is a valuable honey crop. Up to 100 kg of honey is obtained from 1 ha of its sowing. It clears the field early, dries the soil a little, and therefore is one of the best predecessors for winter and spring grain crops. Winter rapeseed is grown as a winter intermediate and post-harvest fodder and siderable crop.

Rape is a valuable precursor, especially for grain crops. Its vegetation lasts 10 months, and during this time, rapeseed plants protect the soil from the negative effects of heavy rains and overheating from the sun's rays, as well as from unproductive evaporation of water from the soil. Unlike sunflower, it dries the soil a little, improves its agrophysical properties and phytosanitary condition, vacates the field early. Plowing rapeseed residues is equivalent to applying 15–20 t/ha of organic fertilizers and can increase grain yield by 0.5–1.0 t/ha. A well-developed rod root system penetrates deep into the soil, improves its structure, loosens it, which is especially important when using heavy tractors. The root system is able to assimilate nutrients from the deeper layers of the soil, from where they are inaccessible to most plants. Plowing of the root system, stubble and chopped straw allows partial return of organic matter to the soil. After its mineralization, 60–65 kg/ha of nitrogen, 32–36 kg/ha of phosphorus and 55–60 kg/ha of potassium enter the soil.

Rapeseed is native to the Mediterranean countries, from where it spread to Asia. Known in culture for 4 thousand years BC. Rapeseed has been grown in Europe since the 16th century, and in Ukraine since the 18th century.

The area of rapeseed crops in the world reaches 24 million hectares with an average yield of 1.5–1.8 t/ha. The global production of this crop in 2013 is forecast at the level of 59.9 million tons. In the 2013-2014 marketing year, the global supply of rapeseed will amount to 66.4 million tons. The largest producers of rapeseed in the world today are the EU countries (21.6 million t), China (13.5 million t), Canada (11.8 million t), India (7.2 million t), Australia (1.9 million t). Ukraine shares the 5th-6th place with Australia in the production of rapeseed.

Data from the State Committee of Statistics of Ukraine indicate that the area of rape harvest in 2012 amounted to 547 thousand hectares, or 35% less than the previous year. The crop was harvested in the amount of 1.2 million tons. Winter rapeseed production dominates in Ukraine. Its share in the area structure is 85–90%. The yield of winter rape is 2.2 t/ha, while the yield of spring rape is at the level of 1.6 t/ha. Cherkasy (123,000 tons), Lviv (122,000 tons), and Vinnytsia (115,000 tons) regions are the largest winter rapeseed producing regions; spring - Chernihivsk (18.6 thousand tons) and Sumy (17.9 thousand tons).

Biological features, varieties. Rape (Brassica napus oleifera DC.) belongs to the cabbage family (Brassicaceae). Two forms of rapeseed are common in production: winter and spring (or colza). In appearance, winter rapeseed is similar to common suripy (Svyripa), but the color of svirypa is grass-green, and the leaves are covered with stiff hairs.

Temperature requirements. Rape is an oilseed crop that is undemanding to heat. Rapeseed seeds begin to germinate at a temperature of +1^{0}C, but to obtain seedlings for 3-4 days, a temperature of +14...17^{0}C is required. The sum of effective air temperatures above +10^{0}C for obtaining friendly seedlings of winter rape is 60–90^{0}C, and the guaranteed production of seeds is 2400^{0}C.

Plants vegetate at +5...6^{0}C and continue autumn vegetation even with the onset of night frosts. For autumn vegetation, a sufficient amount of active (above +5^{0}C) temperatures should be 750–800^{0}C. The growth and development of winter rapeseed in autumn, the architecture of plants at the end of the autumn growing season have a significant impact on the winter hardiness of plants and the overwintering of crops. Plants with a developed rosette of 6–8 true leaves overwinter best, which is achieved by optimal sowing time and recommended plant density.

Hardening of rape occurs in two phases. The first takes place in autumn for 14–20 days at temperatures from +5^{0}C to +7^{0}C and stops with the onset of sub-zero temperatures. During this time, high-energy substances, including soluble sugars, accumulate in the leaves. Then they drain to the root neck and growth point. The main thing in wintering is to increase the resistance of biocolloids against 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 a temperature of -5...7^{0}C. As a result of the outflow of free water from cells in plants, resistance to low temperatures increases. The root neck is the most vulnerable to low temperatures.

Plants with a rosette of 6–10 real leaves, a diameter of the root neck of at least 8 mm and a height of the location of the growth point – no higher than 2–3 cm (Fig. 2.2) overwinter best.

Seedlings of winter rape during the late sowing period, which have 3–4 leaves, do not undergo hardening and die at temperatures of -6...8 ^{0}C. With good hardening, rape tolerates a decrease in temperature at the level of the root neck to -12...14 ^{0}C, and in the presence of a snow cover of 5-6 cm - to -23...25 ^{0}C and even to -30 ^{0}C. It overwinters best at a plant height of 10–15 cm.

The root neck is the most damaged at low temperatures. The causes of freezing can be a sharp and sudden drop in temperature, as well as the overgrowth of rapeseed from the fall, and in the spring, most often during the sudden return of cold weather. In the case of overgrowth, when the soil is not frozen and the plants are covered with a snow cover, there will be a threat of rape crops falling. The reason for this is the large consumption of reserve substances for respiration and growth processes. If this process lasts more than 50 days, as a rule, in addition to falling, the plants will be severely affected by diseases (mildew, fomosis, etc.). Such crops are not able to ensure a high level of productivity and will require special care (microelements, growth-stimulating fertilizers).

Ground frosts down to -5^{0}C lead to the formation of cracks of various depths. Small cracks heal, and more significant damage can lead to breakage of plants and be a reservoir of pathogens.

Rape's resistance to frost also depends on soil moisture. If the soil is overmoistened, it can freeze even at a temperature of -6...8^{0}C. If the soil is dry, rapeseed can withstand low temperatures in the range of -18...20^{0}C for several days. Rape reacts negatively to sudden fluctuations and a long-term decrease in temperature in the fall, when the plants have not yet had time to harden, or in the spring, after the restoration of plant vegetation. During a long cold winter, or contrastingly changing temperatures at the beginning of spring, when vegetation resumes, winter rapeseed plants freeze en masse.

All generative organs, which determine the yield of winter rape, are established at very early stages of plant development. Already in the rosette phase, when 6–8 leaves have formed, the process of their differentiation takes place. About 70% of the yield of winter rape is determined by its development before the onset of winter dormancy (5–7 days at a temperature below +2^{0}C).

The vernalization stage of rape in field conditions takes place in the autumn-winter period for 45–60 days at an average daily temperature below +8°C. during spring sowing, winter rapeseed, as a rule, does not pass the temperature stage and does not form flower-bearing shoots, but develops a rosette with large leaves, which reaches a height of 60–80 cm. This makes it possible to use it for livestock feed in different soil and climatic zones of Ukraine, both in its pure form and in mixtures throughout the summer-autumn period.

Moisture requirements. Rape is a moisture-loving plant. During the growing season, it consumes 1.5–2 times more moisture than grain crops. The transpiration coefficient is 750. For germination, 50–60% of water from the weight of the seed is required. Rapeseed is inferior to wheat in its winter hardiness, and therefore its crops are placed in areas with mild winters and sufficient snow cover.

Deficiency of moisture in the soil in the phase of stemming - flowering leads to weak branching of plants, physiological wilting, falling of buds and flowers, shortening of the flowering phase, reduction of plant productivity. During the flowering of rapeseed, the humidity of the soil should be 80%.

Light requirements. Winter rape is a long-day plant. Clear weather during hardening helps increase rape's frost resistance. During the spring-summer growing season, it grows better with high air humidity at low temperatures.

Soil requirements. Of all oilseed crops, rapeseed is the most picky about soil fertility and responds well to organic and mineral fertilizers. The best for it are black soils, gray and dark gray podzolized soils with the acidity of the saline solution according to the pH value of 6.2–6.5, the potassium content (mg per 100 g of soil) – 2.0–14.5; phosphorus – 6.0–7.5; magnesium – 5.0–7.0; boron (mg per 1 kg of soil) – 0.25; sulfur - 30–60; manganese - 10–15. Soils with a pH of less than 6 require liming.

Unsuitable soils with close groundwater, heavy clay, swampy, saline, acidic and light sandy soils. Rape can't stand the close occurrence of groundwater.

Requirements for power cells. Winter rapeseed for the formation of 1 ton of seeds uses significantly more nutrients than grain crops. The average yield from 1 ton of seeds is: 60 kg of nitrogen, 24 kg of phosphorus, 47 kg of potassium. For the formation of 1 ton of main products, rapeseed carries twice as much nitrogen, phosphorus, and 3-4 times more calcium, magnesium, boron, and sulfur compared to grain crops.

There are single-zero "0" varieties containing no more than 5% of erucic acid from the total amount of fatty acids; two-zero "00" are characterized by a low content of erucic acid and glucosinolates and three-zero "000" with a low content of erucic acid, glucosinolates and fiber and a light (yellow) seed coat.

Zoned varieties and hybrids of winter rapeseed in Ukraine: for grain and fodder use (with a low content of erucic acid and glucosinolates) - Alligator, Atlant, Helio, Dangal, Dembo, Horynskyi, Exotic, Elvis, EC Artist, Landar, Lidarzhet, Nadiya, Nelson, Odila, Oktan, Omicron, Ranok Podillia, Rohan, Black Giant, Sherpa, Yura, PR46W10, PR46W15, PR45D01, PR45D03; for technical needs (with a low content of erucic acid) - Mytnytskyi 2, Ksaverivskyi, Fedorivskyi improved.

Cultivation technology. *Predecessors.* The best predecessors of winter rape are black and busy steam, grain legumes, cereal-legume mixtures for green fodder. It can be grown after clover and early potatoes. In connection with the specialization of both large and medium-sized farms, when more than 50% of the acreage is allocated to grain crops, the most common predecessors are grain ear crops. In this case, the choice should be in favor of grain crops that vacate the field earlier. So, rape seedlings are friendlier, and the development in the initial stages of growth is faster after winter barley than after spring. This significant advantage must be taken into account, especially in years with dry weather conditions during the summer-autumn period. It should not be returned to the same field earlier than after 4-5 years, and it should also be sown after mustard, cabbage and other crops from the cabbage family. Winter rapeseed is a good predecessor for winter and spring cereals, corn and intermediate fodder and cider crops. Cultivation of rapeseed and grain crops in the same crop rotation improves the phytosanitary condition of the fields and minimizes contamination of grain with root rot.

Tillage after busy pairs and early-harvested predecessors includes shelling, plowing and half-pair tillage. During soil preparation, it is necessary to pay attention to the uniformity of the distribution of the remains of the predecessor crop (straw), since, as a rule, they are winter grains. If the straw remains on the field, it must be properly crushed and incorporated into the soil so that it does not hinder the growth of rapeseed. If necessary, add stubble destructors (Biodestructor of stubble, Celulad, etc.), take into account the additional amount of nitrogen fertilizers necessary for the mineralization process. They are husked to a depth of 6–8 cm with disc units, which must be equipped with modern heavy rollers for compacting the soil (in order to provoke the sprouting of dead grain cereals).

Plowing is carried out to a depth of 22–25 cm with plows with front plows in a unit with ring-spur rollers and medium harrows. With the appearance of weeds or soil crust, cultivation or harrowing is carried out. After odd predecessors, the field is plowed by 20–22 cm and simultaneously harrowed. If the predecessor is an early potato, you can limit yourself to surface treatment.

Two weeks after plowing, the first wave of sprouted weeds is destroyed by surface tillage, and the second by pre-sowing tillage. Since after cereals, instead of the recommended 3-4 weeks, there are often 2 weeks before sowing rapeseed, special attention is paid to the quality of plowing. The plow is aggregated with a roller and harrows to accelerate soil settlement.

For pre-sowing processing when growing rapeseed, only combined units are used - RVK-3,6, LK-4, APB-6, KAAP-6, Combi 3900, AG-3, AG-6, Europak, Compactor, Farmet, etc., which provide compaction of the upper layer of the soil and create its fine-grained structure. The depth of movement of the loosening paws should correspond to the depth of sowing and be no more than 3–4 cm. Under the action of combined tools, the soil additionally settles, which compensates for the failure to observe the 1-month interval between plowing and sowing.

If the technology provides for the use of soil herbicides, then they are applied after leveling the field with combine harvesters. They are plowed into the soil with the help of a harrow hitch. 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) for pre-sowing soil treatment. , Trofi 90 (1.5–2.0 l/ha), Triflurex 480 (1.2–3.0 l/ha). Most soil herbicides are effective for 30–40 days after application and cannot reliably control seedlings and seedlings of late spring weed species.

Fertilization. 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. But it should be taken into account that rapeseed is the only winter crop that can accumulate nitrates in the same amount in roots and leaves. Thus, one hectare of well-developed crops of winter rape absorbs up to 80 kg of nitrogen before entering winter, while normally developed crops of winter wheat absorb only 20 kg.

Organic fertilizers are applied under the predecessor at the rate of 35–45 t/ha. The rate of application of mineral fertilizers depends on the predecessor, the fertility of the soil and the programmed yield level and is, on average, $N_{80-150}P_{60-80}K_{80-120}$. The full rate of potassium phosphate fertilizers is applied under plowing, with the exception of $P_{10-15}K_{10-15}$, which is applied to the rows during sowing. It is better to apply nitrogen fertilizers fractionally: a part before sowing, if necessary in autumn top dressing, the rest - in spring. Before sowing, $N_{25-30}$is applied after cereals, after steam precursors - N_{10-15}. Excessive nitrogen nutrition in the autumn period worsens the overwintering of plants and, as a result, decreases crop productivity. Winter rapeseed restores vegetation already at a temperature of +5 °C. The vegetative mass of rape grows intensively during 2-3 weeks after the restoration of vegetation and during this period the most nitrogen is needed. Therefore, almost 80-90% of nitrogen is applied in the first two weeks of spring growth. On fertile soils, the introduction of nitrogen can be carried out in a full dose at one time. 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, in the spring, the first fertilization with nitrogen fertilizers $N_{60-90}$is carried out, at the beginning of budding - the second in a dose of N_{25}. In arid conditions - only in spring N_{60-90}. When choosing nitrogen fertilizers, preference is given to those that contain the amide form of nitrogen, rather than the nitrate form. Nitrates are mainly used on poorly developed crops, if the introduction is carried out after the beginning of vegetation. In other cases, they provoke rapid growth of leaf mass and increase the risk of lodging. The third feeding in the middle of flowering promotes the growth of pods and seed mass. Foliar application of nitrogen is possible in autumn and spring before the budding phase. Rape is less prone to burns than grain. Urea 12% concentration is used.

In order to guarantee a high yield of winter rapeseed (4-5 t/ha), in addition to traditional nitrogen, phosphorus, potassium, and calcium fertilizers, it is necessary to apply fertilizers containing sulfur, magnesium, boron, manganese, zinc, iron, molybdenum, and other trace elements.

It is advisable to use trace elements for pre-sowing seed treatment (e.g. Oil sprout (3 l/t) and in the form of foliar feeding of rapeseed plants along with spraying crops with pesticides (Krystalon, Rostok, Zeolite).

Sowing. High and high-quality crops of rapeseed can be obtained only with timely and high-quality sowing, optimal sowing rates of seeds treated with poisons and observing the recommended depth of wrapping.

In order to protect against diseases and damage by pests in the initial phases 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, d.c. (4.0 l/t), Cruiser OSR, (15.0 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", that is, it has a stimulating effect on the root system, as a result of which plants develop more actively, seedlings are more uniform and better tolerated drought.

The sowing period of winter rapeseed 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 was no higher than 1.0–1.5 cm above the soil surface, the root system penetrated the soil to a depth of 50– 100 cm or more, and the diameter of the root neck was equal to 8–12 mm. Such optimal development of winter rapeseed plants is achieved in most cases 105–110 days after the date of its sowing. In practice, in different soil and climatic zones of Ukraine, winter rapeseed is sown 20–25 days before the optimal time for sowing winter wheat. Optimum dates for sowing winter rapeseed: in the northern regions – August 15–25; in the west - August 15-30; central ones – August 20–30; Eastern - August 25 - September 5; Southern - September 10-20. Recommended sowing dates should be adjusted, taking into account weather conditions and the presence of moisture in the soil. Therefore, they may fluctuate earlier or later by 5–10 days. If drought is predicted in August, it is advisable to sow earlier. This is a risky measure, because in the case of favorable conditions for growth and development in September - October, there is a danger of overgrowing plants and reducing their winter hardiness. Therefore, farms that have decided to take this step must plan to introduce growth regulators in the autumn period.

Adhering to the depth of seed wrapping ensures obtaining friendly seedlings and increasing the resistance of plants against diseases and pests. Rape can't withstand the deep wrapping of seeds in the soil due to the fact that plant seedlings, breaking through to the surface of the soil, are greatly exhausted, lose their resistance to pathogenic microflora and are intensively affected by pathogens of the black leg and die. The depth of seed embedding in the soil is differentiated: depending on the type, mechanical composition, and moisture content of the soil. On light soils, it ranges between 2.5–3.0 cm, on heavy soils – 1.5–2.0 cm.

The optimal sowing rate of winter rapeseed for hybrids is 0.6–0.8, and for varieties 0.8–1.0 million similar seeds per 1 ha (3.5–5.0 kg/ha). For certain rapeseed hybrids of foreign selection, the sowing rate is much lower and varies between 40–50 similar seeds per 1 m2 (0.4–0.5 million similar seeds per 1 ha). When determining seed sowing 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 higher competition between plants, which, in turn, causes overgrowth (plants enter the stemming phase) and a sharp decrease in winter hardiness. At the same time, if the sowing dates are delayed, the sowing rates should be increased, because the probability of entering the winter in the optimal phase decreases, and therefore, the risk of reducing the density during the wintering period increases. It is also advisable to increase the rate of sowing in case of insufficient moisture and poor-quality soil cultivation, when the field germination of seeds decreases.

Exaggerated sowing rates of winter rape contribute to the pulling out of the central shoot, which increases the risk of freezing of plants or their laying during the growing season, creates ideal conditions for the development of diseases, and reduces their productivity. Low sowing rates lead to undesirable consequences: increased weediness of crops, formation of an insufficient number of pods per unit area, and reduced productivity.

Under unfavorable conditions and late sowing dates, the number of seeds per unit of sown area must be increased by 10–20%.

As a rule, rapeseed is sown in the usual row method with row spacing of 12.5–15 cm. Compared to wide-row sowing, such sowings are more productive as a result of continuous shading of weeds by rapeseed plants in the early stages of their development. Wide-row crops (45 cm) are used for seed purposes, here it is necessary to carry out inter-row loosening.

Crop care. After sowing rape, the field is rolled, especially in dry weather. When a soil crust is formed or weeds appear in the white thread phase, pre-emergence harrowing is carried out with light harrows (if no soil herbicides were applied).

In order to increase the winter hardiness of rapeseed in years with long warm weather in autumn and a sufficient amount of precipitation, to prevent overgrowth of plants, one of the plant growth regulators should be applied in the phase of 3–5 leaves: Bereginya, v.r. (2 l/ha); Biotransformer, (300–400 granules/ha); Biosil (Emistim C), v.r., (5–10 ml/ha); Vermistym K, r., (5–8 l/ha); Redostim, river, (50 ml./ha); Retacel Extra R 68, v.r. (up to 6 l/ha); Setar (0.3–0.5 l/ha); Synchronous SL, v.r.k. (1–2.0 l/ha); Stabilan 750 SL, v.r.k., (1.5–2.0 l/ha). By reducing the height of the stem and slowing down the growth of the vegetative mass in the autumn period, they promote the development of the root system, thereby reducing lodging, increasing the number of side branches, and increasing the number of pods and seeds. After all, 70% of the future harvest is laid during the autumn vegetation of rapeseed.

Timely protection of rapeseed crops against grain blight (precursor) is mandatory, as rapeseed is not competitive with it, is strongly suppressed and lags behind in growth. For this, one of the recommended graminicides is used. In the phase of 2–4 leaves, rapeseed crops are treated with herbicides Aramo 45 (1.2–2.3 l/ha), Achiba 50 EC (1.0–3.0 l/ha), Panthera (1.7–2.0 l/ha), Targa super (1.0–3.0 l/ha), Fusilade forte (1.0–2.0 l/ha). Herbicides 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). A tank mixture of herbicides: Butyzan star (2 l/ha) + Salsa (25 g/ha), Galera Super (0.3 l/ha) + Salsa (25 g/ha) has an excellent effect against mullein and other dicotyledonous weeds), Proponit (2 l/ha) + Salsa (25 g/ha).

If the crops are underdeveloped, they should be treated with growth stimulants. For this, one of the following drugs should be used: Adob (macro + micro) (2.5–5.0 kg/ha); Biostim oil (1–2 l/ha); Liquid nitrogen fertilizers (KAS) (50–80 kg/ha); Ecolist is multi-component (2–5 l/ha); Ecolist mono (1–2 l/ha); Novalon (nitriflex) (4–16 kg/ha); Novofert (25–50 kg/ha); Reacom Plus (4–6 l/ha); Root (0.8 l/ha); Salt (1–8 l/ha); Solyubor DF (5–6 kg/ha); Fan; Zeolite (macro+micro) (2–5 l/ha) etc. The application of trace elements can be carried out in conjunction with other plant care measures, if their terms coincide (protection against pests, diseases, etc.).

When the vegetation of winter rapeseed is renewed in the spring, balanced mineral nutrition of the plants should be provided, as well as 1-2 times of their treatment with one of the preparations with retardant properties to delay the stemming phase of the plants and achieve as much branching as possible in the later phases of development.

The pre-spring and partially spring period is one of the most critical for rapeseed plants. A rapid increase in positive temperatures can lead to a shortening of the interphase periods of the culture, so early spring feeding with nitrogen fertilizers is mandatory.

It is necessary to apply nitrogen fertilizers as early as possible, in order to use the conditions of a short day for the vegetative development of winter rapeseed. 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 fertilizers can be used for culture: ammonium nitrate, urea, ammonium sulfate, etc., but preference is given to those containing the amide form, as well as sulfur. It is advisable to use nitrate forms on weak crops, because their use results in intensive growth of the leaf surface, which increases the risk of lodging.

It is advisable to apply nitrogen fertilizers on thawed soil, but too early application can lead to leaching of nitrates or their surface runoff. It is better to use urea to prevent possible leaching of nitrates into groundwater.

As rape plants undergo generative differentiation, there is a further need for nitrogen, so the second dose of nitrogen fertilizers should be applied in the phase of the appearance 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 15).

Table 15 – Prerequisites for increasing or decreasing the nitrogen dose for fertilizing winter rapeseed

<table>
<tr><th>Nitrogen rates should be increased by 20–40 kg/ha</th><th>Nitrogen rates should be reduced by 20–40 kg/ha</th></tr>
<tr><td>weak plant development</td><td>powerful stem development</td></tr>
<tr><td>low content of nutrients in the soil: humus – 1.5–1.8%, P_2O_5< 120 and K_2O< 150 mg per kg of soil</td><td>predecessor: annual grasses, legumes, row crops</td></tr>
<tr><td>predecessor - grain crops</td><td rowspan="3">dry early spring</td></tr>
<tr><td>severe clogging by winter weeds</td></tr>
<tr><td>stand density is less than 30 plants/m^2</td></tr>
</table>

In order to reduce the negative impact of adverse weather conditions on the formation of rapeseed productivity, it is highly effective to apply microfertilizers such as Aquarin, Vuksal, Ecolist, Kristalon, Rostock and others, which contain the required amount of microelements in a form available to rapeseed, along with protection products, to provide them plant in separate growing seasons. With low soil availability, at least two of the most deficient trace elements are added to the top dressing according to the cartogram. It is most expedient to use them in the budding phase in foliar feeding together with spraying against pests.

Rape is damaged by many pests and diseases. To protect against cruciferous fleas, rape flower eater, rape sawfly, cabbage aphid, cabbage whitefly and others, rape crops are sprayed with insecticides Biscay (0.3-0.4 l/ha), Fury (0.07 l/ha), Fastak (0.1-0.15 l/ha). When crops are treated with Fastak insecticide, it is forbidden to use rape stalks (straw) for feed to farm animals, and oil - for food and in the food industry.

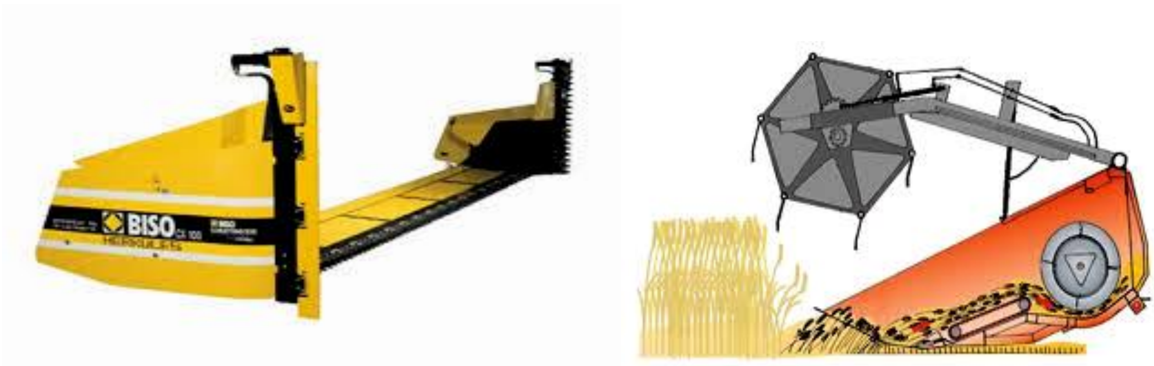
Tzineb (2.4 kg/ha) or 80% Polycarbatsin (2.5 kg/ha) are used against powdery mildew. To prevent the death of bees, rapeseed crops should not be processed during the flowering period.

Harvesting. Rape ripens unevenly, the pods are prone to cracking, which leads to significant seed losses. Rapeseed is harvested both by direct harvesting and separately.

For acceleration and simultaneous ripening, crops are desiccated 7–10 days before harvesting with Reglon Super (2–3 l/ha), Reglon Air (2 l/ha). 12–14 days before harvesting, Basta 150 SL desiccant (2.0-2.5 l/ha) is used. It is advisable to use Roundup (3 l/ha), Dominator (3 l/ha), and Glifogan (3 l/ha) herbicides on grassy areas 2 weeks before harvesting. They destroy weeds and dry up plants. Desiccation reduces seed losses during harvesting and saves energy spent on drying seeds.

To reduce seed losses during harvesting, the crops are sprayed with plant growth regulator Nu-Film 96EC (di-1-P-mentenu). This drug creates a strong, elastic water-resistant film that glues the pods together and prevents cracking. The film limits the inflow of water into the pods, while at the same time water is easily lost to the outside. The film is so elastic that it stretches easily as the weight of the seeds in the pod increases. Plants do not dry out after applying the drug, continue to vegetate and accumulate plastic substances in the process of photosynthesis. This is important because rapeseed pods make up more than 80% of the crop. In the last days of ripening, the yield increase is the highest. That is, this drug does not act as a desiccant - the pods ripen and dry evenly. Apply Nu-Film 96 EC approximately 2-3 weeks before harvesting at a rate of 0.7 l/ha.

The main method of harvesting rapeseed is direct harvesting, in which rapeseed is harvested at the onset of technological ripeness (moisture 10–15%), but before the pods begin to crack. The seeds are dark brown or black, hard. When touching the plants, the seeds should "rustle" in the pods. Optimal humidity is 12%. Harvesting at humidity below 10% is not recommended due to high losses. At a humidity of more than 14%, drying costs increase significantly. The productivity and quality of harvesting depend on the loss of seeds on the cutting device of the combine. Sometimes they can reach up to 90% of all losses during harvesting (several centners per hectare). The use of combine harvesters with Power Flow harvesters or the equipment of the combine harvester with a passive divider or a vertical side knife and lengthening its platform, installing an extended cutting device (the so-called "rapeseed table") significantly reduces seed loss. Only with the help of the rapeseed table or the belts on the Power Flow harvester, the seeds that fly out of the pods already during the cutting of the stalks fall into the harvester, and not on the ground (Fig. 15). Unlike grain crops, rapeseed is threshed well even at night, which makes it possible to use the equipment around the clock. To minimize losses during harvesting, it is carried out with a high cut of the stem, 2-5 cm below the lower tier of pods. Thanks to this, not only the loss of seeds is reduced, but also its humidity and the amount of plant impurities are significantly reduced.



а *б*

Fig. 15 – Reapers for harvesting rapeseed:

а – rapeseed table of the company «Biso»; *б* – scheme of the harvester Power Flow of the combine harvesters Massey Ferguson

Separable method. Split harvesting, as a rule, is associated with significant losses and is used in crops with high weediness, as well as in uneven seed maturation (for example, field edges near forest plantations). The plants are cut into swaths when the lower leaves fall, 50% of the pods become lemon-yellow, the seeds are light cherry, humidity 25–35%. During this period, the most oil, its accumulation stops; high protein content, chlorophyll is completely decomposed. Mowing with ZhVP-6 reapers; ZHP-4.9; ZhVN-6; ZHA-3.5; ZRHB-4.2 at a speed of 4–6 km/h. The cut is 20–25 cm high, but so that the lower pods are not cut off. It is preferable to mow and thresh in the morning and evening. The speed of the reel is equal to the speed of the harvester.

3–6 days after mowing, when the moisture content of the seeds drops to 10–12%, the windrows are threshed with combines equipped with windrow pick-ups. To reduce seed losses, it is advisable to thresh in the morning, evening and night. Separate harvesting is recommended to be carried out on areas overgrown with camomile, tenacious marjoram, or with uneven ripening of rapeseed plants. With uniform ripening and on clean crops, only direct harvesting is carried out.

Rape is harvested with combine harvesters adapted for harvesting small-seeded crops: Massey Ferguson, Klaas, John Deere, Case, Lan, Slavutych. For long-term storage, the moisture content of seeds must be brought up to 6–8%. The seeds, after entering the field, are immediately cleaned and dried. With high humidity, it turns white, moldy and loses its uniformity and technological qualities in 1-2 days.

2.3.3 Spring rapeseed / rape *(Brassicanapus)*

Spring rapeseed contains 35–45 semi-drying oil (iodine number 101), 20–26% protein, 17–18% carbohydrates. Spring rapeseed oil has excellent nutritional qualities, and is also widely used in various sectors of the national economy. Cake from low-eruc varieties is good animal feed, and cake from 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% protein, which is twice as much as in the green mass of corn and sunflower. Spring rapeseed is grown in post-harvest, post-harvest and intermediate crops.

Wild rapeseed comes from European countries. Rape has been cultivated in Ukraine since the beginning of the 18th century. Spring rapeseed is mostly sown in Sumy, Kyiv, Chernihiv and Zhytomyr regions. According to the data of the State Committee of Statistics of Ukraine, as of 2012, the sown area of spring rape amounted to 114.7 thousand hectares against 19 thousand hectares in 1997. The yield of spring rape is 30–50% lower than that of winter rape and is, on average in Ukraine, 1 ,3–1.6 t/ha. Therefore, in regions with appropriate climatic conditions, producers prefer the cultivation of winter rapeseed.

Biological features, varieties. Spring rapeseed is less picky about growing conditions than winter rapeseed. Taking into account the biological features of the culture, the areas near the northern limit of possible sunflower cultivation, where the hydrothermal coefficient is higher than unity, and the sum of positive temperatures is higher than 1800^{0}C, are more favorable for spring rape.

Temperature requirements. Rape is a cold-resistant plant, its seeds germinate at temperatures of +1...3^{0}C, seedlings tolerate frosts of -3...5^{0}C, and adult plants - up to -8^{0}C. Vegetative mass grows best at a temperature of +18...20^{0}C. During flowering and ripening of seeds, the optimal temperature is +23...25^{0}C.

Requirements to moisture. Rape belongs to moisture-loving crops. Its water requirement for the formation of a unit of dry matter is 600–700 units. According to this indicator, rapeseed exceeds cereals by 1.5–2.0 times. For seed germination, 60% of water is needed from its weight, and the optimal moisture in the upper layer of the soil is at the level of 80% of the lowest moisture content.

The need for moisture during the growing season is not the same: in the first 5–7 weeks after the emergence of seedlings, it is insignificant, and plants absorb the most water during the period of budding and flowering. Drought at this time significantly reduces seed yield. As a result of dry weather during flowering, even falling of flowers can be observed (the phenomenon of "inflammation of inflorescences"), and the flowering period will be shortened, which, in turn, leads to a decrease in seed productivity. A well-developed root system is able, under arid conditions, to tolerate significant dehydration of tissues during the day and to quickly restore the assimilation activity of the leaves at night.

Requirements to light. Spring rapeseed is a plant with a long day, quite demanding on lighting. Thickened crops have a small area of plant illumination and are characterized by low productivity and crop quality.

Requirements to soils. Spring rapeseed is less demanding on the soil compared to winter rapeseed due to a more developed system of small roots in the upper horizon of the root system. It needs soils with a neutral or slightly acidic reaction of the soil solution (pH 5.5–6.8). Soils that are heavy in mechanical composition, with a waterproof subsoil layer, and light with insufficient thermal conductivity are not suitable for growing this crop, so rapeseed does not grow well on depressions and in places with a close level of groundwater.

Rape is a cross-pollinated plant. The duration of the growing season is 90–110 days. Seedlings appear 5-6 days after sowing. In the initial period (20–25) days, it grows slowly. Flowering begins on the 35th-45th day after germination and lasts 20-35 days.

Varieties and hybrids that have a low content of erucic acid and glucosinalates include: Arion, Anthocyan, Iris, Klitynny 8, Otaman, Mykytynetsky, Silver, Sirius, PR45N72, Yura, Mirko KL, Delight, Belinda, Geros, Larissa, etc.

Cultivation technology. *Place in crop rotation.* When placing spring rape in a crop rotation, it should be taken into account that in the initial period of development it grows slowly and is quite strongly suppressed by weeds. Therefore, the areas allocated for this culture must be clean of weeds, especially those whose seeds are difficult to separate.

Predecessors of spring rape can be both pure and occupied pairs, as well as winter wheat, barley, legumes; for the conditions of the central forest-steppe - row crops and perennial grasses. It is impractical to grow rapeseed after agricultural crops that have common pests, in particular, sugar beets and crops from the cabbage family. In crop rotation with sugar beets or cruciferous crops, rapeseed should occupy no more than 25% of the area. The return of cultures to the previous place is possible no earlier than after 4-5 years.

It is not recommended to sow spring rape into weak and thinned crops of winter rape, because there is a difference of 3-4 weeks in the ripening of these two forms, and the damage to crops by pests and diseases also increases.

Rape is a vigorous and good predecessor for other cultures. It loosens the soil with its root system, and a relatively large amount of plant residues after harvesting rape contains easily digestible nutrients. Experiments confirm that the yield of cereals after rape is 0.4–0.6 t/ha higher than after cereals as a predecessor.

Tillage. The system of tillage measures is aimed, first of all, at the preservation of moisture and the maximum destruction of weeds, as well as the leveling of the soil surface. After harvesting the predecessor, the stubble is peeled with subsequent high-quality plowing. Hulling the stubble to a depth of 6–8 cm with LDH-10 type huskers and BDT-7 disc harrows gives a good effect. It is recommended to plow the field to a depth of 20–22 cm, and in fields overgrown with perennial weeds – to a depth of 25–30 cm.

One of the main conditions for obtaining a high yield when growing spring rapeseed is thorough preparation of the soil for sowing and the creation of a seedbed. This is due to the shallow seed of the culture. If the soil has not been leveled since autumn, harrowing is carried out with heavy BZTS-1.0 or medium BZSS-1.0 harrows when it is physically ripe.

Pre-sowing treatment is carried out immediately before sowing with KG-4, KPS-4 cultivators to a sowing depth of 2–3 cm with KZK-6 or APOG-6 rolling. The best quality of pre-sowing soil preparation is achieved by using combined units such as Europak, AG-6, etc., which make it possible to perform several technological operations in one pass with high quality.

Fertilization. Rapeseed is demanding on nutrients. For the formation of 1 ton of main products, rapeseed uses (in kg): nitrogen 50–60, phosphorus 25–35, potassium 25–40, and calcium, magnesium, boron, sulfur – 3–5 times more than grain crops.

Wild rapeseed reacts well to the application of organic and mineral fertilizers. Manure (20–30 t/ha) is better applied under the predecessor. In on-farm crop rotations, liquid manure is used for spring rape with an application rate of 50–100 m3/ha. Under plowing, apply the full rate of phosphorus and potash fertilizers. Most of the nitrogen fertilizers (1/2–2/3 of the total norm) are applied to pre-sowing cultivation in the form of ammonium nitrate. The rest of the nitrogen is used to feed plants in the phase of 5–6 leaves and budding.

Spring rapeseed is a crop of an intensive type of nutrition. Fertilizers are an effective means of increasing spring rape yields, one of the most active and fast-acting factors of the external environment that affect the exchange, growth and development of plants, as well as factors that have a direct effect on plants, that is, a direct increase in their productivity. Mineral nutrition has a great influence on the growth dynamics of vegetative organs during the growing season. In addition, it has been established that mineral fertilizers provide a 2-3% reduction in disease incidence. To realize its biological potential, it is necessary to apply optimal rates of mineral fertilizers. The required amount of fertilizers for the northern forest-steppe zone of Ukraine is within $N_{90\text{-}120}P_{60\text{-}90}K_{60\text{-}90}$ for the central - $N_{60\text{-}90}P_{60}K_{60}$. In the Polissya zone, the highest yield of rapeseed green mass was provided by the application of mineral fertilizers at the rate of $N_{150}P_{90}K_{120}$.

A sufficient amount of sulfur is necessary for the successful cultivation of rapeseed. The need for sulfur is 25–25 kg/ha for a yield of 2.5 t/ha. Rapak responds well to the introduction of trace elements: boron, manganese and molybdenum. To obtain a harvest 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 yield of spring rapeseed. Due to the lack of boron in the soil, plants slow down their growth, young leaves have a lighter shade, the edges of the leaf plates are twisted. Spots from reddish to red-purple color are observed on older leaves. In plants lacking molybdenum, necrotic spots are observed on the lower, older leaves, which are accompanied by necrosis of the edges of the leaf plates. The leaves curl at the edges and take on a spoon-like shape, a smaller number of flowers are formed. If molybdenum fertilization is necessary, it is more appropriate to treat rapeseed seeds with this trace element before sowing than to apply it to the soil.

The availability of manganese varies depending on the pH indicator and soil moisture. On light soils poor in this element, its deficiency is manifested at pH values above 6.0. The content of soluble manganese with increasing pH decreases 100 times for each pH unit. Therefore, liming of the soil is important. The pH indicator largely determines the mobility of nutrients and their availability to plants. Depending on the type of soil, the pH should be from 6.2 to 7.0 (lower on light soils, higher than 6.5 on loam). To achieve this, it is necessary to apply lime fertilizers under the precursors of rape, because the pH indicators change only after 18-24 months.

The exact rate of application of mineral fertilizers is calculated based on the supply of nutrients to the soil of the specific field on which it is planned to grow rapeseed.

Sowing. It is necessary to use high-quality seeds for sowing to fully realize the genetic potential of the variety. An important preventive measure against mold, alternaria, fomosis, transferorosis, bacteriosis, etc., is the poisoning 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, (2.0–3.0 kg/t), Rovral FLO, (8.0 l/t). To protect against damage by pests in the initial phases of growth, the seeds must be treated with insecticides (Cruiser 350 FS, (4.0 l/t), Cruiser OSR, (15.0 l/t), Cosmos (4l/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" , that is, it has a stimulating effect on the root system, as a result of which the plants develop more actively, the seedlings are more uniform and tolerate drought better. The use of an insecticidal impregnant is an important element of the protection system, because in the case of a mass population of pests and in hot weather, even in 1-2 days, the seedlings canola can be completely destroyed.

Early sowing times are the best (optimum level of the thermal regime of the soil at a depth of 5 cm - +5...7^{0}C). In this case, rapeseed uses moisture better, is less weedy and damaged by pests. Late sowing results in a 10–30% yield reduction.

Seeds are sown in the usual row method with a row width of 12.5–15 cm, depending on the type of soil and its moisture content, to a depth of 1.5–2.0 cm on medium and heavy soils and 2–3 cm on light ones. The wide-row method of sowing with a row spacing of 45 cm is used on seed plots.

The optimal stand density of spring rapeseed plants for varieties and hybrids differs and depends on the recommendations of the originators of the varieties, their origin and precociousness, and is 80–120 plants/m^2. With the row sowing method, 1.2–1.4 million similar seeds are sown per 1 ha for varieties and 1.0–1.2 for hybrids (the weight rate of seed sowing is 3.5–5 kg/ha). For certain spring rapeseed hybrids of foreign selection, the maximum sowing rate reaches 800,000 similar seeds/ha.

Caring for spring rapeseed crops includes a set of measures aimed at preserving seedlings, destroying weeds, protecting plants from pests and diseases, and creating favorable conditions for their growth and development.

In the first phases of crop growth and development, weeds cause the greatest damage. In the second half of the growing season, rape plants suppress them, because at this time the culture forms a large above-ground mass and can compete with weeds. If the technology provides for the use of soil herbicides, then they are applied after leveling the field with combine harvesters. They are plowed into the soil with the help of a harrow hitch. In particular, Butizan 400, 40% k.e. is used against annual grass and dicotyledonous weeds. (1.75-2.5 l/ha), Butizan Star (1.75-2.5 l/ha), Dual Gold 960 EU, (1.6 l/ha), Komand, 48% (0.2 l/ha) by spraying crops before and after germination.

Most soil herbicides are effective for 30–40 days after application and cannot reliably control seedlings and seedlings of late spring weed species. Therefore, Aramo 50,(1.0–2.0 l/ha), Select 120, (0.4–0.8 l/ha); against dicotyledonous rhizomes before the start of canola stalking - Galera Super, (0.2-0.3 l/ha), Lontrel 300, 30% (0.35–0.5 l/ha), Lontrel grand (0.15–0.20 l/ha), Salsa 75 (20-25 g/ha); against annual dicotyledons and some cereals, Kerb 50W is used, 50% of (1.0 l/ha) in the phase of 3–4 leaves of the culture. 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 complex of advantages provided by the creation of highly effective herbicides Galera and Salsa allows to significantly expand the possibilities and areas of cultivation of traditional varieties and hybrids of rapeseed. Thanks to this, the maximum flexibility in the selection of the varietal composition is ensured, which allows to maximize the yield and profitability, the problems with the control of carrion of resistant rapeseed (for example, Clearfield technology) disappear for several years in the following crops.

Protection of plants from pests and diseases is carried out throughout the growing season. Among the pests that cause the greatest damage to spring rape seedlings are cruciferous fleas, during the period of active growth and development - rape flower borer, rape sawfly, cabbage aphid, seed and stem borer.

The beginning of flowering of spring rape falls on the fading of winter rape, therefore, a strong spread of pests can be expected as a result of their transition from winter rape. When cruciferous flea beetles (5 individuals/m2) or rape flower-eaters (2–3 beetles per plant during the budding period and 5–6 individuals per plant during the flowering period) are detected, rape whiteflies and cruciferous nymphs (3 individuals/m2), aphids (more than 2 colonies/m2) - it is advisable to use insecticides provided for in the "List of pesticides and agrochemicals approved for use in Ukraine". The effective ones are Decis, 2.5% eq., Karate 050 EC, eq., Bazudin, 600 EW, eq., Sumi-alpha, 5% eq., (0.3 l/ha) , Fastak, 10% k.e., (0.1–0.15 l/ha), Buldok, 2.5 k.e., (0.3 l/ha), Nurel-D (0.8 l /ha), Fastak (0.1-0.15 l/ha). When crops are treated with Fastak insecticide, it is forbidden to use rape stalks (straw) for feed to farm animals, and oil - for food and in the food industry.

The most common diseases of spring rape are Alternaria, powdery mildew and bacteriosis. Under favorable conditions for the development and mass spread of diseases, it is necessary to carry out chemical protection of crops. For the detection of signs of fomosis, false powdery mildew in the rosette phase and alternariosis during the formation of pods, the crops are treated with the fungicide Aliette, 80% of the plant. (1.2–1.8 kg/ha) and others. (Table 2.9).

Harvesting. In the pre-harvest period, special preparations - "stickers" are used to reduce crop losses due to cracking of pods. New-film-17 and Elastic are among the most common in production (active ingredient: carboxylate styrene-butadiene copolymer, 450 g/l; preparation form: emulsion concentrate). It is recommended to use the drugs 4-3 weeks before harvesting, when the pod, bending it to a V or U-shaped shape, does not crack. The consumption rate of the drug is 0.8–1.0 l/ha, of the working solution – 250–400 l/ha (for ground spraying) and 50–90 l/ha – for aerial spraying. The principle of action of the drug consists in the formation of a semipermeable polymer membrane on the treated surface of the plant, which allows water to evaporate from the surface of the pod and at the same time prevents the penetration of moisture into the tissues of the plant.

For acceleration and simultaneous ripening, crops are desiccated 7–10 days before harvesting with Reglon Super (2–3 l/ha), Reglon Air (2 l/ha). 12–14 days before harvesting, Basta 150 SL desiccant (2.0-2.5 l/ha) is used. On weedy areas, it is advisable to use Roundup (3 l/ha), Dominator (3 l/ha), and Glyfogan (3 l/ha) herbicides 2 weeks before harvesting. They destroy weeds and dry up plants. Desiccation reduces seed losses during harvesting and saves energy spent on drying seeds.

In order to preserve the rapeseed crop, preference should be given to direct harvesting on non-weeded crops. Direct harvesting is used until the seeds are fully ripe. The optimal moisture content of seeds for threshing should be 10–13%. At humidity below 10%, seed loss can reach 50%. To reduce losses, harvesting should be done in the morning and evening hours. Rape is harvested with combine harvesters, which are adapted for harvesting small-seeded crops. When harvesting, special attention should be paid to the cutting device, since up to 90% of all crop losses are caused by it. It should also be noted that the cutting device must be moved 40-50 cm forward relative to the transverse screw (equipment of harvesters with "rapeseed tables"). To minimize losses, it is recommended to harvest at a high cut, 2-5 cm below the level of the lower tier of pods. Thanks to this, not only losses are reduced, but also the moisture content of the seeds and the amount of impurities are significantly reduced.

Separable method. Separate harvesting, as a rule, is associated with significant losses and is used in crops with high weediness, as well as in uneven ripening of seeds. The plants are cut into swaths when the lower leaves fall, 50% of the pods become lemon-yellow, the seeds are light cherry, humidity 25–35%. The cutting height of the plants should be at least 20-25 cm so that the windrow "hangs" on the stubble and dries. 3–6 days after mowing, when the moisture content of the seeds drops to 10–12%, the windrows are threshed with combines equipped with windrow pick-ups. To reduce seed losses, it is advisable to thresh in the morning, evening and night.

When threshing, ensure that the seeds are not damaged, because their quality deteriorates during storage. The content of extraneous impurities in the bunker mass is allowed no more than 10%; the content of oil impurities (broken and fallen seeds) is no more than 3%. To prevent injury to the seeds, threshing should be done at a drum speed of 600 rpm, and for direct combining, the number of revolutions should be increased to 800 at an increased speed of the combine.

After rapeseed threshing, the seeds must be immediately cleaned and dried to 7–8% moisture.

2.3.4 Mustard*(Sinapis)*

Mustard is a valuable oil crop. Two types of mustard are grown: gray (Sarept) and white. Gray mustard seeds contain 35–47% fat, and white mustard seeds contain 30–40% fat. In addition to fat, mustard seeds accumulate 25–32% of protein and up to 0.5–1.7% of essential oil. Fatty mustard oil belongs to the low-drying ones (the iodine number of gray mustard oil is 102–108, white mustard oil is 92–122).

Mustard seeds contain 25–32% protein, and the cake and meal after special processing can be used in compound feed for feeding animals and poultry. Mustard can be used for green fodder or as a component in fodder mixes (100 kg of green mass of mustard in the period of fodder ripeness contains 11–14 fodder units, each containing 186–196 g of digestible protein).

Mustard seeds also contain glucosides: sinegrin (3.4–4.1%) in gray mustard and synalbin (8.7–9.6%) in white mustard. The presence of these glucosinolates makes it possible to use mustard for the production of mustard and to be part of food seasonings.

Oil is extracted from mustard, which is widely used in confectionery, margarine, bakery industries and directly for food. Oil obtained by cold pressing is of high quality. During hot pressing, sinigrin glucoside, which has a sharp mustard smell and an unpleasant taste, enters the oil.

Table mustard, mustard seeds, etc. are made from mustard cake. In the northern regions, white mustard is also grown as a fodder crop, feeding it 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 flowering, 50–100 kg of honey can be obtained from 1 ha of sowing, which is inferior in quality only to flower and linden honey. Mustard is a phytosanitary agent in crop rotation. It is able to clean the soil from pathogens of root rot that affect grain crops. The root secretions of white mustard provoke the development of nematode cysts, and the larvae that are reborn cannot develop further and die. After white mustard, the number of pests in the soil decreases, in particular wireworms.

Mustard improves the agrophysical properties of the soil, increases the content of organic matter in it. It is a good siderable culture and has valuable phytomelioration properties (root exudates transform inaccessible, difficult-to-dissolve forms of soil nutrients into those available for plants). Mustard, among oil crops as a predecessor, retains the most moisture in the soil. It is one of the best predecessors for many crops, and especially for cereals.

The homeland of gray (Sarepta) mustard is South-East Asia, and the Mediterranean is considered to be the homeland of white mustard. Since ancient times, mustard has been cultivated in India, China, Egypt, and Eastern Asia. In Russia, it was introduced into culture for the first time in Nizhny Volga near the village. Sarepta (that's where it got the name Sarepta) at the beginning of the 18th century.

In Ukraine, blue and white mustard are grown on small areas. The yield of gray mustard is 1.0–1.2 t/ha, white mustard is 1.2–1.5 t/ha.

Biological features, varieties. Mustard in its growth and development goes through four periods, which are divided into 7 phenophases and 12 stages of organogenesis. The periods of the formation of vegetative and generative organs, flowering and ripening of seeds depend on weather conditions and agricultural techniques: in sunny, dry weather and insufficient amounts of nutrients, the duration of the phenophases and stages of organogenesis is shortened, and at the same time the seed yield is reduced. Under optimal weather conditions and with a sufficient supply of nutrients, the duration of the periods of growth and development is extended. As a result, greater plant productivity is formed, which means that the overall seed yield increases.

Temperature requirements. Gray mustard is relatively undemanding to heat. Seeds begin to germinate at a temperature of +3...5^{0}C, seedlings appear after 15-18 days, and friendly seedlings in moist soil - at a temperature of +15...18^{0}C - 5-6 days after sowing. Seedlings are resistant to temperature drops: they withstand frosts of -3...5^{0}C, and during the period of real leaves - a short-term temperature drop to -10 ^{0}C.

Under favorable conditions, plants form a developed rosette. In arid conditions and thickened crops, plants can proceed to stemming, bypassing the rosette phase. The optimal temperature for the growth and development of gray mustard is +18...20^{0}C, and during the formation of pods - +23...25^{0}C.

A characteristic feature of gray mustard is high drought resistance. The growing season lasts 80–110 days, depending on climatic conditions and agricultural cultivation techniques. The necessary sum of effective temperatures to obtain optimal yield is 750–800^{0}C.

White mustard is a more cold-resistant culture than gray mustard. White mustard seeds can germinate at a temperature of +1...2^{0}C. Friendly seedlings appear in moist soil at a temperature of +12...15^{0}C5-6 days after sowing. The stairs can withstand frosts up to -6^{0}C. White mustard continues its vegetative growth and flowering at a temperature of +5^{0}C. To achieve it, it is enough for the air temperature to be +10^{0}C, which is the lowest indicator for cold-resistant crops. White mustard grows and develops better in temperate climates. The vegetation period of white mustard is shorter compared to gray mustard and is 70–90 days. The cultivation of white mustard in the northern regions of Ukraine increases its yield and the oiliness of the seeds, and the iodine number of the oil increases. The sum of effective temperatures for obtaining an optimal harvest is 650–700^{0}C.

Moisture requirements. The critical period in relation to moisture in blue mustard is manifested most during seed germination, as well as during the period of budding - flowering. For seed swelling and germination, the need for moisture is 120% of its weight. The amount of water for the formation of a unit of dry matter (transpiration coefficient) is 420. With relatively significant drought resistance, obtaining a high yield of blue mustard seeds can be ensured under conditions of optimal soil moisture. With a long-term shortage of moisture in the soil, especially during the flowering period, there is a significant reduction in the duration of this phase, the fall of flowers and ovaries is possible, the yield decreases by 15–20%, and in some very dry years – by 30–40%. The optimal supply of moisture for gray mustard is 200–250 mm per growing season.

White mustard needs more moisture than gray mustard. Optimal moisture supply during the growing season is 350–450 mm. In the arid conditions of the south of Ukraine, white mustard is more picky about moisture than gray mustard, and is inferior to it in yield. On irrigation, the yield of white mustard seeds in the experiments of the Institute of Irrigation Agriculture increased by 2–2.5 times.

Soil requirements. Gray mustard is much more picky about soil fertility compared to white mustard. Black soil and chestnut soils are best for it. On poor soils, it develops a weak root system, which significantly reduces drought resistance and productivity. Unsuitable - heavy, flooded and saline soils.

White mustard can be cultivated on less fertile soils: dark gray, gray forest, sod-podzolic soils. It is not suitable for light sandy soils, heavy clay, swampy with a waterproof sub-layer, because the root system does not develop enough in them and soils with a high level of groundwater. Its root system has the ability to assimilate nutrients from poorly soluble compounds. For the formation of 1 ton of seeds, 55–60 kg of nitrogen, 25–30 kg of phosphorus, and 45–50 kg of potassium are removed from the soil.

Gray mustard varieties: Mriya, Tavrychanka, Retro, Terrafit, Rockets, Dizhonka, PR45G12; white: Karolina, Pidpecheretska, Talisman, Berivska, Podolyanka, Svityaz.

Cultivation technology. *Place in crop rotation.* As precursors for mustard, most agricultural crops are suitable: annual and perennial grasses, legumes, cereals (early and late). It is not recommended to sow mustard on cabbage predecessors, the following crops are also not desirable as predecessors: 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 in crop rotation is essential for obtaining consistently high yields and economically profitable production. Mustard is placed in crop rotations that are designed for the growing zone, or specialized crop rotations are introduced, where the share of mustard can occupy 25–33% at maximum saturation with grain crops. The introduction of specialized crop rotations makes it possible to exclude mustard from beet crop rotations and significantly reduce the harmfulness of the beet nematode on both crops. When growing mustard in a field crop rotation, it is necessary to return to the previous place no earlier than after 3-4 years, maintaining a gap between sugar beets of at least 3 years.

Tillage. The improved tillering is used to grow mustard. Weed-free fields are husked two times at 6–8 and 8–10 cm and plowed at 22–25 cm.

In the presence of perennial weeds, the soil is layered and plowed at 27–30 cm. Effective snow retention. In the spring, when the soil reaches physical maturity, the fields are harrowed with toothed harrows to seal in moisture and carry out pre-sowing cultivation to a depth of 3–4 cm with simultaneous harrowing and sanding.

Fertilization. Mustard, like other crops, is autotrophic in terms of nutrition, i.e. plants synthesize organic matter by assimilating mineral salts, water and carbon dioxide. Plants absorb 95% or more of carbon dioxide through the leaves, and can also absorb ash elements (K, Na, Ca, Mg, P, Si, Cl), sulfur, and nitrogen from aqueous solutions through foliar feeding. However, the main amount of nitrogen and ash elements enters plants from the soil through the root system.

The growth and development of plants, their resistance to diseases and pests, and ultimately the yield of seeds depends on the availability of mustard nutrients. For high efficiency of mineral fertilization and obtaining an optimal yield of mustard seeds, it is necessary to regulate the acidity of the soil. When the pH (saline) of the soil is below 6.5, it is necessary to carry out liming. Only if there is a sufficient amount of lime in the soil can the so-called soft humus be formed, which is the most valuable form of humic substances.

Phosphorus and potash fertilizers are better to apply under plowing or pre-sowing cultivation, and nitrogen fertilizers - before sowing the crop. In zones of sufficient moisture, nitrogen must be applied separately: 2/3 of the norm - before sowing, the rest - in top dressing. Mustard is a halophilic crop, when chlorine-containing forms of potash fertilizers are applied, plants respond well to them and productivity increases. Sulphates are more effective than potash fertilizers on acidic soils.

Fertilizer application rates are calculated based on the size of the planned harvest, soil fertility and the predecessor. Fertilizer rates, depending on the cultivation technology, are: N – 40–80, P_2O_5 – 40–60, K_2O – 40–80 kg/ha of active substance. In addition to macrofertilizers, mustard plants also need microfertilizers for balanced nutrition if they are not enough in the soil. The functions of each power element are specific and no element can replace another.

Sowing. High yields of mustard can be obtained only with timely and high-quality sowing, optimal sowing rates of seeds treated with disinfectants, with compliance with the recommended depth of wrapping. For sowing, sorted conditioned seeds with a germination rate of at least 85% and a purity of 98% are used. The list of pesticides and agrochemicals approved for use in Ukraine does not include seed dressings or mustard growth stimulants. However, if necessary, the preparations registered for rapeseed are used in production: Acrobat (2 l/t), Maxim XL (5 l/t), TMTD (3.0 l/t). To protect against damage by pests at the initial stages of growth, the seeds must be treated with insecticides (Cruiser 350 FS, (4.0 l/t), Cruiser OSR, (15.0 l/t). Seed treatment with recommended insect-fungicidal poisons makes it possible to protect seedlings, seedlings and young plants for 30-45 days.

Mustard, as a long-day plant, requires early sowing. Under such conditions, time is gained for good vegetative development, the threat of damage by pests decreases, and mustard crops are much less affected by diseases. With late sowing, mustard plants quickly enter the generative phase, which reduces the seed productivity of plants.

The timing of sowing mustard depends on the cultivation zone and the climatic conditions prevailing during the sowing period. Research and production have proven that this culture should be sown as early as possible. This is approximately during the period of spring barley sowing, or immediately after the sowing of early spring cereals.

Mustard is sown in continuous rows with a row spacing of 12–15 cm. The optimal mustard seed sowing rate is 1.8–2.0 million similar seeds/ha. A decrease in the sowing rate or an increase in it leads to a decrease in productivity.

The depth of sowing seeds depends on the type of soil, mechanical composition and humidity. On light soils, the optimal depth of seed wrapping in the presence of moisture is 2.5-3.0 cm, on heavy soils - 1.5-2.0 cm. Mustard is sown with seed drills that can provide the established sowing rate and the corresponding depth of seed cultivation. It is better to compact the soil for sowing mustard before sowing, because when rolling after sowing, in the event of precipitation, a soil crust is formed, which can lead to liquefaction of seedlings.

Crop care. Caring for mustard crops includes a set of measures aimed at preserving seedlings, creating optimal conditions for plant growth and development, protecting crops from weeds, diseases and pests. Harmful organisms lead to significant losses (30–60%) or to complete loss of the crop.

When sowing with poisoned seeds in the initial phases of mustard growth and development, weeds can cause the greatest damage. This is due to the fact that in the initial stages of growth, mustard grows more slowly than weeds - early spring, rhizome and rhizome. Among the biological methods of controlling the number of weeds, sowing on weedy fields of vetch-oat or other mixtures, the green grass of which suppresses weeds, and the clogging of the field decreases in the following years, can be considered effective.

Among the agrotechnical measures for protection against weeds, the following are effective: husking or discing the stubble immediately after harvesting the predecessor, plowing. To protect against rhizome weeds (creeping wheatgrass), it is effective to carry out cultivation on a disc field, using units with spring legs. With high weediness of crops by rhizome and rhizome weeds, it becomes necessary to use continuous action chemicals based on glyphosate.

Various studies have established that chemical protection is expedient and economically justified when more than 100 weeds of various species per 1 m2 are infested, with the exception of tenacious weeds and perennial rhizome weeds. Based on the reserves of weed seeds in the soil (especially in the Western region of Ukraine), the use of soil herbicides for mustard cultivation is economically feasible. Soil herbicides that can be used to protect crops from weeds may contain active substances: clomazone, metazachlor, trifluralin. Preparations, with the active substance trifluralin, are used for sowing with mandatory cultivation by a cultivator or heavy harrows. Herbicides with the active ingredients clomazone and metazachlor are best applied after sowing (up to three days).

uring the growing season, if soil herbicides were not applied, when mustard crops are weeded, post-emergence herbicides are used: Galera Super (0.2-0.3 l/ha) or Lontrel Grand, 75% v.r. (0.12–0.2 l/ha). Preparations are applied starting from the phase of 2–4 real leaves before the beginning of the appearance 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, samphire poppy, camomile, bitter gourd, quinoa, galinsoga, as well as bitter gorse, birch and scotch in the initial stages of development (1–2 true leaves).

Graminicides are effective against annual grass weeds, which are especially common in Polissia and Forest Steppe and can cause great damage to mustard crops: Aramo 45 (1.2–2.3 l/ha), Achiba 50 EC (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) and others If mustard crops are weedy with creeping wheatgrass, use one of the above-mentioned preparations, with higher application rates.

The effectiveness of herbicides and other pesticides, which are used for protection during the growing season, improves when auxiliary substances (adjuvants) are added to the working solution. These substances help 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 the wax coating and hairiness of the leaves. The use of these substances in tank mixes makes spraying resistant to being washed away by precipitation. One of the best drugs of this group is Sylvet. Application rate on cabbage crops: 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.

Pests and diseases can cause significant damage to mustard crops. Crop failure from these pests can reach 30–50% or more. The most common pests of mustard include: cruciferous fleas (black, light-legged, wavy, blue, notched), rape sawfly, rape flower eater, cabbage aphid. To protect mustard crops against pests, the drugs Vantex, 6% m.c. are registered and approved for use. (gamma-cyhalothrin, 60 g/l) – 0.06 l/ha, Nurel D, 55% k.e. (chlorpyrifos, 500 g/l + cypermethrin, 50 g/l) – 0.6 l/ha.

Among the diseases of mustard, the most common are: black leg, false powdery mildew (peronosporosis), alternaria, fomosis, powdery mildew, slimy bacteriosis. Under favorable conditions for the spread and development of diseases, it is recommended to treat crops with fungicides. Against peronosporosis: preparations based on mancoceb, metalaxyl, fosetyl aluminum; Alternaria, fomosis: drugs based on boscalid, dimoxystrobin, carbendazim, methanazole, propiconazole, tebuconazole.

Harvesting. Gray mustard and white mustard differ in their ability to self-sprinkling. White mustard is characterized by a lower ability to crumble, and gray mustard crumbles more than rapeseed. Therefore, the choice of terms, methods and technical means of harvesting mustard are of decisive importance for obtaining final results.

In order to accelerate the ripening of seeds, as well as with high weediness of mustard crops, desiccation of crops is carried out two weeks before harvesting with one of the preparations based on glyphosate: Glifogan, Dominator, Roundup with a consumption rate of 3.0 l/ha or the preparation Reglon Super 150, v.r. (3.0 l/ha). When carrying out desiccation, the intensity of damage to crops by diseases decreases.

In the pre-harvest period, substances with adhesive properties are used to reduce crop losses during biological ripening of seeds, especially gray mustard. One of the most common in use is Elastic (active ingredient: carboxylate styrene-butadiene copolymer, 450 g/l; preparation form: emulsion concentrate). The drug is recommended to be used 4-3 weeks before harvesting, when the pod, bending it to a V or U shape, does not crack. The consumption rate of the drug is 0.8–1.0 l/ha, of the working solution – 250–400 l/ha (for ground spraying) and 50–90 l/ha – for aerial spraying.

The principle of action of the drug as a pod adhesive consists in the formation of a semipermeable polymer membrane on the treated surface of the plant, which allows water to evaporate from the surface of the pod and at the same time prevents the penetration of moisture into the plant tissues. Unlike pinolenes, Elastik does not require daylight for polymerization, which is an important advantage when using the drug in the evening or evening. Elastic is a fully synthetic product, which is characterized by a stable quality of effective action. It can be used in tank mixes to improve the effectiveness of desiccants. At the same time, the consumption rate of the drug is 0.5–0.7 l/ha.

In order to preserve the mustard crop and its quality, preference should be given to direct harvesting. Direct harvesting with a combine harvester begins when the seeds are fully ripe, the main stem has a moisture content of no more than 15%. Mustard must be collected only with those combines that are adapted for harvesting small-seeded crops. To minimize harvest losses, it is recommended to mow at a high cut (5–10 cm below the level of pods of the lower tier). Thanks to this, not only losses are reduced, but also the moisture content of the seeds and the amount of impurities are significantly reduced.

Practice shows that when harvesting mustard, the reel of the reaper must be shifted upwards and as far back as possible, so as not to cause the seeds to shake out of the pods and spill them in front of the reaper. It is even recommended to remove the reel when the gray mustard is thickly stalked. Finger rakes should enter the stem at a depth no greater than their width. The speed of the reel should be close to the speed of the harvester.

White mustard is harvested by direct harvesting during the period of full seed maturity, as its pods almost do not crack when ripe.

Cleaned seeds must be stored with a moisture content of no more than 10%.

2.3.5 **Rye**(*Camelina sativa L.*)

Rye seed contains 35–46% fat, which is used mainly for technical purposes. High-quality varnishes and paints, green soap are made from oil. Oil is used in the textile and metallurgical industries. The nutritional value of castor oil is low. In terms of taste, it is significantly inferior to sunflower oil due to its bitter taste. During long-term storage of rye oil, its bitterness increases.

Rye pomace is fed to animals in small doses. This is due to the fact that it contains glucosides that are harmful to the body. 100 kg of cake contains 115 fodder units.

Rye has a short growing season and can be grown as an intermediate and post-harvest crop.

In Ukraine, ginger is grown on small areas in Polissia and in the Northern Forest Steppe. The average seed yield is 1.0–1.2 t/ha.

Biological features. Rye is a spring annual herbaceous plant of the cabbage family. A cold-resistant culture that is not picky about the conditions of the external environment. The seeds of rye germinate at a temperature of +1...2^{0}C. The stairs tolerate frosts up to -12^{0}C. During the growing season, it is not very sensitive to drought. It does well on sandy and podzol soils. Heavy clay soils are not suitable for growing rye. Rye is a self-pollinating, early-ripening, short-day crop. The duration of the growing season of rye is 60–90 days.

In Ukraine, the following rye varieties are zoned: Hirskyi, Stepovy 1, Mirage.

Features of cultivation technology. The best predecessors of rye are winter cereals and row crops. The main cultivation of the soil is the same as for other oil spring cabbage crops. As a very small-seeded crop, it requires careful pre-sowing soil cultivation.

Rye responds well to the introduction of mineral fertilizers, especially phosphorus. Complete mineral fertilizer in the norm of $N_{45}P_{45}K_{30}$ is applied under sedge cultivation. Phosphorous fertilizers are applied to the rows during sowing.

Rye is sown early, at the same time as early spring cereals in the usual row method. The seeding rate is 8–10 kg/ha. The seeds are wrapped to a depth of 1.5–2 cm. When the top layer of the soil dries, the wrapping depth is increased to 3–4 cm with post-sowing rolling.

To protect against weeds, rye crops are harrowed across the sowing direction with tooth harrows during the germination period. When pests appear, crops are treated with insecticides.

Rye is collected both separately and by direct combining. Separate harvesting begins when the lower pods turn brown and the seeds harden in them. Rye, cut into swaths, after drying is picked up and threshed by converted grain harvesters for harvesting small-seeded crops. Seeds are stored at a humidity of no more than 9–10%.

2.3.6 Oily flax *(Linum usitatissimum L.)*

The concept of "oily flax" unites plants of two groups of varieties: curly flax and mezeumok flax. More fat is contained in the seeds of curly flax - 44% against 42% - in mezeumka. At the same time, the height of mezeumka plants is greater, the stems contain more fiber and they can be used for the production of textile fiber, and from the latter - yarn. Curly straw fiber can only be used to make cotton wool, paper and as packaging material.

Flax seeds contain 42-48% fat. Its composition includes, depending on the variety and growing conditions, five fatty acids in the following percentage ratio: oleic - 17.6%, linolenic - 56.6, linoleic - 14.5, palmitic - 5.7 and stearic - 3 %. Fatty acids, which are part of linseed oil, belong mainly to the group of unsaturated, so it dries well and is in demand as a raw material for the paint, paint, perfume industry, etc. The indicator of the content of unsaturated acids in the oil is the iodine value. For linseed oil, this indicator is 165–192. Flax cake is a valuable concentrated feed for animals (protein content - 33%, oil - 7%, fiber - 9%).

Oily flax is a valuable food and medicinal product. The high content of unsaturated fatty acids in the oil prevents the occurrence of vascular diseases. Flax seeds, according to the practice of folk and scientific medicine, have medicinal properties. In addition to fat, it contains protein, carbohydrates, organic acids, vitamin A, and enzymes. If it is poured with hot water, boiled and infused for a few minutes, and then strained, we will get a mucous liquid, the use of which treats stomach ulcers and gastritis. From flax seeds, the drug linetol is obtained, which is used to treat skin burns. The oil can be eaten. It was almost the only one among the oils that saved the inhabitants of Polissia in the pre-war and first post-war decades. Here, in the estates, flax-mezeumok was grown, the seeds of which were used to obtain edible oil, and the fiber was obtained from the stalks for the own production of various fabrics for household use.

Pomace, which is a product of seed processing, contains from 6 to 12% fat, 38% protein. The nutritional value of 1 kg of it is 1.15 calories. and has 260 g of digestible protein. Chaff, which is formed when flax is threshed and seeds are cleaned, is also valuable for feeding animals, especially pigs. In terms of nutrition, 1 kg of it is 0.27 calories. and has 20 g of digestible protein.

Nowadays, the demand for flax seeds is growing all over the world, and the scope of its application is expanding. It is used for the production of dietary treatment products, the production of cosmetic preparations, and new therapeutic agents.

In recent years, a clear trend has been observed in Ukraine regarding the growth of linseed oil production. This is primarily due to the export demand for flax seeds from the EU, the USA, and Canada, which amounts to about 40,000 tons. In 2012, 62,900 hectares of this crop were planted in Ukraine. The main regions for the cultivation of linseed are the south, although in recent years the area has been increased precisely in the central and northern regions.

Biological features, varieties. During the growing season (85–110 days), the following phases of growth and development are distinguished in flax: seedling, Christmas tree, budding, flowering, maturation.

Temperature requirements. Oil flax is more demanding of heat than long-grain flax. It needs little heat and moisture during seed germination. The duration of swelling is 50 hours, seeds begin to germinate at a temperature of +3...5^{0}C, seedlings appear at +6^{0}C. Flax seedlings withstand frosts up to -3...4^{0}C, and two-week-old plants - up to -6^{0}C. However, the culture is demanding on heat during ripening (optimal temperature +20...22^{0}C). In cloudy weather with a decrease in temperature, it reaches slowly.

Moisture requirements. Flax is a drought-resistant crop. The need for water is less than that of long-legged flax, but its transpiration coefficient is high - 420–690. When there is not enough water in the first half of the growing season, the development phases are much shorter, the harvest is reduced. The root system is poorly developed compared to other crops, but it is characterized by a high absorption capacity. It constantly grows deep and absorbs moisture from the deeper layers of the soil, thanks to which it has a higher drought resistance compared to other wet crops.

Soil requirements. Flax is demanding on soil fertility. For 1 ton of seed crop, it removes 2-3 times more nitrogen, phosphorus and potassium from the soil than grain crops. With this in mind, flax crops must be placed on soils with sufficient available nutrients. The best soils for it are chernozem and chestnut soils. It is not advisable to sow curly flax on heavy waterlogged and salty soils.

In Ukraine, 12 varieties of linseed are grown for the production of linseed oil, of which for growing in the forest-steppe zone - Iceberg, Blue-orange, Debut, Eureka, Golden, Reliable, Orpheus, Southern Night, Simpatik, etc.

Cultivation technology. *Predecessors.* The best precursors for flax are winter cereals, legumes, row crops, and perennial grasses. Flax is not recommended to be sown only after sunflower to prevent damage by fusarium and other diseases, and also after cabbage to reduce damage by fleas. The return of flax to its previous place in the crop rotation is no earlier than after 5–6 years.

Tillage. The main cultivation of the soil is carried out according to the system of improved zaab. Immediately after harvesting the predecessor, the stubble is peeled to a depth of 6–8 cm. When weed seedlings appear, the field is cultivated with cultivators with simultaneous harrowing. A combination of plowing the soil with the use of herbicides is effective for controlling rhizomatous weeds (field thistle, milk thistle). After weeds grow in the rosette phase (4–5 leaves), they are sprayed with Roundup herbicide at a dose of 4–6 l/ha. In late September - early October, the field is plowed to a depth of 22-25 cm with mandatory leveling. If the ridge has not been leveled since autumn, then it is harrowed in early spring. But after spring leveling, moisture is quickly lost in the seed layer of the soil. Pre-sowing cultivation to a depth of 3–4 cm is carried out on the field leveled in the fall. 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 lumps, compact the soil and create optimal conditions for seed germination. No agrotechnical measure affects the field germination of seeds and stem alignment as much as pre-sowing treatment.

Fertilization. Curly flax plants have a short growing season, the root system has a rather weak absorption capacity, so the culture responds well to the application of mineral fertilizers. The optimal norms are N45–60 P60–80 K70–90. Phosphorus and potash fertilizers are applied during the main cultivation, nitrogen - in the spring, during pre-sowing cultivation, paying special attention to the uniformity of their application. Flax-curly assimilates the largest amount of nitrogen from the beginning of the seedling phase to flowering. Plants need phosphorus throughout the growing season. The need for potash fertilizers increases during budding - flowering and seed formation.

Sowing. Flax seeds are poisoned 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 poison. Often, in order to protect seedlings from linseed mealybugs, the seeds are treated with insecticides: Cruiser 350 FS (0.5 l/t).

Sowing flax is carried out as early as possible, at the same time as early spring crops, which contributes to the better development of the root system of plants, they germinate faster and overtake the growth of weeds. The growth and development of flax takes place in more favorable conditions with relatively low air temperature and sufficient soil moisture. Plants of the early sowing period are more resistant to damage by diseases and lodging, and mature earlier.

The depth of seed wrapping is 3–4 cm, with mandatory rolling of the field after sowing. They are sown with seed drills equipped with anchor coulters, in the usual row method with a row spacing of 15 cm and a sowing rate of 5–7 million similar seeds per 1 ha, or 50–70 kg/ha. For the use of oil flax for the production of fiber and oil, the sowing rate is increased by 10–15 kg.

A significant decrease in field germination is observed when the seeds are wrapped in parched 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 direction of the rows.

Crop care. Curly flax grows slowly at the beginning of the growing season and reacts very negatively to weeding of crops by reducing the yield and quality of products. The root system of weeds is much more developed than that of flax. First of all, it is necessary to make full use of the possibilities of agrotechnical methods of weed control. These include crop rotation, semi-steam or improved soil tillage, high-quality spring soil preparation, a rational fertilization system, timely and high-quality sowing with conditioned seeds, etc.

On flax-curly crops against annual grass and dicot weeds before sowing, during sowing, after sowing, but before the appearance of crop seedlings, soil herbicide Treflan (1.6-2.0 l/ha) is applied (with immediate wrapping).

However, flax crops are often heavily weeded by such weeds as wild radish, field mustard, quinoa, mustard, red flax, spergel, spirip, cornflower blue, field chamomile, thistles, chicken millet, mouse gray, wheatgrass, etc. To control their quantity in flax crops, use the 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), Dikopur MCPA (0.5-0.75 l/ha), Lontrel (0.1-0.3 kg/ha), Lontrel Grand (0, 04-0.12 kg/ha), Linseed, 85% (8-10 g/ha), Peak (0.015-0.020 kg/ha), Harmony (15-25 g/ha). For more effective weed control, it is recommended to use tank mixture: Harmony, 10 g + 2M-4X, 600 ml/ha. It is not recommended to use PARA Trend 90 on flax crops. The interval between Harmony treatments and graminicides should be 5 days.

To protect flax crops from annual and perennial grass weeds, it is necessary to apply the herbicides Zelek Super (1-1.25 l/ha), Panther (1-2 l/ha), Select 120 (0.4-1.8 l/ha 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 chosen depending on the species composition of weeds. Highly effective are tank mixtures of anti-grass and anti-tuberculosis preparations, for example, Lenok + Pantera.

To protect crops from flax flea, spray crops with Fury 10% (0.15 l/ha). To protect against a complex of diseases (fusarium, anthracnose, rust, strand) in the phase of Christmas trees, they are treated with copper chloride, 90% z.p. (2.2 kg/ha); Benlat, Fundazol, 50% z.p. (1 kg/ha).

Harvesting. Curly flax is a culture with an unfinished type of vegetation, so shoots may grow in rainy weather: in this case, it is necessary to apply desiccation with Basta or Reglon Super (five to ten days before harvesting).

Mowing in swaths begins when the pods reach 50–75%, the moisture content of the seeds is 25–30%. The height of the cut should be 12–14 cm. The swaths are selected and threshed at a seed moisture content of 12%. When used for oil and fiber, flax is cut into rolls in the yellow ripeness phase. The height of the cut is 10 cm. When using desiccants and under dry conditions, oil flax is collected by direct harvesting with grain harvesters.

2.3.7 Oil poppy *(Papaver somniferum)*

According to the nature of use, cultivated poppy is divided into two groups: oily and intoxicating. Oil poppy seeds contain 46-56% drying oil (iodine number 131-143), 20-25% proteins, 19-20% carbohydrates, 5-7% ash and 6-10% fiber.

Poppy seeds are cold-pressed to extract oil, which is used as a food product or in the confectionery and canning industries. The oil obtained by the extraction method is used for the production of oil and high-quality paints, as well as the highest grades of soap. Oil poppy seed cake contains about 32% protein and 10% oil. Its seeds are also used in the confectionery and bakery industry, and meal is used for animal feed.

Opium poppy is grown to obtain a narcotic substance - opium, which is used as a raw material for the manufacture of medicines. The plants of this poppy have thick-walled pods with a well-developed milk system.

Opium is obtained from milky juice (latex), which includes about 25 alkaloids (morphine, narcotine, codeine, etc.).

Poppy comes from the Mediterranean. Poppy was known in Greece in the 5th century BC, from there it reached India and China through the countries of Asia Minor. In our country, the first information about poppy culture dates back to the period of Kievan Rus (XI century). In Asian countries, poppies are grown for the production of the narcotic substance - opium, which is used for the production of medicinal drugs.

Quite high prices for poppy products make it highly profitable.

Until 1986, the area of oil poppy varieties in Ukraine occupied 8 thousand hectares. Its boxes were used in the pharmaceutical industry. A large number of medical preparations were made on their basis. As a result of the fight against drug addiction in 1986, the cultivation of poppy seeds was prohibited. However, during the time of independence, the Government of Ukraine approved the "National Program for Combating Drug Abuse and Their Illegal Traffic" and instructed the Ukrainian Academy of Agrarian Sciences (UAAS) to develop new varieties of oil poppies with a low content of narcotic substances. Scientists of the Institute of Cruciferous Cultures of the National Academy of Sciences of the Russian Academy of Sciences developed the Berkut oil poppy variety with a low content of narcotic substances (0.05-0.07%), which is ten times less than the varieties that were grown in Ukraine before 1986. The Berkut oil poppy variety passed the state variety test and was entered into the Register of Plant Varieties of Ukraine in the "Oil Crops" section in 1996, the Gerlach and Coral varieties were entered into the Register in 2001. By order of the Ministry of Agrarian Policy of Ukraine dated 03.03.2000 No. 29, the charter of the specialized association of agricultural producers "Ukrmak" was approved as the main organization for the cultivation and use of poppies. It is responsible for providing agricultural enterprises of all forms of ownership with seeds of the first reproduction of poppy varieties included in the "Register of Plant Varieties of Ukraine".

In Ukraine, only oil poppy is grown. It is mostly sown in Poltava, Kharkiv, Vinnytsia, Khmelnytsky and other regions. The average yield of poppy seeds in Ukraine is 0.8–1.0 t/ha, at the variety centers – about 2.0 t/ha.

Biological features, varieties. Oil poppy is very picky about soil and climatic factors. The plant cannot withstand significant shading, it needs much more moisture than grain crops. Therefore, it is sown mainly in Polissia, Forest Steppe and in separate subzones of the Steppe.

Temperature requirements. Poppy is a fairly cold-resistant plant. Its seeds begin to germinate at a temperature of +2...3^{0}C, the seedlings tolerate frosts down to -5^{0}C. Favorable temperature for plant growth before flowering is +15^{0}C, and during flowering - seed ripening - +20...25^{0}C.

Moisture requirements. In different periods of growth and development, the demand for moisture is not the same. The poppy shows the greatest need for water before the end of flowering, after which the demand for moisture decreases and moderately dry and warm weather is best for crop formation at this time. Poppy seeds absorb 100–110% of water by weight.

Soil requirements. The poppy is quite a picky culture for soils. It requires fertile soils of sandy and loamy mechanical composition. The best for poppies are chernozem and chestnut soils, as well as non-waterlogged soils of river valleys. Dry sandy and heavy waterlogged soils, salt marshes and salt marshes are unsuitable for growing poppies. It requires a neutral or slightly acidic reaction of the soil solution.

Requirements for power cells. An important biological feature of the poppy is the high need for mineral nutrients: for the formation of one ton of economic products, the poppy spends twice as much phosphorus and potassium as for the production of 1 ton of wheat grain. For the formation of 1 ton of seeds and the corresponding amount of straw, the poppy takes 55 kg of nitrogen, 22 kg of phosphorus, 53 kg of potassium and 56 kg of calcium from the soil.

Of the selection varieties of poppies in Ukraine, Berkut, Blue Jubilee, Lubenskyi 7, Koral, Novinka 198, and Start are regionalized.

Cultivation technology. The best predecessors for poppies are those crops that leave behind a weed-free field with a sufficient amount of crop residues and moisture. For the conditions of Polissia and Forest Steppe, the best predecessors are winter cereals and legumes, sugar beets, potatoes, rapeseed, and mustard. In the soil and climatic conditions of the steppe zone, the best precursors are steam, busy steam and winter crops that follow pure steam.

It is not recommended to place poppy crops after sunflowers, perennial grasses, corn and other crops whose root system penetrates deeply and dehydrates the soil during the growing season. Unchanged poppy crops are inadmissible, they are sown in the previous place no earlier than after 3-4 years. The oil poppy itself is a good precursor for many agricultural crops.

Tillage. The most important stage in poppy cultivation is the main and pre-sowing tillage. After cereals, legumes, and rape, it is necessary to carry out husking and harrowing, which creates favorable conditions for the germination of weed seeds, accelerates the decomposition of crop residues, inhibits the development of diseases, and reduces moisture loss from the arable layer. After that, herbicides of continuous action (Roundup, Hurricane Forte, etc.) are applied and plowed to a depth of 20–25 cm.

Spring tillage consists of early spring harrowing and pre-sowing tillage. Pre-sowing processing is carried out at the optimal time, which coincides with the full maturity of the soil. It is best to carry out pre-sowing soil cultivation with the help of combined tools - RVK-3.6, RVK-5.4, Compactor, Europak. If pre-sowing cultivation is carried out by cultivators, then after cultivation, the soil is rolled with ring-spur rollers.

Fertilization. It is better to apply organic fertilizers (20–30 t/ha) under the predecessor of the poppy. When fertilizing poppies, it is necessary to observe the ratio N:P:K=1:1:1. Phosphorus and potash fertilizers are applied under the main tillage at the rate of 45–60 kg/ha of each element. 45–60 kg/ha of nitrogen are applied during pre-sowing cultivation, and during sowing, superphosphate is applied to the rows

(P_2O_5 15–20 kg/ha). Many years of experience show that it is not recommended to apply nitrogen fertilizers during sowing, as it can suppress the development of the root system. Therefore, the rest of nitrogen fertilizers (30–40%) are applied during top dressing in the phase of a developed rosette. In addition to basic nutrients, poppy needs trace elements, primarily boron and molybdenum. Microelements, as a rule, are applied foliarly.

Sowing. In order to protect against the effects of diseases and damage by pests in the initial phases of growth, the seeds must be treated with the Cruiser OSR treatment, t.c.s. (35.0 l/t), TMTD, Vitavax (3 l/t). In addition, Cruiser produces the so-called "vigor-effect", that is, it has a stimulating effect on the root system, as a result of which plants develop more actively, shoots are more uniform and tolerate drought better.

Timely, high-quality sowing at the optimal time ensures the production of friendly poppy seedlings. Late sowing of oil poppy leads to the loss of seedlings. Poppy seeds are sown in early spring, in the first days of going into the field, at the same time as barley and oats. Approximate sowing dates in the Steppe zone are the third decade of February - the first decade of March, provided that the soil has already matured well, in the Forest Steppe - the second - third decade of March, and Polissya - the third decade of March. As a rule, reseeding of poppies does not succeed, and therefore the field is sown with late crops. The term of sowing depends on the temperature regime. As a rule, poppy should be sown only in well-cultivated and matured soil, the temperature of which at a depth of 10 cm is above +30C. Well-prepared soil contributes to the uniform laying of seeds at the same depth, which for the oil poppy is from 1.5 to 2 cm. When sowing seeds deeper than 2.5 cm, the seedlings may not break through to the soil surface.

The best method of sowing is wide-row with 45–60 cm between rows. With high agricultural culture and the use of herbicides in the technology of growing poppies, it is possible to sow in the usual row method. The seed sowing rate is 2 kg/ha. In case of late sowing of oil poppy, the seed sowing rate is increased to 10–20%. Precision seed drills are used for sowing.

Crop care. Poppy seeds practically do not germinate if the rains have passed and a soil crust has formed. For its destruction, harrows, rollers or rotary hoes are used. When seedlings appear, the first inter-row loosening (layer) is carried out to a depth of 2–3 cm. As necessary, another 3–4 loosening of the inter-rows is carried out to a depth of 6–8 cm.

If the density of seedlings allows, crops are harrowed across the rows. Harrowing is most effective when the weeds are in the white string phase.

In the phase of 2–3 real leaves, the density of plants is formed. The optimal number of plants per 1 m2 is 60–70 pcs. It is allowed to place 2-4 plants together. with a distance between them of 15 cm. After the formation of density, there can be from 7–10 to 20–25 plants per 1 m of row, depending on the width of the rows. There should be 350–500 thousand plants per hectare.

To protect crops from annual dicotyledonous weeds in the phase of 2-4 leaves, the herbicide Callisto (0.2-0.25 l/ha + surfactant (required) is applied to poppies). Herbicides Dicuran (2.5-3.0 kg /ha), Starane Premium (0.3–0.4 kg/ha) is recommended to be applied in the phase of 4–6 poppy leaves.

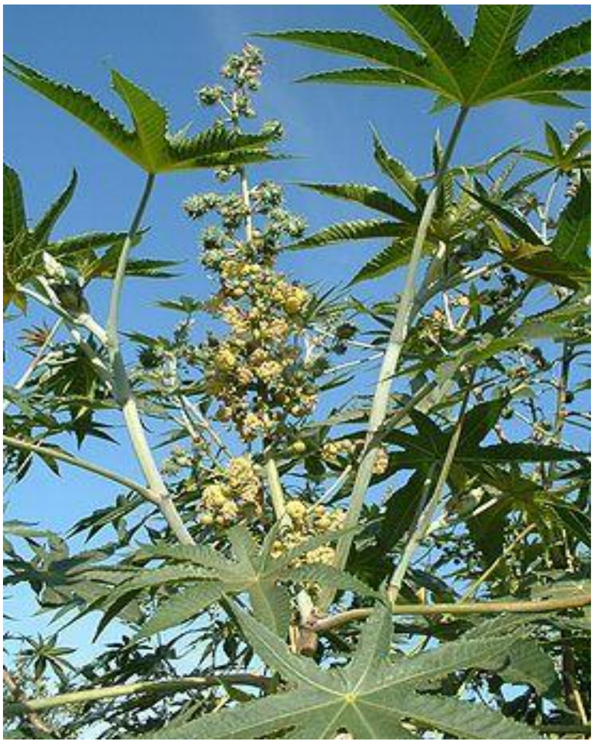
Harvesting. Signs of poppy ripening are browning of leaves and pods. Ripe seeds fall out with a characteristic noise when the boxes are shaken. Poppy seeds are collected by direct harvesting and separately.

In poppy plants, the pods are at different distances from the soil surface, so it is recommended to harvest them with direct harvesters, which ensure uniform cutting of the pods with short segments of stems. Before harvesting the poppy plantation, it is necessary to clean it of high-stemmed weeds, prepare an indoor teak, grain cleaning machines and containers. The speed of the harvester when harvesting poppy seeds should not exceed 5–6 km/h. The threshing machine of the combine is installed so that during threshing, the pods and seeds, crushed into parts, enter the hopper. The gaps between the decks and the drum are set at 8–10 mm, and the speed of rotation of the drum of the thresher should be within the range of 800–1000 revolutions per minute. If the poppy pods are poorly separated from the stalks, the gaps in the threshing machine reduce or increase the number of revolutions of the drum. When harvesting and threshing very dry poppy seeds, in order to prevent excessive crushing of the pods, the gap between the drum and the tray is increased, and the number of revolutions of the drum is reduced. All viewing windows of elevators, shutters of grain augers, bunkers and other places where there may be loss of seeds are sealed.

The collected mass is unloaded from the harvester's hopper and transported to the covered stream, where the seeds are immediately separated from the crushed pods, as the delay in separating the pile leads to rapid self-heating. Seed separation is carried out on an OVP-20 grain cleaning machine, poppy seed cleaning is carried out on Petkus-Gigant, Petkus-Selectra and other cleaning machines.

Separable method. First, the poppies are cut into swathes with reapers on a high cut. Cropped poppies are often placed in windrows or worts for drying. This measure is used in unstable weather. Dried plants from rolls or worts are threshed with combine harvesters. Combine harvesters are being converted for threshing small-seeded crops. When threshing, measures should be taken to avoid clogging poppy seeds with soil. Soil-contaminated seeds lose their nutritional qualities. After threshing, the seeds are dried to ensure their moisture content does not exceed 10%. For food purposes, seeds, as well as boxes, can be dried at a coolant temperature of +60 0C. Poppy seeds are stored in dry, ventilated rooms with air humidity not higher than 60%. For long-term storage, it is better to store them in bulk (in warehouses with a wooden floor with a layer of 15–20 cm.) and shovel them at least once a month, control the moisture of the seeds, and, if necessary, dry the grain.

2.3.8 Castorbean*(Ricinus)*



Castor bean is an important high-oil crop. Its seeds contain 50–55% non-drying oil (iodine number 82–86), and the kernel – 65–70%. The oil is very viscous, does not solidify at low temperatures (-15...18^{0}C), catches fire only at high temperatures (+300...310^{0}C), dissolves poorly in gasoline 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 - aviation, leather, perfumery, electrotechnical, soap making, textile, pharmaceutical, metalworking, etc. It is also used for the production of linoleum, various synthetic substances and in construction.

Cold-pressed castor oil, which does not contain poisonous substances, is used for medical purposes.

Castor leaves can be used to feed some types of silkworms. The seeds and pulp contain a very poisonous substance - ricinin (taxalbulin), so they are not used for animal feed. Cake is made into glue and used as fertilizer

Castor oil comes from Africa. It has long been cultivated in Egypt, from there it spread to Asia and America, and later to Europe.

Sowing of castor is concentrated mainly in tropical and subtropical countries, occupying 1.3 million hectares, its yield is 0.9 t/ha, production is 1.2 million tons. Its main sowing is concentrated in South and Southeast Asia and South America. Castor seeds are mostly produced in India, Brazil, and China, and they are grown in Ecuador, Thailand, Pakistan, Indonesia, and Ukraine.

Biological features, varieties. Castor oil (*Ricinus L.*) belongs to the milkweed family (*Euphorbiaceae*). In the conditions of Ukraine, it is grown as an annual plant, and in tropical countries as a perennial.

One species (*R. communis*) is common in production, from which four subspecies have been identified. Two subspecies are of greatest importance: Iranian castor (*R. persicus*) and blood-red (*R. sanguineus*). Castor varieties belonging to the first subspecies have green or green-red above-ground organs, and the fruits crack when ripe. In the second subspecies, the above-ground organs are blood-red, the fruits do not crack when ripe.

During the growing season, castor goes through the following phases of growth and development: germination, formation of the central tassel, flowering, ripening of the seeds of the central and side tassels of the first, second and subsequent orders. The allocation of V.O. is of practical importance. Moshkinim interphase periods of castor: germination (sowing - seedlings - 10-15 days), vegetative growth (seedlings - flowering of the central tassel - 35-70 days, fruiting (flowering of the central tassel - harvesting ripeness - 35-90 days). The duration of the growing season depends from forms is 130–155 days.

Temperature requirements. This is a heat-loving plant, its seeds begin to germinate at a temperature of +12...13^{0}C. However, friendly steps appear at +16...18^{0}C. Castor seedlings die in frosts of -1^{0}C, and adult plants cannot withstand temperature drops to -3^{0}C in autumn. Normal growth and development of plants occurs at a temperature of +25...30^{0}C. At lower temperatures, the ripening period is delayed, the yield and oiliness of the seeds decreases. High temperatures have a negative effect on productivity. For the formation of a normal crop, the sum of active average daily temperatures of 3000–3500^{0}C is necessary.

Moisture requirements. Castor is a moisture-demanding culture. In areas where less than 300 mm of precipitation falls during the growing season, it is impossible to grow a high crop without applying measures to accumulate moisture in the soil (deep plowing, irrigation, etc.). The transpiration coefficient varies widely - from 300 to 600. Optimal soil moisture is 70–80% RH. However, excessive humidity, especially in the autumn period, leads to excessive growth of the vegetative mass, prolongs the growing season and reduces the oil content of the seeds. With a lack of moisture in the soil, the yield drops sharply, and with dry weather, there is a massive shedding of flowers and fruits; at the same time, the output of oil is noticeably reduced.

Light requirements. Castor oil 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 crops and excessive thickening of plants. Therefore, for better lighting of castor, it is important to destroy weeds in a timely manner and to form the optimal density of plants.

Soil requirements. Castor oil is quite picky about soil and nutrients. The best for it are well-permeable, fertile sandy and loamy black soils, chestnut and gray forest soils. Heavy clay, swampy, saline and light sandy soils are not suitable for castor. The optimum reaction of the soil solution is pH 6–7.3. In terms of nutrient removal, castor oil significantly exceeds winter wheat. With the formation of 1 ton of seeds, it removes 64–68 kg of nitrogen, 14–20 kg of phosphorus, and 52–56 kg of potassium from the soil.

In Ukraine, the following castor varieties are zoned: Hromada, Khortytska 1, Khortytska 3, Khortytska 7, Olesya, Roksolana, Rosava.

Cultivation technology.*Predecessors.* Castor crops are placed after the best predecessors - winter wheat, legumes, busy pairs. Castor oil should not be sown after crops that dry the soil - sunflower, corn. To reduce fusarium damage, castor is sown in the same field no earlier than after 8 years. Castor oil is a good precursor for grain crops.

Tillage. After harvesting winter crops, peeling is carried out to a depth of 8–10 cm with harrowing, and in dry weather with rolling. They are plowed for frost in the second half of September - at the beginning of October to a depth of 25–27 cm.

Pre-sowing cultivation consists of early harrowing in one or two furrows and several subsequent cultivations, which are carried out as needed from the beginning of spring work until sowing castor. The pre-sowing period is used to clean the field of weeds and preserve moisture in the soil. The first time, it is cultivated to a depth of 10–12 cm across the direction of plowing with simultaneous harrowing and rolling. After 10–15 days, weeded areas are cultivated a second time to a depth of 8–10 cm, and immediately before sowing – to the depth of seed wrapping (6–8 cm). Simultaneously with cultivation, the area is harrowed, and in dry weather - rolled.

To protect against weeds under pre-sowing cultivation, during sowing or after sowing, but before the emergence of castor beans, the herbicide Treflan (2–5 l/ha) is applied with immediate wrapping. The herbicide application rate is reduced on light soils, and increased on medium and heavy soils.

Fertilization. Ritsina responds well to organic fertilizers. Application of 20 t/ha of manure significantly increases seed yield. The effectiveness of mineral fertilizers depends on the characteristics of the soil. On leached chernozems, the greatest yield increases are provided by nitrogen-phosphorus, and on carbonate and ordinary chernozems, phosphorus or nitrogen-phosphorus. Organic and mineral fertilizers ($N_{40}P_{60}$ or P_{60}) are added to the main fertilizer. On leached chernozems, the doses of nitrogen-phosphorus fertilizers are increased to $N_{60}P_{90}$. It is quite effective to apply fertilizers to the rows during sowing at the rate of $N_{10}P_{10–15}$. If fertilizers were not applied in the fall, then in the spring they are applied locally at the same time as sowing, wrapping 7–8 cm deeper than the seeds.

Nitrogen and phosphorus fertilizer application rates when growing castor under irrigation conditions are increased to 90–120 kg/ha.

Castor is sown during the period of persistent warming, when the average daily temperature of the soil at the depth of seed wrapping reaches +10...12^{0}C and the danger of seedling death from frost has passed. For the southern regions of Ukraine, the best time to sow castor is the end of April. Seeds are treated with Vitavax before sowing to protect against diseases.

Castor is sown in a wide-row dotted method with a row width of 70 cm. There should be 40–50 thousand plants per hectare. With the dotted sowing method, 5–6 seeds are sown per meter of row length. For small-seeded varieties, the sowing rate is 10–12 kg/ha, for large-seeded varieties – 20–25 kg/ha. The seeds are wrapped to a depth of 7–8, and in case of insufficient soil moisture - 10 cm.

Crop care. It is not recommended to roll the crops, as this leads to the breaking off of the cotyledons during the emergence of seedlings and a decrease in the yield.

Crop care begins with harrowing, which is carried out as needed, stopping 4-5 days before the emergence of seedlings. There is a special need for harrowing in cold rainy weather, when seedlings will appear after 20-25 days. As soon as seedlings appear, inter-row cultivation is carried out. When 3-4 real leaves appear on the plants, the crops are thinned. With the dotted method of sowing, 3–4 plants are left per meter of row length. Plant density should be 40–45 thousand/ha in the southern regions of the Steppe, and 50–55 thousand/ha in the northern regions.

The number and depth of loosening are set taking into account the weediness of the field and weather conditions. The first cultivation is carried out to a depth of 6-7, and the second - to 9-10 cm. Later, in rainy weather and on irrigated areas, the depth of cultivation is increased to 10-12, and in dry weather - reduced to 6-7 cm.

Irrigation is of great importance for increasing the yield. Pinching of castor is recommended to increase the yield and accelerate ripening. It is carried out in two ways - by pinching the growth point of the main plant stem during the formation of 4–5 true leaves (used in southern regions) or by pinching the growth point on the side branches during the formation of 2–3 leaves. Pinching is carried out only on the side branches in the seed areas. It promotes better development of the central cluster and accelerates ripening and increases the yield by 0.15–0.25 t/ha.

In order to speed up the ripening of castor beans, 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 ripens unevenly: first the lower bunches on the main stem, later on the branches of the first and second orders. They begin to collect castor oil when the pods dry and turn brown in the central bunches, and for branched varieties - in the clusters of the first order. Castor varieties, on plants of which the pods do not crack, are collected in a single-phase method with a KKS-6 castor harvester. At the same time, 80% of pure seeds and up to 20% of unripe pods are obtained. Clean seeds are cleaned, sorted and dried to a moisture content of 12%. Green boxes are cleaned of coarse impurities with an OVP-20A machine and dried. During air-solar drying, the pile is spread out in a layer of 10–15 cm on the sites and periodically shoveled. The duration of drying, depending on the weather, is 3–10 days.

Seed castor is dried at a temperature of +35...40, and commercial castor - +65...75 ^{0}C. Seeds are stored at a humidity not higher than +10 ^{0}C.

Castor varieties, the boxes of which crack when ripe, are harvested by hand. At the same time, the tassels are cut, taken to the stream, threshed, dried and sorted.

2.3.9 Safflower *(Carthamus tinctorius)*

Safflower is an oil crop grown in arid regions. Safflower seeds contain 32–37% semi-drying oil (iodine number 115–155) and up to 12% protein. In terms of oil production from 1 hectare, safflower is inferior to sunflower and rapeseed, but is superior to mustard, flax, and rye. Safflower oil (extracted from seed kernels) tastes almost like sunflower oil. It is used for food purposes and is used in various branches of the food industry. This oil is widely used in cooking in Eastern countries.

Safflower oil is widely used in cosmetology. Due to the fact that it is very rich in unsaturated fatty acids, it permeates the skin faster and is absorbed almost instantly. It has a softening and moisturizing effect, provides a barrier (protective) function of the skin.

Safflower oil is also used as a raw material for technical needs. The oil extracted from the whole seed has a bitter taste and is used for the production of oil, white paint, enamels, soap, and linoleum. Safflower seeds are good feed for poultry. Cake is a good concentrated feed for animals. 100 kg of cake contains 55 fodder. unit The cake is used as fertilizer.

The yellow carthamine dye is extracted from safflower flowers, which is used in carpet production and fabric dyeing, as well as in cooking as a substitute for saffron.

The homeland of safflower is Ethiopia and Afghanistan. It was grown in the territory of Egypt, India and China before our era, long ago - in Central Asia, Saudi Arabia, Syria, Palestine, North Africa, Transcaucasia and Turkmenistan, in the territory of Europe, in Russia - from the 18th century. In Ukraine, safflower appeared in the second half of the 18th century. Today, safflower is grown mainly in the southern arid regions. The average yield of seeds is 1.0–1.2 t/ha, under favorable conditions – up to 2.0 t/ha and more.

Biological features, varieties. Phenological observations of the development of safflower focus on the same phases as in sunflower, because these crops are from the same family and are very similar in biology. The duration of the growing season is 105–130 days.

Safflower is an annual herbaceous plant of the aster family. It is a heat-loving and very heat-resistant plant, it can withstand long drought well, it is adapted to a dry continental climate. Seeds germinate at a temperature of +2...3^{0}C. The stairs withstand frosts up to -3...6^{0}C. The safflower is the most picky about heat during the period of flowering and ripening. In wet and cloudy weather, flowers are fertilized much worse than in dry weather. The safflower is undemanding to soils, it even tolerates salinity. However, when grown on fertile black soils, the productivity of safflower increases significantly. Safflower is a short-day plant.

Cultivated varieties of safflower differ from each other in the duration of the growing season, yield, huskiness, fat content in the seeds, as well as the presence or absence of spines on the leaves and basket wrappers. 3 varieties of safflower are included in the Register of varieties suitable for distribution in Ukraine - Sunny, Steppe and Professor Mashanov.

Features of cultivation technology. Safflower is placed in a row wedge of crop rotation. The best predecessors for it are winter and spring ear crops, which are sown in pairs or after perennial grasses, as well as in rows. It is permissible to place safflower after corn. Safflower is a good precursor for spring ear crops.

Cultivate the soil for safflower in the same way as for sunflower. In weedy fields, good results are provided by deep plowing in combination with layer-by-layer peeling. Under the main treatment, mineral fertilizers are applied at the rate of $N_{45}P_{60}K_{30}$. The effectiveness of fertilizers increases in wet years.

Sow safflower in the early season, simultaneously with early spring grain crops, seeds with a germination rate of not less than 95%, purity not less than 95%. The method of sowing is wide-row with 45 cm between rows. The seed sowing rate is 10–12 kg/ha. The seed wrapping depth is 5–6 cm, when the top layer of the soil dries, the wrapping depth is increased to 6–8 cm.

Caring for safflower crops is the same as for sunflower crops. It consists in rolling the soil after sowing, harrowing before and after the emergence of seedlings (in the phase of two or three pairs of real leaves across the rows) and 1-3 inter-row cultivations (if absolutely necessary).

Safflower is collected by direct harvesting, because the seeds do not fall out of the basket when they ripen. However, if the timing of the start of harvesting is delayed and sowing is stopped, the seeds are sprinkled during harvesting. Harvesting begins when all the plants and baskets turn yellow, and the seeds harden with converted and adjusted harvesters.

2.3.10Coriander*(Coriandrum sativum)*

Coriander is one of the most important essential oil crops. Coriander fruits contain 1.5–2.7% essential oil, the main component of which is the terpene alcohol - linalool, which is used as a starting material for the synthesis of aromatic substances. Coriander essential oil and its constituent parts are used in perfumery and cosmetics, confectionery, liquor and vodka, tobacco and other industries. In addition to essential oil, coriander fruits contain 17–28% fatty oil, which is used in the textile and metallurgical industries, as well as for the manufacture of soap and printing inks.

Coriander seeds are used in bakery and confectionery production and as a spice for canning fish, pickling cucumbers, etc. Coriander meal, which contains about 6% fat and up to 30% protein, is used for livestock feed. Coriander is considered a good honey plant - bees can collect about 500 kg of honey from one hectare.

Coriander comes from the Mediterranean and is one of the oldest cultivated plants. It has been grown in Ukraine since the beginning of the 19th century. and is now a leading essential oil crop. It is most common in the Zaporizhia, Mykolaiv, and Kirovohrad regions. Seed yield is 1.2–1.5 t/ha.

Biological features, varieties.*Temperature requirements.* Moderately demanding on heat. Its seeds begin to germinate at a temperature of +6...8^{0}C. Friendly stages appear at a temperature of +10...12^{0}C. The stairs withstand frosts down to minus -7...8^{0}C. The optimal temperature for plant growth is +18...200C. Coriander is most demanding of heat in the flowering and ripening phase. However, excessively high temperature at this time has a negative effect on fruit formation. The sum of positive temperatures for full ripening of coriander fruits is 1900–2000^{0}C.

Moisture requirements. Coriander is a moisture-loving plant. For swelling, the fruits absorb 120–125% of water from the weight of the seeds. After sprouting to mass stemming, coriander consumes little moisture and tolerates soil drought well. The critical period in providing moisture is the flowering phase. The transpiration coefficient is about 600.

Light requirements. Coriander is a light-loving plant with a long day. With shading, branching of plants is reduced.

Soil requirements. Coriander is quite picky about soils and nutrients. The best for him are soils that have a good structure, a sufficient supply of nutrients and a neutral reaction of the soil solution. The highest yields are provided on fertile chernozems when phosphorus-nitrogen fertilizers are applied. Heavy clay, sandy and saline soils are not suitable for it.

In culture, winter and spring forms of coriander are known. In Ukraine, the spring form is grown, which is characterized by a long period of seed germination (from 15 to 20 days) and slow growth at the beginning of the growing season. Under normal growing conditions, the vegetation period lasts 95–110 days. During the growing season, the following phases take place: sprouting, stemming, flowering and ripening.

Varieties: Kirovohradsky, Garant, Amber, Velvet, Nectar, Garant, Medun.

Cultivation technology. *Predecessors*. Coriander crops are placed after winter crops in fertilized pairs, legumes and fertilized row crops. It should not be placed after crops that dry the soil and leave fields late - sunflower, sugar beet, Sudan grass. They return to the previous field no earlier than after 4–5 years.

Coriander is a good predecessor for winter cereals, corn, and sunflower.

Tillage. The system of the main tillage after grain crops consists in husking stubble and early plowing to a depth of 27–30 cm. Effective and semi-steam tillage. After row crops, plowing is carried out to a depth of 22–25 cm. Early plowing provides higher crop growth compared to late. Spring tillage consists of harrowing, harrowing and pre-sowing cultivation with simultaneous harrowing. The best quality of soil preparation for sowing is provided by the use of combined units of the Europak type. In weed-free fields, one cultivation is limited to the depth of seed wrapping (3–4 cm).

Fertilization. Due to the increased requirements of coriander for nutrients, especially nitrogen, organic and mineral fertilizers must be applied under deep plowing. When placing coriander crops after winter crops fertilized with manure, only complete mineral fertilizer is applied at the rate of 45-60 kg/ha of active substance under the plowing. If organic fertilizers were not applied under the predecessor, they should be applied under coriander (20–30 t/ha). Adding granulated superphosphate (50–70 kg/ha) and ammonium nitrate (25–30 kg/ha) to the rows during sowing is also effective.

Coriander is sown in early spring in the first days of field work. For sowing, germinated seeds (fermentation) are used, which accelerates the emergence of seedlings by 5–6 days and increases the yield by 200–300 kg/ha. The technique is as follows: soaked seeds (at the rate of 60 liters of water per 100 kg of seeds) are thoroughly mixed and rolled into a heap, where they are gradually heated to +18...20^{0}C. At this temperature, the seeds are kept until germination. As soon as 2–3% of the seeds germinate, they are unfolded and gradually dried. Before sowing, the seeds are treated.

Sowing is carried out by conventional row or wide-row methods with a row width of 45 cm. The sowing rate for continuous row sowing is 20–25 kg/ha or 2.5–3.0 million s.h. of seeds per 1 ha, and with wide rows - 10–14 kg/ha or 1.5–1.8 million sh. seeds/ha. The seeds are wrapped to a depth of 3–4 cm.

Crop care. After sowing, the crops are rolled with ring-tooth or ring-spur rollers. Conventional harrows or rotary hoes are used to protect crops from weeds and destroy the crust before and after emergence. Cultivators carry out 2-3 inter-row cultivations on wide-row crops.

To control the degree of weediness of crops, soil herbicides Gezagrad (2–4 l/ha), Treflan (6 l/ha) (with immediate wrapping), Dual Gold (1.3 l/ha), Linuron (4–6 kg /ha), and in the phase of 2–3 true leaves of post-emergence coriander – Luvaram (1.3–1.6 l/ha), 2.4-D (2.0–2.5 l/ha).

In order to improve pollination, an apiary at the rate of 2 bee colonies for each hectare of area is taken to the crops during the flowering period.

Harvesting. Coriander ripens at different times. Overripe fruits easily fall off and litter the field with carrion. In addition, in overripe fruits, the amount of fat increases and the content of essential oil decreases. In this regard, special attention is paid to the timing and quality of coriander harvesting. It is collected both by direct combining and separately. To accelerate the ripening of coriander, during the browning period, 40–50% of the umbels of crops are treated with Reglon Super (desiccation) at a dose of 2–3 l/ha. After 3–5 days, coriander is harvested by direct harvesting.

Separate harvesting begins when 30–40% of the fruits are browned, and more than 80% of the fruits are in the seed areas. Coriander is mowed with reapers, leaving stubble 20–25 cm high. When the fruits reach a moisture content of up to 15% in the windrows, the windrows are picked up and threshed with grain harvesters 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% and stored in dry rooms.

2.3.11 Cumin *(Carum carvi)*

Cumin seeds contain 4–7% essential oil and 14–22% fatty oil. Essential oil is used in the liquor and vodka, pharmaceutical, perfumery, tobacco industries, etc. Cumin seeds, which have a pleasant spicy taste, are used in cooking, the canning industry, and in the production of special types of bread. Fatty oil is used as a technical raw material. Cake is a good concentrated fodder for livestock. Meal is used for cattle feed. Cumin is a valuable honey-bearing plant.

Homeland of cumin is Europe, where it is often found in the wild on meadows, forest edges, and slopes. This is one of the most ancient plants, its seeds were found in Stone Age buildings. Cumin was grown in Kievan Rus as early as the 8th century, and since the 16th century. essential oil is extracted from it. The main areas of cumin in Ukraine are concentrated in Lviv, Ternopil, and Khmelnytskyi regions. Its yield is 0.6–0.9 t/ha, it can reach 1.2–1.5 t/ha.

Biological features, varieties. *Temperature requirements.* Cumin is undemanding to heat. Seeds begin to germinate at a temperature of +6^{0}C. It is characterized by high winter resistance. In the rosette phase, it withstands severe frosts, which is due to the presence of a significant amount of sugars in its roots during wintering. A temperature above +30^{0}C has a negative effect on the formation of the crop and the accumulation of essential oil.

Moisture requirements. A biological feature of cumin, like other plants from the celery family, is a long period of seed germination (110–116% of fruit mass needs moisture for swelling). It forms high yields only in conditions of sufficient moisture. The most moisture is needed during stemming and flowering.

Light requirements. This is a light-loving plant, especially in the first year of vegetation. When sowing under the cover of other crops, its yield decreases. In thickened crops, with shading in the rosette phase, in the second year of vegetation, cumin does not form flower-bearing shoots.

Soil requirements. Cumin grows well on different types of soil. Waterlogged, acidic, overdried soils are not suitable for it.

At the beginning of the growing season, cumin grows very slowly: from the appearance of seedlings to the formation of the first real leaf, 11-13 days pass, so the crops can become weedy. In the second year of life, under conditions of high agricultural technology, all plants, as a rule, go into the generative phase. The most suitable for cumin are chernozems and gray podzolized soils, light in mechanical composition with shallow groundwater.

Varieties: Podilskyi 9, Pultivskyi, Sluch, Tonus.

Cultivation technology. *Predecessors*. Cumin crops are placed on well-cultivated soils after fertilized winter crops. In the year of fruiting, it vacates the field early, therefore it is a good predecessor for winter and other crops.

Soil cultivation consists of two peelings and deep plowing of 27–30 cm. In the spring, harrowing and cultivation are carried out. Pre-sowing tillage is carried out with the help of combined tools.

Fertilization. Manure (25–30 t/ha) and complete mineral fertilizer (30–40 kg/ha of active substance) are applied under cumin. When placing cumin after fertilized winter crops, only mineral fertilizers are applied.

Cumin makes good use of fertilizers that are applied in two doses. In the first year of vegetation, at the last loosening of the rows, phosphorus and potassium fertilizers are applied at 40 kg/ha of each element. In the second year after overwintering, nitrogen fertilizers are applied in early spring at the rate of 40–50 kg/ha.

Sowing. The best time for sowing is early spring at the beginning of field work. However, summer sowing in July after early busy couples is also effective. Germinated seeds are used for spring sowing. The technology of germinating cumin seeds is the same as that of coriander.

Cumin is sown in wide rows with 45 cm between rows. The sowing rate is 8 kg/ha or 1.7–1.8 million similar seeds per 1 ha. The seeds are wrapped to a depth of 2–3 cm.

Crop care. After sowing, the area must be rolled. Caring for cumin crops before emergence consists in destroying the bark with light harrows or rotary hoes. As soon as the seedlings appear, the crops are harrowed. Since cumin develops a small rosette of leaves in its first year of life, which slightly shades the soil, the crops become weedy, and during the rains the soil is very compacted. With this in mind, crops should be cultivated with cultivators at least 4–5 times during the growing season. In the first year of vegetation, the crops are fed with complete mineral fertilizer at the rate of 20–30 kg/ha of the active substance: the first time in the spring and the second time in the fall. Thickened crops are thinned during the period of formation of 3–4 real leaves, leaving plants at a distance of 10–12 cm in a row.

Crop care for the second year consists in harrowing the crops across the direction of the rows, two or three loosening of the soil between the rows, and early spring feeding with complete mineral fertilizer at the rate of 20–25 kg/ha of the active substance. Fertilizers are applied during the first spring loosening of the soil, wrapping them to a depth of 10–12 cm.

In very weedy fields, the herbicide Treflan (4–6 l/ha) is applied for pre-sowing cultivation, or Gezagard (4–5 l/ha) before the emergence of cumin seedlings.

Harvesting. Cumin fruits do not ripen at the same time, and ripe ones easily fall off. 35–40% of the fruits are harvested by separate method after browning, and 50–60% by direct harvesting. The cut cumin is left in the rolls for 3-4 days to dry. The dried rolls are immediately threshed. Seed moisture during storage should not exceed 10–11%.

2.3.12 Fennel*(Foeniculum vulgare)*

Essential oil (4–6%) is extracted from fennel fruits, which consists of 50–60% anethole. Essential oil and anethole are used in the food, perfumery and cosmetic, pharmaceutical and other industries. Anethole is used for the synthesis of obepin, an aromatic substance used in perfumery. The fruits also contain 18–20% fatty oil, which is used for technical needs. Fennel fruit meal, which contains 18–22% protein, is used as a concentrated feed. Fennel is a honey crop.

The homeland of fennel is considered to be the Mediterranean region. Now it is grown in Western Europe, India, Japan and other countries. In Ukraine, fennel began to be grown in the 1930s. The main crops of fennel are concentrated in the Chernivtsi region and the Crimea. The average yield is 0.5–0.6 t/ha.

Biological features, varieties.*Temperature requirements.* Fennel seeds begin to germinate at a temperature of +6...8^{0}C, and friendly germination occurs at +20^{0}C. The stairs withstand frosts up to -8^{0}C.

Moisture requirements. Fennel is a moisture- and light-loving plant. The most moisture is needed from the beginning of stemming until full flowering. Shading and cloudy cold weather lengthen the growing season. Drought during the flowering period reduces the yield.

Soil requirements. Fennel grows well and produces high yields on chernozem and dark gray podzolized soils.

It begins to bear fruit in the first year of life. The growing season lasts 139–147 days. Varieties: Marshmallow, Crimean, Mertsyshore, Chernivtsi 3.

Features of cultivation technology. In crop rotation, fennel is placed after winter and spring cereals, sugar beets, potatoes, annual herbs, etc.

Soil cultivation is carried out in the same way as for other essential oil crops of the celery family. In the fall, it is recommended to apply complete mineral fertilizer under the fennel at the rate of $N_{40-60}P_{60-80}K_{60-80}$. During sowing, granulated phosphorous superphosphate (10–15 kg/ha

P_2O_5) is applied to the rows.

Fennel is sown at the same time as early spring cereals in a wide-row method with rows 45–60 cm apart. The seed sowing rate is 8–10 kg/ha. It is wrapped to a depth of 2–3 cm. After sowing, rolling is carried out with ring rollers.

Crop care includes pre-emergence and post-emergence harrowing and inter-row loosening. In the period of the phase of the first or second real leaves, the density of the crops is formed with the help of transverse thinning (bouqueting according to the scheme: cutout 30 cm, bouquet 20 cm) or manual weeding. 6–8 fennel plants are left on 1 m of row.

Fennel harvests separately. They begin to collect when the fruits are ripe on umbrellas of the first order. A sign of fruit ripening is their easy disintegration into two halves. After drying, the swathes are picked up and threshed by converted grain harvesters. Cleaned and sorted seeds are stored at a humidity of no higher than 12–13%.

2.3.13 Anise*(Pimpinella anisum.)*

Anise fruits contain 2.5–4% essential oil, 16–22% fatty oil and up to 20% protein. The main component of anise essential oil is anethole alcohol (80%), which is widely used in medicine, veterinary medicine, perfumery, food and pharmaceutical industries.

Anise seeds are used in baking, in the production of preserves and confectionery. Young leaves and inflorescences are used for salting and pickling vegetables and fruits.

Varnishes, paints, soap, oleic acid, etc. are made from fatty oil. The cake is used as a good concentrated feed for animals. 100 kg of cake contains 85 fodder. unit Anise is a honey crop.

Anise comes from Asia Minor. Now it is grown in many countries of Asia and Europe. In Ukraine, anise is grown on small areas in the forest-steppe zone. Yield is 1.0–1.5 t/ha.

Biological features, varieties. Anise (Pimpinella anisum L.) is an annual plant of the celery family (Apiaceae).

Temperature requirements. Anise, compared to coriander, is a more picky culture to heat. Seeds begin to germinate at a temperature of +4...5^{0}C, but friendly shoots appear at +10...15^{0}C. The optimal temperature for plant growth and development is +24...25^{0}C. Anise plants are most sensitive to heat during flowering, fruiting and ripening.

Moisture requirements. Anise is a moisture-loving plant. For seed germination, about 150% of its mass needs water. The most picky about moisture during flowering and fruiting.

Soil requirements. Anise is quite picky about soils and nutrients. The best for it are fertile light and medium loamy soils free of weeds. Unsuitable clay and sandy soils, as well as soils with a high level of groundwater. Anise is particularly sensitive to the presence of nitrogen and potassium in the soil.

Anise is a light-loving plant. The duration of the growing season is 120–150 days.

The Artek variety is included in the list of recommended varieties.

Features of cultivation technology. In crop rotation, anise is placed after winter cereals, row crops, and annual grasses. Do not sow after coriander, which clogs crops with carrion.

Tillage consists of plowing to a depth of 22-25 cm, early spring harrowing and pre-sowing cultivation. Complete mineral fertilizer is applied under plowing at the rate of 45–60 kg/ha of nitrogen, phosphorus and potassium. When sowing, granulated superphosphate (10 kg/ha P_2O_5) is used, and when the rosette is formed, the leaves are fed with nitrogen-phosphorus fertilizers (10–15 kg/ha each).

Before sowing, air-heat heating and etching (TMTD, 4 kg/t) of seeds are carried out. Anise is sown at the same time as early spring crops. In weed-free fields, the usual row method is used, and in weedy fields, the wide-row sowing method (45 cm) is used. The sowing rate for the usual row method of sowing is 18–20 kg/ha, and for the wide-row method - 10–12 kg/ha. The seeds are wrapped to a depth of 3–4 cm.

Crop care includes pre-emergence and post-emergence harrowing and at least three inter-row treatments on areas with wide-row sowing.

To control the weediness of crops, the soil herbicide Treflan (3.0-4.0 l/ha) is used, which is applied under pre-sowing cultivation or before the seedlings for harrowing. Anise is also resistant to herbicides of the 2,4-D group, which can be applied in the rosette phase of anise (2–4 true leaves). By combining the application of the soil herbicide Treflan (3.0–4.0 l/ha) with post-emergence 2,4-D (2.0–2.5 l/ha), it is possible to control the weediness of crops and avoid manual weeding.

Harvesting. Anise ripens unevenly and crumbles easily when left standing. They begin to collect it during the period of maturation of medium umbrellas. Fruits at this time acquire a greenish-gray color. In this condition, the anise crops are harvested separately. Thinned and fallen crops are collected by direct harvesting at the beginning of full ripeness of the fruits. Seeds are cleaned, sorted, dried and stored at a humidity of no more than 12%.

2.3.14 Peppermint*(Mentha piperita)*

Essential oil is extracted from leaves (2–4%), inflorescences (4–6%), stems (up to 0.3% of the weight of dry matter). The components of peppermint oil are menthol (41–84%), menthone (9–25%), pinene, limonene and other substances. The more menthol in the oil, the higher its quality. Menthol has the ability to expand the 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. Peppermint oil is used in the pharmaceutical, food, perfume, and liquor industries. Mint leaves are used in medicine and as a spice for pickling and preserving vegetables. Fresh and dry leaves are used to flavor various dishes, drinks, tea, and vinegar. Contains ascorbic acid (up to 25 mg %), carotene (up to 8 mg %), rutin (up to 14 mg %), has a characteristic refreshing cool taste.

Mint decoctions help with diseases of the respiratory organs and stomach, with angina, dizziness, have an analgesic, vasodilating and calming effect.

Peppermint was introduced into culture about 300 years ago. Mint comes from England. In Ukraine, it began to be grown at the beginning of the 18th century, and now its main areas are located in the Chernihiv, Cherkasy, Sumy, Kyiv and Poltava regions. The yield of dry above-ground mass is 1.5–2.0 t/ha.

Biological features, varieties.*Temperature requirements.* Mint is undemanding to heat. In the spring, mint vegetation resumes at a temperature of +2...3^{0}C. It tolerates frosts up to -8^{0}C well during this period. The optimal temperature for growth is +18...20^{0}C, and for the synthesis of essential oil - +22...25^{0}C. During the growing season (from germination to flowering), mint needs temperatures ranging from 1,500 to 16,00^{0}C. Higher temperatures in the summer months restrain branching, productivity, and the oil content decreases. In years with warm winters, mint overwinters well, but at temperatures of -15...20^{0}C it freezes without snow cover or special shelter. Above-ground shoots (whips) die first, and then rhizomes. In conditions of prolonged low temperature, the number of inflorescences on plants decreases and rare flowering of grass stands is observed.

Moisture requirements. Mint is a moisture-loving plant. Optimum conditions for its growth and development are at soil moisture not lower than 80%. It is especially picky about 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, as a result of which a low yield of above-ground mass is formed and the collection of high-quality oil is reduced. Mint does not tolerate prolonged drought and responds well to irrigation.

Light requirements. Peppermint is very picky about light. It is a long-day plant and grows best with sufficient light. For normal development, it needs at least 12 light hours. If you move the culture to the north, where the length of the day increases, mint shortens its growing season, develops and blooms faster. With a favorable length of day and sufficient lighting, it forms high yields of aerial phytomass with a high content of high-quality oil. With insufficient lighting, a smaller leaf surface is formed, the leaves quickly die and the yield of quality oil is sharply reduced.

Soil requirements. Mint is characterized by increased requirements for soil fertility and moisture. It grows best on alluvial soils in river valleys, as well as in areas with a high level of groundwater, which are not flooded in the spring. The most suitable soils for it are chernozems, which are light in terms of mechanical composition, and cultivated peatlands.

Mint is propagated by rhizomes, shoots or seedlings. It is propagated by seeds only in selection. The vegetative period of mint (from planting to the technical maturity of the leaves) lasts 120–130 days.

Mint varieties are zoned in Ukraine: Zagrava, Ukrainian pepper, Prylutska 14, Likarska 1, Lidia, Chornolista.

Cultivation technology. *Predecessors*. Given the high requirements for soil fertility, mint is placed in special crop rotations. The best predecessors for it are vegetable crops, perennial legumes, fertilized winter crops. It is usually grown in one place for 2-3 years in a row, but the plants are very affected by rust.

Soil cultivation for mint is the same as for other industrial crops. When placing it after fertilized winter crops, peeling is carried out, and then plowing to a depth of 22–25 cm. After perennial grasses, tobacco, hemp, vegetable crops, plowing is carried out immediately after harvesting. In early spring, harrowing and cultivation are carried out in 2 furrows to a depth of 10–12 cm.

Fertilization. Organic and mineral fertilizers are mandatory when growing mint. Under mint, it is recommended to apply manure at the rate of 30–40 t/ha and complete mineral fertilizer at the rate of 60–70 kg/ha of nitrogen, 45–50 kg/ha of phosphorus, and 60–70 kg/ha of potassium on podzolized chernozems. On cultivated peatlands, only phosphorus-potassium fertilizers are applied in increased doses.

*Planting.*When growing mint with rhizomes or shoots (whips), after spring cultivation of the soil, furrows are cut to a depth of 8–10 cm. The width of the rows is 45–50 cm. Rhizomes or shoots are planted in the first days of spring work at the same time as early spring sowing, laying them to the bottom of the furrow in the wet soil with a continuous tape. The rhizomes are pressed to the moist soil, and the furrows are wrapped with plumes. Up to 1.0–1.5 tons of rhizomes are planted per hectare. Mint is also planted with seedlings in furrows, cut with a marker and pre-watered. The width of the rows, as when planting with rhizomes, is 45–50 cm, the distance between plants in a row is 12–15 cm.

Crop care. One or two harrowings with medium or heavy harrows are carried out before the stairs. After germination, harrowing is stopped when the height of the plants reaches 6–8 cm. After germination, 3–4 cultivations and 1–2 fertilizing are carried out. The first loosening of the soil between the rows is recommended to a depth of 10–12, and subsequent ones to a depth of 6–7 cm.

An important measure to increase the yield of mint is its feeding with local and mineral fertilizers. The most effective early fertilization is carried out during the first and second inter-row cultivations (the first 5-6 days after the emergence of seedlings).

Treflan (4 l/ha), Nabu (2–3 l/ha), Poast (2–3 l/ha) herbicides are used for mint planting in weedy fields. In the phase of 4–6 leaves in mint, the crops will be treated with Bazagran (3 l/ha) or Gezagard (3–5 l/ha).

On mint plantations left for the second year, plowing is carried out to a depth of 15–18 cm with a full rotation of the plow in autumn at the beginning of a persistent cold. In dry years, plowing is carried out in early spring.

Plantations are harrowed and disked in early spring. As soon as the seedlings appear, the rows are cut 45–50 cm wide with cultivators with knife legs or thinning machines.

The mint plantations of the third year are treated with BDT-3 disc harrows to a depth of 5–6 cm. After each mowing, the mint plantings are fed with mineral fertilizers in a dose of $N_{90}P_{120}K_{90}$.

Mint responds well to irrigation. With irrigation, two crops are harvested a year. Irrigation maintains soil moisture at the level of 80–85% RH. The best method of irrigation is sprinkling with an irrigation rate of 450–500 m^3/ha of water.

Harvesting. Mint is collected 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). During this period, there is the highest yield of leaves and yield of oil.

Before harvesting, the fields are carefully cleaned of weeds and wild mint species, because the latter reduce the quality of the raw material. Mint is harvested with legume harvesters, and in small areas it is mowed by hand. The cut mint is raked into small rolls and left for 1-2 days to dry.

Well-dried mint is transported on special trains and laid out in rolls or narrow, pointed piles, where it is dried. Rolls and heaps are translated every day. The dried plants are threshed. Rubbing leaves leads to loss of oil. When growing high-menthol varieties, leaves and stems are used to extract essential oil.

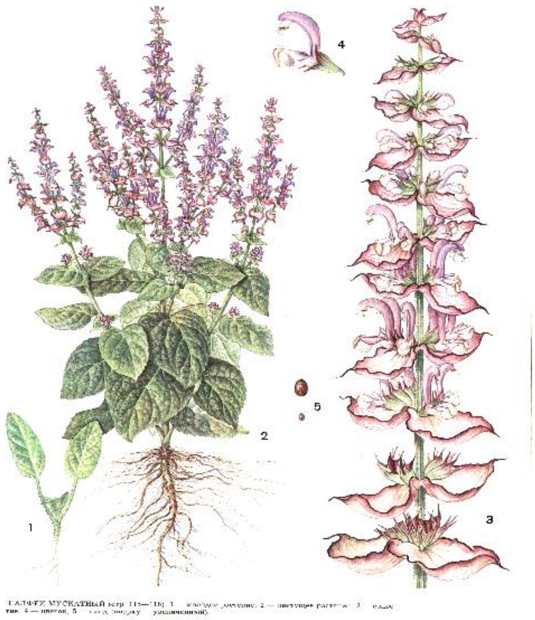
According to modern harvesting technology, mowed and air-dried plants are collected by balers in bales weighing 25–40 kg and sent to the factory.

Matochnyky. Matochnyky are laid to grow planting material. For each hectare of mint area, 0.1–0.15 ha of rootstocks are required when planting with rhizomes, and 0.1 ha when planting with seedlings. Areas where the largest mint harvests are collected and which are placed in places protected from cold winds are left under the queens.

It is necessary to carry out special weeding on the mother plants, and the crop is harvested later than on ordinary commercial crops (during the period of full flowering). This contributes to the better development of rhizomes and increases their winter resistance. During harvesting, the plants are mowed at a height of 15 cm so that snow is retained in winter. Matochniks left 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 rhizomes begin to be selected. To do this, use the KPM-2 root-harvesting thinner or cultivate the area along and across and comb the rhizomes with harrows.

Rhizomes and shoots that are not damaged by frost and diseases are selected for planting.

2.3.15 Sage nutmeg *(Salvia selarea)*



The inflorescences of clary sage contain 0.2–0.35% of valuable essential oil, the main component of which is esters (50–77%). Oil with a pleasant smell of ambergris, orange, bergamot. Sage essential oil is used in the perfume, cosmetic, food, soap industries and in medicine. A special quality of the oil is its fixing properties, and it is used for the synthesis of a wide range of persistent aromatic substances. The fatty oil obtained from the seeds of sage (25-32%) is used for the production of high-quality oil and is used in ceramic and porcelain production. Sage is a valuable honey crop.

Sage nutmeg is a relatively young culture. It was first cultivated in France. It has been grown in Ukraine since 1929. The main crops are located in the Crimea and Zaporizhzhia region. The yield of inflorescences is 3.0–4.0 t/ha.

Biological features, varieties.*Temperature requirements*. Sage is an undemanding to heat culture. Seeds begin to germinate at a temperature of +8...10^{0}C. It is characterized by relatively high cold and frost resistance. Seedlings can withstand a drop in temperature to -6...8^{0}C, and adult plants in the phase of a developed rosette - up to -30^{0}C. The optimal temperature for growth and development is +18...20^{0}C. During flowering, an elevated temperature of +25...30^{0}C is favorable, thanks to which the content of essential oil increases.

Moisture requirements. Sage is a drought-resistant plant, but demanding moisture during germination. The seed absorbs 3–4, and the fruit shell 40 times more water than its own weight. Sage needs a significant amount of moisture in the spring period, when plants of the second year of life develop a large leaf surface and form inflorescences. At the same time, during the ripening period, sage easily withstands drought.

Light requirements. Sage is picky about light, especially at the beginning of development. Young plants do not tolerate shading well. It develops better with a daylight length of 14–16 hours.

Soil requirements. Sage is not picky about soils. It can even be grown on stony soils, but chernozems and carbonate loamy soils are best for it. Sandy soils are not suitable.

Sage is a cross-pollinated plant. They are 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, inflorescences and fruits. On crops of the second year of life in the southern regions of Ukraine, flowering begins in early July and ends in August.

Varieties: One-year, Crimean late, Crimean one-year, Mriya, S-785. Varieties are suitable for mechanized cultivation and harvesting.

Cultivation technology. *Predecessors*. Sage is mixed in after winter wheat or row crops in field and fodder rotations. Return to the previous place after 4-5 years.

Tillage. The main tillage is husking of stubble followed by plowing to a depth of 27–30 cm. In very weedy fields under sage, layered tillage is used, which involves plowing without a shelf and with a shelf to different depths. To combat rhizome weeds (creeping wheatgrass, gumii), the field is disked lengthwise and crosswise to a depth of 10–12 cm to crush the rhizomes, after which they are deeply plowed with a plow with a front plow. 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), Promethrin (3 l/ha), Poast (1.5–3.0 l/ha) are applied to pre-sowing cultivation.

Fertilization. Under deep plowing, complete mineral fertilizer is applied at the rate of 60 kg/ha of the active substance of each element. In the second year of life, during the period of recovery of spring vegetation, $N_{40–50}P_{40–50}K_{40–50}$are applied.

Sage is sown before winter, when the soil temperature drops to +4...5 0C, so that the seeds do not germinate before the onset of cold weather. The method of sowing is wide-row with a row spacing of 70 cm. The depth of seed wrapping is 2–4 cm. The seeding rate is 8–12 kg/ha, which provides a seeding density of 300–400 thousand plants per 1 ha in the first year of vegetation, and 150– 200 thousand/ha.

Crop care. At the beginning of spring work, the crust is destroyed by harrowing crops across the direction of the rows. In the phase of 1–2 pairs of leaves, the interrows are loosened to a depth of 6–8 cm. After the rows are closed, interrow processing is not carried out.

In the first and second year of life, crops are fertilized with nitrogen and phosphorus fertilizers at the rate of 30 kg/ha of the active substance, working them with cultivators-plant fertilizers to a depth of 10–12 cm. Effective fertilization in the first year in the phase of two pairs of true leaves, and in the second - at the beginning of vegetation.

After harvesting, sage stubble is cut at a low cut and removed from the field. Immediately after that, the inter-rows are loosened to a depth of 8–10 cm. On the plantations of the second year of life, harrowing is carried out across the rows in two tracks in the spring. Later, the rows are loosened to a depth of 7–10 cm.

Mandatory agricultural measure is the fight against the sage weevil and mosquito, for this the crops are treated with one of the preparations: Aktelik, Bazudin, Karate Zeon.

Harvesting. The harvesting of sage begins when the essential oil content in the inflorescences is at least 0.12%. The period of technical maturity of sage coincides with the milky-waxy maturity of the seeds in the lower fruits of the inflorescence. Inflorescences are mowed with ordinary silage or converted grain harvesters.

The mown mass is immediately transported for processing, because even short-term (within 3–4 hours) storage leads to the loss of 40–50% of the essential oil.

2.3.16 Lavender*(Lavandula vera)*

Essential oil accumulates in all parts of plants, but the most of it is in inflorescences - 0.8–3.0%. In essential oil, its main components have the greatest value - linalyl acetate (30–56%), linalool (10–12%), as well as geraniol, nerol, camphor, etc. The oil is used in the perfumery and cosmetic, soap-making, food, and pharmaceutical industries. Flowers and oil are used in medicine to treat various diseases, it is a good antiseptic. Lavender is a valuable honey plant, 100–150 kg of honey is collected from 1 hectare.

Lavender was first cultivated at the end of the 16th century. in

England. It is also common in France, Bulgaria, Hungary, Spain, and Japan. In Ukraine, industrial crops were planted in the Crimea. Lavender in production is propagated vegetatively. The largest cultivated areas are located in the Crimea - 3.6 thousand hectares. The average yield of fresh inflorescences is 2.0–3.0 t/ha. The yield of essential oil is 15–35 kg/ha.

Biological features, varieties.*Temperature requirements.* As a mountain plant, lavender is quite cold-resistant. In the Crimea, it tolerates a drop in temperature to -20^{0}C. In the presence of a snow cover with a thickness of 25 cm - up to -28^{0}C. Older plantations are less resistant to frost. Seedlings in the phase of 4–5 pairs of leaves withstand frosts up to -8...10^{0}C. Warm weather is best for lavender during the growing season, and hot weather during flowering. This helps to increase the yield of raw materials.

Moisture requirements. Lavender belongs to drought-resistant crops. An excess of soil or atmospheric moisture leads to diseases and loss of plants. However, the lack of moisture in the first half of the growing season (before flowering) leads to a decrease in yield.

Light requirements. Lavender is a light-loving plant. Shading reduces the size of the flowers, the oil content in them, the shoots are strongly elongated. It is grown on areas with a southern slope.

Soil requirements. Lavender is undemanding to soils and grows well on poor sandy and carbonate soils. Heavy, cold soils with high acidity, with a high level of groundwater are unsuitable for lavender.

Lavender is a cross-pollinated culture. The main method of its reproduction is vegetative. Plants reach full development in 3–4 years.

Zoned varieties of lavender are resistant to diseases and pests and are suitable for mechanized cultivation: Record, Stepova, Sinyeva, Rannia.

Cultivation technology.*Site selection*. They place lavender outside of crop rotation, as it grows in one place for 15–25 years. New plantations are established after grain crops or annual grasses. Lavender can be grown in open spaces.

Tillage. After harvesting the predecessor, herbicides of continuous action (Hurricane Forte, Roundup) are applied. On the areas set aside for lavender, plowing is carried out 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 steam. At the end of September - beginning of October, the field is cultivated with chisel cultivators to a depth of 22-25 cm.

Fertilization. Lavender responds positively to fertilization. Under plantation plowing, 30–35 t/ha of manure are applied along with mineral fertilizers (N80-100P80-100). For the following year, in autumn, full mineral fertilizer is applied in the norm N80-90P80-90K80-90. When planting lavender, superphosphate (P10) is applied with irrigation water. Fertilization of lavender plantations with mineral fertilizers begins in the second year of life with the beginning of industrial harvesting of inflorescences. It is better to fertilize with nitrogen fertilizers in the spring, and with phosphorus-potassium fertilizers in the fall.

Planting Lavender seedlings are planted with a lavender planting machine or by hand according to schemes of 1.0x0.5 m or 1.2x0.5 m. The planting depth is 20–25 cm. During planting, the root neck is deepened below the soil surface by 5–6 cm. The optimal planting period is the second half of October and November. You can plant in the thaw in winter or early spring.

Recently, lavender plantations are established by sowing seeds in a permanent place in November ore, before the soil freezes. The sowing rate is 4.5 kg/ha, the width of the rows is 1 m.

Care. Care consists in loosening the rows (4-5 times), timely planting of lavender instead of dead plants. The first loosening of the inter-rows is carried out at the end of March with a cultivator KRN-4.2 to a depth of 8–10 cm. The next ones are to a depth of 10–12 cm. Every year after harvesting the kushi inflorescences are pruned, removing dry and damaged branches. Following this, the bushes are rejuvenated by cutting them to 1/2 of the annual growth with a POL-1 machine. Plantation rejuvenation is repeated every 5-6 years of industrial use. To destroy weeds, in addition to continuous action herbicides, soil herbicide Treflan (2.5 l/ha), post-emergence 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. The crop is harvested 4-5 days after the beginning of flowering, when 50% of the flowers have bloomed in the inflorescences (end of June - beginning of July). Cut the peduncles 10–12 cm long. Freshly collected inflorescences are immediately sent for processing. On rainy and cloudy days, the yield of oil decreases, so the inflorescences are not harvested in such weather.

2.4 FIBER CROPS

Fiber crops are grown for fiber, which is used for the production of various fabrics for household and technical purposes. In world agriculture, spinning crops are grown, which are divided into two groups. The first group includes the most widespread spinning crop in the world - cotton, in which elementary fibers are formed on the skin of the seed in the form of modified cells of the epidermis, and the second group - bast crops (long flax, hemp), in which the fiber is formed in the stems in the form of long bast fibers.

The seeds of all spinning crops contain oil, which is not inferior in quality to sunflower oil and is used for food and for various technical needs. Oil production waste - cake and meal is a valuable concentrated feed for animals.

Long-spun flax and hemp are grown in Ukraine, and cotton, jute, kenaf, and rope are among the less common and promising spinning crops.

2.4.1Flax-long *(Linum usitatissimum)*

Flax is the main spinning crop in Ukraine. It gives two valuable products: fiber and seeds. The main production of long-stemmed flax is the fiber formed in the stalks. The yield and quality of fiber depends on the morphological characteristics of the stems, the amount of which, depending on the variety and growing conditions, can be 20–30%. Long and thin stems have more fiber and are of better quality than thick and short ones.

The quality of flax fiber is much higher than that of hemp, jute, and rope. It is twice as strong as cotton and three times as strong as wool. At textile enterprises, various fabrics are produced from the fiber, which are distinguished by a long period of wear, are very hygienic, antistatic, easy to wash, and are resistant to rotting. This is a very valuable linen batiste, clothes, sheets, canvas. Tarpaulins, burlap, packing fabrics, ropes, twine, threads, and fire hoses are made from poor quality fiber.

Flax seeds contain 35–39% quick-drying oil and up to 23% protein. Oil is a valuable food product and is used in the food, margarine, and confectionery industries. Thanks to the content of unsaturated fatty acids (oleic, linoleic, linolenic, isolinolenic), the oil helps to reduce cholesterol in the blood. The oil dries quickly, it is suitable for the production of oil, varnishes, paints. It is used in soap making, pharmaceutical, electrical engineering, paper, rubber and other industries. Flax seeds and oil are used as medicines. Linetol is obtained from the oil for the treatment and prevention of atherosclerosis.

Recently, the pith, which remains after the fiber is separated from the stems, has also been widely used. It is used in linen factories to make plates for the production of furniture, as well as paper, cardboard and technical ethyl alcohol.

Flax also has fodder value. One kilogram of seeds contains 1.8 food units. A valuable concentrated feed is cake - a by-product of the processing of flax seeds into oil, containing 6-12% fat, 32-36% easily digestible proteins. In terms of nutrition, 1 kg of cake is equivalent to 1.2 fodder units. It is used as an important component in the production of compound feed. In terms of fodder qualities, the cake of other plants prevails, because it is easily digested by animals

Dovgunets flax is an ancient culture, known as far back as 4–5 thousand years BC. in India, China, Egypt. In our country, it spread in the 15th century. At the beginning of the 18th century state rope and linen factories were built in Russia. From the first years of the XX century. our country has become the main exporter of fiber abroad. At the end of the 20th century in Ukraine, long flax was sown, depending on fiber needs, on an area of 100–160 thousand ha. However, in recent years, the area of long-leaved flax has sharply decreased. Its largest cultivated areas are concentrated in Zhytomyr, Chernihiv, Volyn, Lviv, Rivne, Ivano-Frankivsk and Kyiv regions. The average yield of fiber in Ukraine is 0.4–0.5 t/ha. In flax farms, where intensive flax cultivation technology is implemented, the yield of long fiber reaches 1.0–1.2 t/ha and seeds – 0.5–0.8 t/ha.

Biological features, varieties. Flax belongs to the flax family (Linum L.) and includes more than 200 species. There is one species of industrial value - common cultivated flax (Linum usitatissimum L.). The European-Asian subspecies of cultivated flax is divided into 4 groups of varieties: flax-dovgunets, mezeumok, kudryash, slanky.

A significant part of crops in our country is devoted to flax, which is grown primarily for the production of fiber. Fiber in the form of fibrous or bast bundles, arranged in a ring in the bark of the stem, consists of individual elementary fibers glued together with a pectin substance. Elementary fibers are elongated cells 15–40 mm long with pointed ends. Each bundle contains 25–40 fibers. The bundles, connecting with each other, form a tape of technical fiber.

The amount and quality of fiber is not the same in different parts of the stem. 12% of fiber is located at the base, up to 35% in the middle part. The fiber in this part is long, thin, tightly bundled, and of high quality. In the upper part of the stem, the fiber is about 28–30%. The number of elementary fibers in the bundle decreases, so the fiber here is less strong.

The quality of the long fiber is evaluated by the number, which is determined organoleptically - by comparison with a standard sample.

According to the standard, long fiber is evaluated by numbers depending on the quality. In addition, the quality of long fiber is characterized by technological features - strength, flexibility, tonality, quality, spinning ability.

Temperature requirements. Flax is a culture of a temperate climate. Flax seeds begin to germinate at +3...5^{0}C. The optimal temperature for its growth and development is +16...17^{0}C. Young seedlings can withstand frosts up to -3.5...4^{0}C. The optimal temperature for the growth and development of plants is: during the seedling period +9...12^{0}C, in the Christmas tree phase - +14...16^{0}C, during the flowering period - seed formation - +16...18^{0}C.

The sum of effective temperatures for its development during the growing season is 1400–2000^{0}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 stalks with a low content of coarse fiber.

Moisture requirements. Flax is very demanding on moisture. Its transpiration coefficient is 400–430. It grows best at soil moisture of 70% RH. The most water is needed in the phases of budding and flowering. 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 cause the development of fungal diseases, lodging and rotting of flax plants. At the same time, mechanized harvesting becomes more difficult, part of the harvest is lost, and its quality deteriorates. At the same time, plants cannot withstand excessive water content in the soil. Flax does not grow well on overmoistened soils and in fields with close groundwater.

Light requirements. Flax belongs to the long-day crops with relatively low intensity of sunlight. It has been established that a long day contributes to a better development of the technical length of plants, the formation of fiber of better quality. With intense sunlight, branching of the stem increases, which reduces the amount and quality of fiber. The most favorable 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 lines is also important. If they are placed from north to south, then the rows are better illuminated, the growth and development of long-leaved flax is enhanced.

Requirements for power cells. Flax is a culture that is very demanding on the content of nutrients in the soil. This is explained by the fact that it has a poorly developed root system, which, in addition, is characterized by a low absorption capacity. Flax has a short period of absorption of the main mass of nutrients, it is limited to the phases of budding and flowering. The overall nutrient requirement of flax is very high. For the formation of 1 ton of fiber, flax takes 80 kg of nitrogen, 40 kg of phosphorus, and 17 kg of potassium from the soil. Nutrients from mineral fertilizers are used unequally by flax: nitrogen – 70–80%, phosphorus – 15–20%, potassium – 50–60%.

Soil requirements. Long-leaved flax needs a structurally fertile and cultured soil with a slightly acidic reaction (pH 5.9–6.5). It grows best on sod-podzolic loamy or loamy-sandy soils. Flax also gives good yields on fertilized sod-podzolic sandy and sod-brown earth soils.

Light sandy and loamy soils are not suitable for it, as they are poor in nutrients and do not hold moisture well. On sandy soils, flax suffers from drought. Heavy clay soils slowly warm up in the spring, after rain they form a crust, which is an obstacle to the emergence of delicate flax seedlings to the surface of the soil. It is not recommended to sow flax on acidic peat soils. A coarse and brittle fiber is formed on limestone soils

Zoned varieties of flax in Ukraine: Tomsky 16, Irma, Kyivsky, Rushnychok, Sinilga, Ukrainian 3, Mogilivsky 2, Charivny, etc.

Cultivation technology. *Place in crop rotation*. Long-legged flax is demanding of its predecessors. With frequent cultivation on the same field, the "flax fatigue" of the soil occurs, the yield of flax decreases or completely dies due to the accumulation of pathogens of fusarium, anthracnose and polysporosis in the soil. To prevent flax disease, flax should be grown in one field no earlier than after 6-7 years. Crops are placed on low areas of the crop rotation, avoiding closed saucers, because it can get wet. According to research institutions and best practices, the best predecessors of long-legged flax are winter wheat after a layer of perennial grasses or spring cereals after fertilized row crops. According to research institutions, when full mineral fertilizer was applied after perennial grasses, winter cereals and potatoes, almost the same yields of flax were obtained, but the yield and quality of long fiber were higher when it was grown in a layer of perennial grasses, more often after winter wheat.

Lately, long-leaved flax usually lies down after high-yielding perennial grasses. This is explained by the fact that grasses accumulate a lot of nitrogen in the soil. At the same time, the yield and quality of fiber and seeds decrease. Taking this into account, in advanced farms, flax is grown mostly on the rotation of the layer of perennial grasses after winter wheat.

Complete mineral fertilizer ($N_{60–80}P_{60–80}K_{60–80}$) should be applied under winter and spring cereals, which are used as precursors of flax. Flax does not deplete the soil. After it, winter and spring cereals, potatoes, buckwheat and other crops can be grown in crop rotation.

Tillage. High-quality soil cultivation provides optimal water, nutrient and air regimes for plants. He should clean the field of weeds as much as possible, create a fine-grained structure, perfectly level the surface of the soil. The method of soil cultivation depends on the type of soil, its predecessor, weediness and humidity. Tillage is divided into main and pre-sowing.

The main processing depends on the predecessor. After perennial leguminous grasses, the field is plowed with a plow with a plow to a depth of 20–22 cm, and if the arable layer has a greater thickness, to 25–27 cm. After grain predecessors, the soil for flax is recommended to be cultivated according to the type of improved zaab. The stubble is peeled to a depth of 6–8 cm with LDH-10 or LDH-15 peelers, or to a depth of 10–12 cm with BDT-, BDV-6.3 disk peelers or PPL-10-25 plow peelers. Field plowing is carried out early, with the appearance of weed seedlings, to a depth of 20–

22 cm of the plow layer.

The semi-steam method provides greater efficiency in cleaning the top layer of the soil from weeds. Its essence consists in plowing with simultaneous harrowing (in dry weather - rolling) immediately after harvesting the predecessor - no later than August 15. To evenly distribute and wrap the turf, front plows are installed 32–34 cm ahead of the main plow bodies to a depth of 8–10 cm. The plowing depth should not exceed the depth of the plow layer. During plowing, it is important not to turn podzol (infertile soil layer) onto the soil surface, because even a small amount of it in the plowed layer reduces the field germination of seeds, stem density and contributes to the disease of plants with Fusarium wilt.

As the weeds germinate, the soil is cultivated 2-3 times with the help of KPS-4 with simultaneous harrowing. The first cultivation is carried out to a depth of 10-12 cm, the second - to 8-10 cm, the third - to 6-8 cm. Weed seeds germinate from the top layer of the soil and are destroyed by the next cultivation. A new seed emerges on the surface, which also germinates and is destroyed. At the same time, such processing exhausts and destroys the vegetative organs of rhizome and rhizome weeds. The last cultivation is carried out 2-3 weeks before the onset of frost, so that the weed seeds that have been burned from the lower layers of the soil have time to germinate and the seedlings are destroyed by frost.

When flax is placed after potatoes or root crops, the field is plowed for frost without preliminary husking or is limited to surface shallow tillage.

Spring tillage consists in preserving moisture in the soil, creating an even surface of the field, a solid bed for seeds, which ensures uniform wrapping of seeds to a depth of 1.5–2.0 cm. Early spring tillage begins with the onset of physical maturity of the soil. Use a hitch of heavy or medium harrows and harrow in 2-3 tracks to loosen the top layer of the soil well. Medium and heavy loamy and compacted soils are cultivated with a cultivator with arrow feet after early harrowing, or instead of it. At the same time, the depth of such cultivation should not exceed the depth of the last autumn cultivation. 5–7 days after early spring tillage, when the weeds have germinated, 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 wet soils, it is cultivated a second time, simultaneously with harrowing.

On light, excessively loose soils, to ensure uniform seed wrapping, the field is rolled before sowing. This increases field similarity by 10%. The quality of soil cultivation is of great importance for obtaining friendly and leveled stairs.

The best quality of soil preparation for sowing is provided by the use of combined units RVK-3,6, LK-4, APG-6, Compactor, Europak, etc. In one pass, they cultivate, destroy weeds, level, crush lumps, compact the soil and create optimal conditions for seed germination. No agrotechnical measure affects the field germination of seeds and stem alignment as much as pre-sowing treatment.

After harvesting the predecessor, in the case of severe weeding by perennial cereals (grasses, etc.), it is recommended to apply herbicides of continuous action to the stubble: Roundup, Uragan, Buran, Glyfos, Glifogan. Plowing for frost is carried out after complete death of weeds, no earlier than 3 weeks after spraying the field.

Fertilization. Flax unevenly absorbs nutrients by phases and periods of growth, and also uses them unevenly. Flax consumes the most nutrients from the soil in the budding phase - 48% of nitrogen, 65% of phosphorus and 59% of potassium from the total amount of nutrients absorbed during the growing season. Therefore, easily soluble fertilizers are best for him. In particular, ammonium nitrate and ammonium sulfate, potassium salt, kalimagnesia, boron superphosphate, etc. are used. Chlorine-free are considered the best potash fertilizers. You can also use complex fertilizers: amphos and RKD (liquid and complex fertilizers).

When applying fertilizers for flax, it is necessary to take into account the effect of each of the main nutrients on the yield and fiber quality. It has been established, for example, that sufficient supply of plants with nitrogen has a positive effect on the yield of long fiber, excessive - causes plants to lie down and increased damage to flax by diseases, which reduces the yield of fiber and worsens its quality. A sufficient level of phosphorus nutrition contributes to the shortening of the growing season of flax with a simultaneous increase in fiber yield. Rational potassium nutrition increases the number of elementary fibers in fibrous bundles, which positively affects the output of long fiber and its quality. Potassium, in addition, increases the resistance of flax against laying.

The rates of applying mineral fertilizers for flax are determined according to the agrochemical soil survey. According to research institutions, in order to obtain a high fiber yield (at least 10 tons/ha) on sod-podzolic soils containing up to 15 mg of P2O5 per 100 g of soil, 90–120 kg/ha of the active substance should be applied to flax phosphorus fertilizers. On cultivated crops containing more than 15 mg of mobile phosphorus per 100 g of soil, such a harvest can be obtained when applying it at 60–90 kg/ha. The rate of potash fertilizers for flax depends on the availability of exchangeable potassium in the soil. On well-supplied soils with potassium (at least 20 mg of K2O per 100 g of soil), 60–90 kg/ha are applied, and on insufficiently well-supplied soils (10–15 mg of K2O per 100 g of soil) – 90–120 kg/ha of the active substance .

When determining the rates of nitrogen fertilizers for flax, the features of the predecessor are taken into account. After cereals with a grain yield of more than 4.0 t/ha, apply 20 kg/ha of the active substance of nitrogen fertilizers (70 kg/ha of ammonium nitrate), with a yield of 2.0–4.0 t/ha – up to 25–30 kg/ha (80–90 kg/ha of ammonium nitrate). Only on poorly cultivated soils with a grain yield of less than 2.0 t/ha, nitrogen fertilizers are applied up to 50 kg/ha (up to 150 kg/ha of ammonium nitrate).

Phosphorous and potash fertilizers should be used in autumn for plowing or deep cultivation, nitrogen fertilizers in spring for pre-sowing cultivation. A part of phosphoric fertilizers (50 kg/ha of superphosphate) is applied to the rows during the sowing of flax.

On soils insufficiently supplied with nitrogen, complete mineral fertilizer is applied in the N:P:K ratio as 1:2:3, and on soils rich in nitrogen

- 1:3:4.

Of the trace elements, flax needs boron the most. Boric superphosphate or boric acid are used. When spreading 200–300 kg/ha of boron superphosphate, long-leaved flax is supplied with boron. Boric acid (0.3–1.5 kg/ha) should be applied together with herbicides. On peat bogs, copper sulfate (25 kg/ha) or pyrite nitrite (250–500 kg/ha) is used.

Turf-podzolic soils for flax must be limed. However, limestone fertilizers, when applied directly under flax, negatively affect the quality of the fiber, so they fertilize the precursor. Depending on the acidity of the soil, the following doses of fertilizers 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-mung composts are not applied directly under flax, because this causes unevenness of the stems, the plants often lie down, and the quality of the fiber deteriorates.

Sowing. Cleaned, sorted flax seeds with purity of 98–99%) and germination of 90–95% are used for sowing. It must be disease-free, free from weeds and other impurities, uniform in size and well-filled, brown in color, shiny, smooth, not musty and not bitter.

To increase germination and germination energy, air-heat heating of seeds is carried out for 4-5 days in the sun. It is poured with a thin layer of 5–10 cm on a stream or on a tarpaulin and shoveled several times a day. Poisoned seeds are not subjected to air-heat heating. The seeds are poisoned with poisoners 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 poison. Often, in order to protect seedlings from linseed mealybugs, the seeds are treated with insecticides: Cruiser 350 FS (0.5 l/t).

Early- and mid-ripening varieties of flax should be given preference for timely harvesting and improvement of the conditions for laying the crop (August). Early-ripening varieties have a growing season of 65–75 days, medium-ripening varieties – 76–85 days, late-ripening varieties – 86–105 days.

Friendly seedlings, leveled stems, high yield, provides such a method of sowing, in which the seeds are more evenly distributed on the area, wrapped to the same depth. For this purpose, flax is sown mainly in narrow rows with a row width of 7.5 cm using SZL-3.6, SZ-3.6A-02, SZ-5.4-02 or pneumatic "Mistral" seed drills. With intensive cultivation technology, permanent technological ruts are left unsown to care for crops, covering the 8th and 17th seeding devices (as in the case of growing grain crops) for applying fertilizers, herbicides, insecticides, and defoliants.

An increase in the width between the rows worsens the uniformity of the standing of the plants on the square, they thicken in the rows. For seed purposes, flax is sown in wide rows (45 cm) or in a strip method (45x7.5x7.5 cm) with a lower seeding rate. Flax seeds are small, have a small supply of nutrients, so they are sown shallowly. On loamy and loamy soils, the optimal seed wrapping depth is 1–1.5 cm, on light sandy soils 1.5–2 cm, but no more than 3 cm. If the seeds lie deeper than 3 cm, sowing is stopped, the field is additionally rolled and then sown. When the seeds are wrapped deeper than 3 cm, the seedlings thin out, an uneven stem is formed. Increasing the sowing depth to 5 cm sharply reduces germination: cotyledons cannot break through to the soil surface and die. It is of great importance that the flax planters are equipped with anchor coulters, which compact the "seed" groove, draw moisture from the lower layers of the soil, ensure uniform deep wrapping of the seeds with loose soil, simultaneous germination of plants and their uniform development.

The morphological structure of flax stalks and the number of normally developed pods on 1 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 fibers in them are thin and elongated, so the fiber is more flexible and strong than when the plants are sparsely planted. Thicker plant stems with lower fiber content and poorer quality are formed in thinned crops. The number of seed pods, on the contrary, is greater on the stems of thinned crops.

The optimal density of plants before harvesting for lodging-resistant varieties is 2000-2200 pcs./m2 (20-22 million/ha), for medium-resistant varieties - 1800-2000 pcs./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) seeds in well-prepared soil. Varieties more resistant to lodging (Mohyliovsky) are sown at 25–27 million/ha, and less resistant (Tomskyi 16, Ukrainian 2) at 23–25 million/ha. On fertile soils, to avoid laying down of flax, the sowing rate is reduced by 10–15%, on heavy loamy soils, on the contrary, it is increased by the same amount.

Flax is a culture of early sowing periods. It is sown in optimally early periods, simultaneously with early spring grain crops, or immediately after the completion of their sowing. A mandatory condition is sowing in well-developed soil, when it is not smeared during cultivation and is warmed at a depth of 10 cm to +5...80C.

When flax is sown at the optimal time, the plants develop a better root system, they quickly descend and outgrow weeds. The growth and development of plants takes place in more favorable conditions with a relatively low air temperature and sufficient soil moisture, they are more resistant to damage by diseases and laying, they mature earlier, which makes it possible to harvest in July - August, and laying of the trust - in August. Flax must be sown within 3-4 days. If the sowing time is late, the yield of fiber and seeds decreases, and the quality of the products decreases.

Crop care. After sowing, the field is rolled. Crop care also includes timely destruction of the soil crust, which can form after rains on loamy soils, protection from weeds, pests, diseases, and sometimes - feeding. The soil crust makes it difficult for flax sprouts to reach the surface, increases water evaporation, worsens the air and nutrient conditions of the soil, which negatively affects the growth and development of plants. It is destroyed with light harrows ZBP-06, net harrows BSN-4 or BS-2, ring-spur rollers ZKKSH-6, scarred rollers, rotary hoes MVN-2.8. The unit must move across or diagonally to the direction of the rows. It is better to harrow when the sprouts are short, no longer than the length of a flax seed. By rolling, the crust is destroyed both before and after the emergence of seedlings.

Flax grows slowly at the beginning of the growing season and reacts very negatively to weeding of crops by reducing the yield and quality of products. 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, lowering soil temperature, and are a source of pests and diseases. First of all, it is necessary to make full use of the possibilities of agrotechnical methods of weed control. These are the observance of crop rotation in crop rotation, semi-steam or improved basic tillage, high-quality spring soil preparation, rational fertilization system, timely and high-quality sowing with conditioned seeds, etc.

On flax crops, against annual grass and dicotyledonous weeds before sowing, during sowing, after sowing, but before the appearance of crop seedlings, soil herbicide Treflan (1.6-2.0 l/ha) is applied (with immediate wrapping). However, long flax crops are often heavily weeded by such weeds as wild radish, field mustard, quinoa, bitter gorse, red flax, spergel, spiriva, blue cornflower, field chamomile, thistles, chicken millet, gray mouse, wheatgrass, etc. To control their quantity in flax crops, use the 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), Dikopur MCPA (0.5-0.75 l/ha), Lontrel (0.1-0.3 kg/ha), Lontrel Grand (0, 04-0.12 kg/ha), Peak (0.015-0.020 kg/ha), Harmony (15-25 g/ha). For more effective weed control, it is recommended to use tank mixture: Harmony, 10 g + 2M-4X, 600 ml/ha. It is not recommended to use PARA Trend 90 on flax crops. The interval between Harmony treatments and graminicides should be 5 days.

To protect flax crops from annual and perennial grass weeds, it is necessary to apply the herbicides Zelek Super (1-1.25 l/ha), Panther (1-2 l/ha), Select 120 (0.4-1.8 l/ha 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 chosen depending on the species composition of weeds. Highly effective are tank mixtures of anti-grass and anti-tuberculosis preparations, for example, Lenok + Pantera.

Great damage to flax crops can be caused by diseases that sharply reduce the yield and quality of flax products. In some cases, crops are significantly thinned out or completely die. The most harmful are: fusarium wilt - plants shrivel, leaves wither and dry, roots rot; fusarium browning - at the beginning of ripening, the entire above-ground part of the plants turns brown, the stem becomes brittle, the pods fall off; rust, orange-rust spots in the form of bumps appear on the leaves and stems; polysporosis - brown and then dark brown spots form on the stems of flax in the affected areas, the stem becomes brittle; bacteriosis - the growth point or the top of the plant dies, young plants die en masse, during the period of budding and flowering, the leaves turn yellow and turn red, twist; strand - yellow-brown spots appear on the cotyledon leaves, later the leaves on the stem turn brown and fall off, the stem is also spotted.

Plants can be protected from disease by agrotechnical measures. This is, first of all, the return of long-growing flax to the same field no earlier than in 6-7 years. The scientifically based ratio of nitrogen, phosphorus and potassium increases the resistance of plants to damage by fusarium, anthracnose, rust, and ascochitosis. Not only a lack of fertilizers can be harmful, but also their excess. For example, one-sided nitrogen nutrition causes recumbency, impression of diseases; an excessive amount of lime contributes to the spread of bacteriosis. It is important to observe optimal sowing dates and sowing norms.

Protection of plants from diseases with the help of fungicides is combined with the treatment of crops against weeds or pests. In the phase of Christmas trees against anthracnose, strands of flax are treated with Fundazol (50% s.p.) at the rate of 1.0 kg/ha. To protect against fusarium wilt, anthracnose, flax is sprayed along the steps and in the "herringbone" phase with a 0.4% suspension of copper chloride (90% by weight) at a rate of 2.2 kg/ha. 300 g of boric acid is added to the tank mixture, and other trace elements, if necessary.

Flax is damaged by many types of pests, but the greatest damage is caused by the flax flea, flax thrips, flax fruit-eater, gamma borer, alfalfa borer

Harvesting. There are 4 phases of maturity in long-leaved flax:

green, early yellow, yellow and full.

In the phase of green maturity, the stems and pods are green, the leaves dry up and turn yellow in the lower third of the plant. The seeds contain a milky liquid. The fiber in this phase is thin, but weak. In the phase of early yellow ripeness, leaves fall off on the lower half of the stem and all leaves, except for the apical one, turn yellow. The seeds in 65–75% of the yellow-green pods are light green with a yellow nose. In other boxes it is light yellow. When harvesting flax in this phase, the fiber has the highest qualities. In the phase of yellow ripeness, the plants and all the leaves turn yellow. In 50% of the boxes, the seeds are yellow, in the rest - light brown. There are boxes with pale green seeds. The quality of the fiber in this phase slightly deteriorates. In the phase of full ripeness, the leaves fall, the pods turn brown, the seeds turn brown, harden, and the fiber is coarse and hard.

Harvesting of flax should begin 2-3 days after the onset of early yellow ripeness, and the main harvest - in the phase of yellow ripeness. If necessary, in the phase of early yellow maturity, crops are desiccated with Reglon Super desiccant (2.0-3.0 l/ha). The harvester method provides a high level of mechanization of harvesting (LKV-4A, LK-4K or foreign-made harvesters) and post-harvest processing of flax products (Fig. 4.2). The flax harvester selects the flax, combs the boxes, spreads the straw on the flax field or ties it into bundles, collects the flax pile in trailers.

Several methods of harvester harvesting of flax have been developed and put into production: with simultaneous binding into sheaves and sale of straw to the primary processing plant; with spreading in ribbons on the flax field, picking up and tying the straw into bundles after drying with PTN-1 and PTP-1 pickers and selling the straw to the flax factory; with spreading in ribbons on the flax field to obtain trest with use for turning over the stalks during sieving OSN-1 and collecting the finished trest with pick-ups PTN-1, PTP-1 with tying into sheaves and selling it to the flax factory.

The research of many scientific and research institutions shows that the production of a trust on a lion's pasture is almost no different from its laying on natural meadows. The laying conditions can be improved by sowing under the flax such perennial grasses as meadow fescue, pasture ryegrass, and others.

During laying, when the upper layer turns gray, the trust tape is turned over with an OSN-1 machine. This improves its physical and mechanical properties and qualities. The trust is raised when it acquires a gray color, the fibrous layer is separated by continuous bands along the entire length of the stem, the wood easily breaks and separates from the fibrous layer. PTN-1 and PTP-1 pick-ups are used to raise the trust.

The most progressive way of selling raw flax is according to the field-plant scheme. When harvesting flax with an LKV-4P combine harvester with simultaneous tying of straw into bundles, it is taken to the flax factory after drying. Developed and implemented industrial methods of preparation of trust. First of all, it is thermal soaking in a liquid heated to +25 0C. The process lasts 3–4 days, and with improved technology (liquid regeneration, use of accelerators), the trust can be ready in 40–60 hours.

After the end of soaking, the liquid is drained, the trust is washed with cold water, unloaded and squeezed with special OPL-2, OPL-2MS machines. During squeezing, the trust is washed first with cold and then with hot water, and after that it enters the conveyor dryer.

The dried trusta is milled on MLKU-6A grinders. The resulting fiber is processed on TL-40A flax spinning machines to obtain long fiber. Waste after beating is processed on special KL-25M machines and short fiber is obtained.

2.4.2 Hemp*(Cannabis sativa)*

Hemp is a spinning crop grown for fiber and seeds. Hemp fiber (yield 18–23%) is long, coarse, but has great strength and does not rot during prolonged exposure to water. Fabrics, tarpaulins, canvas, burlap, fire hoses, ropes, twine, cords, and valuable paper are made from the fiber. Hemp fabrics are antistatic, hygienic, absorb up to 30% of sweat and 95% of ultraviolet rays. Clothes made of such fabric are recommended to be worn daily by people prone to rheumatism, skin allergies, and spine diseases. Coarse, short fiber (tow) is used to rope ships, walls of houses, etc.

From the waste of the primary processing of hemp - firewood, plastic, building thermal insulation boards, furniture boards, plywood, briquettes for fuel, cellulose are made.

Hemp seeds contain 30–35% fat, 18–23% protein, 20% starch, 15% fiber, 4–5% ash. Hemp oil has high taste qualities, it 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 contains antibacterial and antiviral bodies. Thanks to this, new drugs for the treatment of asthma, sclerosis, epilepsy, cosmetic drugs for skin care, etc. have been created. Quick-drying oil is widely used for the production of oil, paints, varnishes, putty, soap, etc. Paints made on hemp oil are very stable. Therefore, they are used when painting iron roofs and other external metal objects.

Vitamins and phytin, which are used in medicine, are also extracted from hemp seeds. Extracts from hemp leaves have pronounced antibacterial properties.

Hemp cake is a valuable concentrated protein feed for animals. It contains 25–30% protein, 8–10% fat, 20% fiber, etc. 1 kg of cake in digestible protein content corresponds to 2.9 kg of oats or 3 kg of barley, 3.1 kg of corn, 15.3 kg of potatoes.

Hemp is suitable for growing on reclaimed land.

Today, technologies for the production of decorative materials for rooms (for wood, marble, other types of stone) from hemp fiber and wicks have been developed. In combination with other components, it is possible to obtain products that are not inferior to natural diamonds and quartzites in terms of strength and can withstand high temperatures and aggressive environments. Hemp raw material is suitable for the manufacture of individual components in automobile and aircraft construction. It is considered the culture of the XXI century.

Hemp is a very ancient culture. The first memories of her are found in Indian literature dating back to the 18th-19th centuries. B.C. It appeared on the territory of Russia in the 9th century, and in the 16th century. Hemp fiber has become an important part of Russian exports to other countries. Hemp is grown in India, China, Italy, France, Hungary, and Poland.

Over the past few years, the cultivated area of hemp in Ukraine has decreased from 60,000 ha to 8–10,000 ha in 2010. It is grown in the Sumy, Chernihiv, Poltava, Volyn, Cherkasy, Dnipropetrovsk, and Mykolaiv regions. The average fiber yield is 0.6–0.7 t/ha. In the best farms, 1.5–1.7 t/ha of fibers are collected.

Biological features, varieties. Temperature requirements. Hemp seeds begin to germinate at a temperature of +1...2^{0}C, but friendly seedlings appear at +8...10^{0}C. Seedlings withstand short-term frosts up to -4...5^{0}C. The optimal temperature for hemp growth is +20...25^{0}C. A decrease in temperature below +15^{0}C, especially in the phase of budding and flowering, delays the growth and development of hemp.

Moisture requirements. Hemp is a moisture-loving plant. Optimum humidity for plant development is 70–80% RH. The maximum need for moisture is observed in the period from budding to the beginning of seed maturation. The transpiration coefficient of hemp is 400–800.

Light requirements. Hemp is a light-loving plant with a short day. With extended days, the growing season is lengthened, so when grown in northern regions, southern varieties of hemp have a high yield of stems, but the seeds, as a rule, do not reach maturity.

Soil requirements. High yields of hemp are harvested on fertile soils with a close to neutral reaction of the soil solution (pH 7.1–7.4). The most suitable for it are chernozems, soils of river valleys and drained peatlands. You can grow hemp on fertilized dark and light gray podsolized soils.

Requirements for power cells. Hemp is very demanding on the content of nutrients in the soil. For the formation of 1 ton of air-dry mass, plants remove 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 in the period from the beginning of budding to flowering, although nitrogen fertilizers have a positive effect on growth and development, starting from the phase of three pairs of leaves.

Phosphorus is absorbed by hemp throughout the growing season, and the critical period is from the emergence of seedlings to the formation of 5-6 pairs of leaves and the formation of seeds. Providing plants with phosphorus at the beginning of cannabis development eliminates the negative effect of excessive doses of nitrogen.

Potassium is intensively consumed by hemp in the first half of the growing season. Its lack at this time delays the growth of stems and the development of generative organs, reduces the yield of fiber.

Monoecious hemp varieties are zoned in Ukraine: Glukhivski 33, Dniprovski odnodomni 6, Dniprovski odnodomni 14, Zolotoniski 15, Zolotoniski odnodomni 11, Synelnikovski.

Conditions of hemp cultivation in Ukraine. Modern breeding varieties of hemp, entered in the Register of Plant Varieties of Ukraine, contain 0.03–0.06% of the narcotic active substance tetrahydrocannabinol (THC), with a permissible content of 0.15% according to the legislation of Ukraine and 0, according to the legislation of the EU countries. 20%. However, the current legislation of Ukraine provides for the following conditions for the cultivation of hemp: the farm has the right to grow hemp only if it has a License issued by the Ministry of Agrarian Policy of Ukraine for a period of 3 years; every year, the farm must receive the approval of the Department for Combating Illegal Drug Trafficking of the Regional Department of the Ministry of Internal Affairs of Ukraine.

Cultivation technology. Predecessors. Hemp is sown after potatoes, sugar beets, and corn, under which high rates of organic fertilizers are applied. Grain legumes are good predecessors. It is not advisable to place hemp after sunflower, because the fields are very clogged with carrion, which makes harvesting difficult and worsens the quality of the products.

Hemp is grown in special or field crop rotations after row and vegetable crops, perennial grasses, and legumes. Crop rotations with a short rotation period (4-5-field) are widespread, which are usually placed on lowland soils and drained peatlands.

Tillage. After harvesting the early predecessors (winter, leguminous), layer-by-layer peeling of the stubble is carried out: the first - with disk tools to a depth of 6–8 cm, the second - with plowshares to a depth of 10–12 cm. In case of strong clogging with annual dicotyledonous weeds, herbicides of the 2,4-D group are used (1.5–2 l/ha) and plowing is carried out two weeks later. In the case of rhizome weeds, immediately after harvesting early crops, double peeling is carried out with disk peelers to the depth of the rhizomes. With sufficient supply of moisture, heather seedlings appear in these fields after 15–20 days. In order to completely destroy them, during this period it is necessary to carry out plowing. When placing hemp after late crops (potatoes, sugar beets), plowing is carried out immediately after harvesting the predecessor. The depth of plowing under hemp is at least 22-25 cm.

In early spring, when the soil is physically ripe, loosening is carried out with trail harrows in a unit with heavy tooth harrows. It is quite efficient to carry out several operations simultaneously. For example, cultivation with simultaneous leveling and rolling of the soil provides a higher yield than pre-sowing cultivation. In areas of sufficient moisture on compacted soils and when manure is applied under plowing, the soil should be plowed with plows with front plows in a unit with ring-spur rollers. After that, harrowing is carried out with cultivator harrows.

Fertilization. Due to the relatively weak development of the root system compared to the above-ground mass, hemp responds well to the application of organic and mineral fertilizers.

Organic fertilizers, in particular manure, are of great importance for increasing productivity. 30–40 t/ha are applied in the middle zone, and 15–20 t/ha in the southern regions. Various composts are also used: peat manure, peat manure in the same proportions as manure. In the experiments of the research institute of bast crops, when 20 t/ha of manure is used, the yield of fiber increases by 100–200 kg/ha, depending on the soil and climatic conditions. The aftereffect of manure is evident on light soils for 3–4 years, and on heavy soils for 6–8 years. On light soils, it is advisable to grow and plow harvest lupine, which is not inferior to manure in terms of efficiency.

The largest crops of high-quality hemp are harvested when organic and mineral fertilizers are applied. At the same time, the doses of mineral fertilizers are reduced by 2 times compared to separate application. Nitrogen fertilizers are the most effective for hemp on all soil types, except cultivated peatlands.

The following rates of application of mineral fertilizers are recommended: on sod-podzolic and gray podzolic sandy soils - N120P90-120K90-120, on gray and dark gray podzolic loamy soils - N90-120P60-

90K60-90, on podzolic chernozems - N60-90P60-90K60- 90 on ordinary chernozems - N45-60P45-60K45-60, on floodplain soils - N60-90P60K60, on cultivated peatlands - P45-60K120-150 kg/ha of active substance.

On peatlands, it is necessary to apply fertilizers containing trace elements: copper (5–6 kg/ha in the form of copper sulfate), boron (1–1.5 kg/ha of boron-magnesium fertilizer), etc.

Hemp absorbs sparingly soluble phosphorus compounds well, so it is advisable to use phosphorite flour on soils with high acidity and poorly leached chernozems. However, granulated superphosphate is considered the best phosphorus fertilizer for all soil conditions.

Manure, composts, phosphorus and potash fertilizers are most effective when applied in the fall under plowing, and nitrogen fertilizers - in the spring for cultivation. High yield increases are ensured by the introduction of granulated superphosphate into the rows during sowing (50 kg/ha with continuous and 30 kg/ha with wide-row sowing methods).

Wide-row crops are fertilized with nitrogen fertilizers when 2–3 pairs of leaves are formed - they are worked into the soil to a depth of 10–12 cm. Fertilization with phosphorus and potassium fertilizers is ineffective. Fertilization with manure (5–7 t/ha) is also useful. Acid soils should be limed.

Hemp plants are sensitive to boron, bromine, zinc and copper. Optimum application rates of copper and boron - 300 g/ha, zinc and bromine - 100 g/ha. Microfertilizers can be applied in several ways: by direct application to the soil, pre-sowing treatment of seeds and foliar feeding of plants.

Sowing. Cleaned, large seeds with purity of at least 96% and germination of 70–90% are used for sowing. The higher the germination, the higher the yield and the better the fiber quality. When sowing seeds with 70% germination, the fiber yield decreases to 25%. Hemp seeds decrease their germination every year, and after 5 years, they lose it completely. Thus, seeds with laboratory germination of 96–98% reduce it to 71–76% in the second year, and to 45–58% in the third, to 20–29% in the fourth, and to 4–6% in the fifth.

Good results are provided by pre-sowing heating and etching of TMTD at the rate of 2–3 kg per 1 ton of seeds.

For the cultivation of hemp for greens (fiber), seeds and fiber, the best method of sowing is narrow-row (7.5 cm) and row (15 cm). The best conditions for the growth and development of the green hemp culture are created by the narrow-row method of sowing (the fiber yield of southern hemp increases by 23% under such conditions due to more uniform placement of plants on the area). Agrisem, Amazone, or domestic SZU-3,6 grain seeders are used for sowing; SZ-3,6. Sowing with a SZL-3.6 flax seeder with anchor coulters provides more uniform wrapping of seeds to the optimal depth, obtaining friendly seedlings, uniform development of plants during the growing season and, as a result, an increase in fiber yield by 150 kg/ha.

Hemp seeds are sown in wide rows with 45 cm between rows in the northern regions and 45–70 cm in the southern regions. They are sown with beet (CCT-12B), vegetable (CO-4,2) or grain seed drills with the appropriate overlap of seeding devices.

Hemp is an early sowing crop. They are sown immediately after sowing early spring crops, when the soil at the depth of seed wrapping warms up to +5...8 0C. Early crops are more resistant to hemp fleas, suppress weeds better, mature 10-15 days faster, and are more productive. In addition, harvesting and soaking can be carried out under better climatic conditions.

The optimal rate of sowing by narrow-row method for green grass is 4–5 million pieces/ha or 70–90 kg/ha of monoecious and 90–110 kg/ha of dioecious. When growing for fiber and seeds, it is recommended to sow 2.5–3 million pieces/ha in a narrow row and row method. Such crops are almost as good as wide-row crops in terms of seed yield, but provide a higher yield of fiber of better quality.

Elite seed crops are sown in a wide row (45–70 cm) method (0.6–0.9 million pieces/ha (10–15 kg/ha). Seeds of reproduction are sown more –

1.2–1.8, and the II reproduction is even more - 1.8–2.4 million pieces/ha.

The depth of seed wrapping on heavy soils with sufficient moisture is 2–3, and on lighter ones - 3–4 cm. In the southern regions, seeds are wrapped by 4–5 cm.

Crop care. Soil crust on hemp crops is destroyed by pre-emergence harrowing with light or medium harrows, rotary hoes. It is held on the 4th day after sowing. To protect against weeds on wide-row crops, mechanized inter-row loosening is carried out. The depth of the first loosening is 5–6 cm, the second – 7–8, the third – 5 cm. Deep loosening (12–14 cm) dries out the soil and damages the root system of plants. The most effective loosening is in the phase of the first pair of true leaves. In the seed plots, protection against weeds must be started after the emergence of seedlings, in the phase of the first pair of true leaves, and finished before the rows are closed, i.e. after the formation of 5 pairs of leaves.

To protect crops from annual cereal and dicotyledonous weeds, before sowing with cultivation in the soil by pre-sowing cultivation, or 3–4 days after sowing with cultivation in the soil by pre-emergence harrowing, herbicides Dual Gold (1.6–2.0 l/ha) are applied or Lenatsil (1.2–1.5 kg/ha), or their tank mixture (Dual Gold 1.3 l/ha + Lenatsil 1kg/ha).

In the post-emergence period, herbicides Achiba 50 EC (1.5 l/ha), Pantera (1.0–1.8 l/ha), Miura (0.8–1.2 l/ha) are applied against annual grass weeds , Targa Super (1.5–3.0 l/ha), Poast (1.5 l/ha), Nabu (1.5 l/ha). Spraying of hemp crops is carried out in the phase of 2-4 leaves of weeds.

To destroy pests during the growing season, insecticides are used: Sumithion (1.0–1.5 l/ha) – against hemp fleas, corn moth: Zolon (3.0 l/ha) – against leafhopper, corn moth.

On the seed plots, during the first and second loosening, the inter-row crops are fed with complete mineral fertilizer ($N_{20}P_{20}K_{20}$).

Harvesting. The largest yield of fiber of the highest quality can be obtained by harvesting during the flowering period of plantain. In the case of two-sided use, first choose a flat surface, and after 35-40 days - a matrix. The plane is collected by hand at the end of flowering, and the matrix - during the ripening period in the middle part of the inflorescence. On the seed plots, the matrix is collected separately during the period when the seeds reach 70% or by direct harvesting when the seeds reach 75%. The best method of harvesting is direct harvesting with the KKP-1.8 harvester. With separate harvesting, the seeds are milked 3–5 days after mowing. After threshing, the straw is sorted and taken to hemp farms, and the seeds are dried to standard humidity (11–12%).

Hemp can be sold in the form of straw. To obtain trust, they are soaked in ponds, lakes, rivers, and in special reservoirs. During summer soaking in water with a temperature of +18...20 0C, 7–8 days are necessary, during autumn - in colder water (+10...12 0C), the duration of soaking increases to 15–18 days. If the water temperature drops to +6...7 0C, bacteria do not develop, pectin substances are not destroyed and the urination process stops.

As a result of soaking, the fibrous bundles should be easily detached from the core. The trust is dried, the wick is partially separated on the MLKU-6 hemp planter; the long fiber is separated from the trust on the PTM-1 heating machine; a short fiber suitable for spinning is obtained on a tow-making machine from waste carding. The quality of long felted fiber is determined by its number (from 4 to 10).

2.4.3 Cotton*(Gossypium hirsutum)*

Cotton is the main spinning crop in world agriculture. Cotton fiber is the most important type of plant raw material for the textile industry. This is due to the high technological qualities of cotton fiber. It is thin, light, but strong enough to tear and bend, is easily dyed, has high hygienic and good thermal insulation properties. From the fibers of long-staple varieties of cotton, chintz, satin, batiste, knitwear, flannel, paper and many other fabrics are made. Shorter fiber is used for the production of decorative fabrics, linen, blankets, towels and other products. Valuable semi-wool fabrics are made from a mixture of cotton fiber and wool. Cotton wool, artificial felt, cellulose, valuable paper, cellophane, artificial silk, film, plastic, lacquers for covering metal parts of machines, artificial leather and many other products are made from the lint. From 1 ton of raw cotton, 300–320 kg of fiber and 600–650 kg of seeds are obtained. From this amount of fiber, you can get 3.5–4 thousand m2 of fabric.

Cotton seeds, which make up about 65% of the mass of raw cotton, contain 20–30% semi-drying oil (iodine number 102) (35–40% in the kernel). The oil is used for food, for the production of soap, glycerin, stearin, oil, etc. Cotton seed cake is a good concentrated feed for animals, which contains up to 40% protein. However, it should be fed in small quantities, because it contains the poisonous substance gossypol. The cake should not be used for fattening pigs.

Ethyl and methyl alcohol, glucose, furfural, lignin, resins, feed proteins are produced from seed husks. Cotton stalks and box leaves are used to make acetic acid, paper, as fuel. Citric and malic acids, various resins are obtained from the leaves and bark of the stems.

As a row crop, cotton is of great agrotechnical importance.

Cotton is an ancient crop and is the only crop that was grown before the discovery of America in both the Old and New World areas. But the cultivated species of cotton originating from America differ significantly from the cultivated species common in Asia: the somatic cells of the American species have 52 chromosomes, while the Asian ones have 26. They also differ in fiber length: in the former, it reaches 30–50 mm and more, and in others - about 20 mm.

Cotton has been grown in Ukraine since 1929. However, in 1954, they stopped sowing cotton because of the low yield and fiber quality. It was economically more profitable to import raw materials from the republics of Transcaucasia and Central Asia. However, in recent years, cotton cultivation has been resumed in Ukraine (in the Kherson region). It is planned to expand the area of its crops to 3 thousand hectares by 2015.

Cotton is the main spinning crop of the world. The world area of its crops is about 35 million hectares, and the gross collection of raw cotton is 42–45 million tons. Cotton is grown in more than 60 countries of the world. The largest cultivated 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 average world yield of raw cotton is about 1.5 t/ha.

Biological features, varieties.*Temperature requirements.* All cultivated types of cotton are very demanding of heat. The minimum temperature for seed germination is +10...12^{0}C, the optimal temperature is +25...30^{0}C. The sum of active temperatures during the growing season is 2800–3600^{0}C. Plants are suppressed at temperatures below +20^{0}C. Cotton does not withstand frost below -2^{0}C both at the beginning of the growing season and in autumn.

Moisture requirements. In relation to moisture, cotton is a relatively drought-resistant plant. The deeply penetrating root system helps it use moisture from the subsoil layers. The transpiration coefficient varies from 400 to 800. However, high yields are obtained only if the plants are sufficiently supplied with moisture, which is achieved by irrigation. With insufficient soil moisture, the boxes fall off. Cotton is the most demanding of moisture during flowering and fruiting. The quality of the fiber depends on the air humidity. A thinner and longer fiber is obtained at high humidity. The total need for water for the formation of a high yield is 5–8 thousand m3/ha.

Light requirements. Cotton is a light-loving crop with a short day. Insufficient lighting inhibits plant development and increases vegetative mass. With insufficient lighting, lack of moisture and nutrients, buds and ovaries drop. This is most often observed on weedy, insufficiently fertilized, untimely irrigated and poorly cultivated areas.

Soil requirements. Gray soil and meadow-swamp soils are best for cotton. Soils with a high level of groundwater and high acidity (pH 7–8) are not suitable for it. Cotton has high requirements for nutrients. A favorable ratio of nitrogen, phosphorus and potassium shortens the growing season of plants by 5-10 days and increases their resistance to diseases. For every 1 ton of raw material, the cotton plant takes 46 kg of nitrogen, 16 kg of phosphorus and 18 kg of potassium from the soil.

The duration of the cotton growing season, depending on the variety, is 130–150 days. The growing season consists of the following phases: seedling, budding, flowering, ripening.

Dniprovskyi 5 cotton variety is recommended for cultivation in Ukraine.

Cultivation technology. *Predecessors*. Alfalfa is the best precursor for cotton. According to the data of state-owned varieties, the yield in the first 2–3 years increases by 50–60% or more compared to the yield of cotton grown in permanent crops.

The value of alfalfa as a precursor to cotton lies in the fact that it removes a lot of salts from the soil, enriches the soil with nitrogen, reduces the level of groundwater, which prevents repeated salinization, improves its physical properties, activates the activity of soil microorganisms. Corn is also a good precursor to cotton. , sorghum, annual legumes. Monoculture cultivation of cotton leads to a decrease in yield by 30–50%.

Tillage. If cotton is sown after alfalfa, fennel plowing is carried out to a depth of 27-30 cm in late October - early November, and after cotton - as the fields are cleared, to the same depth. Winter and spring plowing is less effective.

In 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 at 18–20 cm and harrowed in 2–4 furrows. After harrowing, the soil surface is leveled.

Fertilization. Cotton is very demanding of nutrients, so when it is grown in one field for several years in a row, complete mineral fertilizer is applied at the rate of nitrogen 140–160 kg/ha, phosphorus 80–100 kg/ha, potassium 30–50 kg/ha of the active substance. When sowing cotton after alfalfa in the first two years, the rate of nitrogen application is reduced to 50–70 kg/ha. It is better to apply organic fertilizers under the predecessor. Effective post-harvest sowing of sideral crops on green manure.

It is advisable to use nitrogen fertilizers in small amounts: 25% of the estimated rate before sowing, 75% - in top dressing. At the same time as nitrogen fertilizers, a part of phosphoric and potassium fertilizers is added to the top dressing. Fertilization is carried out during the period of budding.

The pre-sowing application of granulated superphosphate or nitrophoska at the rate of 100 kg/ha gives significant increases in yield. They are introduced at a distance of 5–8 cm from the row to a depth of 12–15 cm.

Cotton is sown in a dotted pattern with a row width of 60–90 cm, when the soil at a depth of 10 cm warms up to a temperature of +12...150C. The seed sowing rate is 80–90 kg/ha, the wrapping depth is 4–5 cm.

Crop care. The first measure of care for crops is to destroy the soil crust before the emergence of seedlings with rotary hoes. The density of the plant stand is formed during the period of formation of two true leaves, leaving 7–9 plants per 1 linear meter of the row, or 80–100 thousand plants per 1 ha. Inter-row tillage is carried out as the soil compacts and weeds appear, as well as after each watering, as soon as the soil is sufficiently dry.

During the growing season, it is recommended to maintain soil moisture at the level of 65–80% of full moisture content at all times. Depending on the characteristics of 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 way of irrigating cotton is sprinkling, which reduces water consumption per unit of crop by half, compared to furrow irrigation.

An important agromeasure for increasing the yield of cotton is cutting the tops of plants (chipping) when 14–16 fruit branches are formed.

Picking cotton is a long and time-consuming process. This is due to the fact that the ripening of the pods takes 2-3 months. It should be borne in mind that the most valuable raw cotton is formed in boxes that have ripened and opened before the onset of frost. It is from these boxes that the highest yield of high-quality fiber and seeds is obtained. Cotton is harvested in several periods as the bolls reach maturity. 2–3 pickings of raw cotton are carried out before the onset of frost and 1–2 after the onset of frost (Fig. 4.3).

Defoliation (drying of leaves) is carried out on cotton crops to quickly reach and open the bolls, improve the working conditions of harvesting machines, increase their productivity and shorten the harvesting period. The best time for defoliation is the opening of 4–5 pods on a plant of thin-fiber varieties and 3–4 pods on plants of medium-fiber varieties. Basta (2–3 l/ha) and Reglon Super (2 l/ha) are used for defoliation. As a rule, cotton is harvested in rows, the first time - 8–10 days after defoliation, when 55–60% of the bolls are opened. The next harvest is carried out 12–15 days after the first, when 25–35% of the boxes are opened.

APPROXIMATE LIST OF TEST TASKS

Question 1. Match the named bread groups and their representatives

Real bread	A. Rye
Sourdough bread	B. Barley
	C. Rice
	D. Millet
	E. Sorghum
	F. Wheat
	G. Oat

Question 2. Match the named crops and types of fruits

A. Small box	Buckwheat
	Millet
B. Peanut	Rapeseed
	Sunflower
C. Bean	Safflower
D. Pod	Peanuts
E. Seeding	Poppy
I. Grain	Flax
	Soy
	). Triticale
	. Sugar beets

Question 3. Match the given crops with the amount of moisture needed for seed germination

1. Oat	A. 25-30 %
2. Millet, sorghum	B. 100-110 %
3. Sugar beets	C. 160-170 %
4. Peas, soy	D. 55-60 %

Question 4. From the given list, choose the correct statements that characterize the flowering and pollination of the named cultures:

A. Buckwheat B. Oat C. Corn D. Wheat	The height of anthers and pistil receptacles are differentin flower Pollination of your plant with pollen. Pollination with pollen from the flowers of another plant. Different timing of male and female maturation generative organs. Male inflorescences ripen earlier Pollination of the same unopened flower with pollen. Female inflorescences ripen earlier

Question 5. Which of the following cultures belong to typical cross-pollinated cultures?

1. Barley, 2. Corn, 3. Hemp, 4. Rice, 5. Beans, 6. Sunflower, 7. Flax, 8. Buckwheat.

Question 6. Which of the following cultures are anemophilic based on their adaptation to pollen transfer?

1. Asparagus, 2. Corn, 3. Alfalfa, 4. Sorghum, 5. Beans, 6. Sunflower, 7. Vet, 8. Buckwheat, 9. Rye.

Question 7. Choose the correct ones and place the phases of growth and development of cereal crops as they pass

1	Bushing
2	Output to the tube
3	Flowering
4	Spiking
5	Seedling
6	Maturing
7	Yellow ripeness
8	«Tree»

Question 8. Sowing suitability of seeds (SS) is calculated according to the formula……

(in the answer sheet, enter the correct answer using the formula)

Question 9. From the given list, choose the statements characterizing the achievements of the presented scientists.

	A. The author of the classic textbook "Vegetation", the law of homologous series and

1. I.I. Tumanov 2. M.I. Vavilov 3. F.M. Cooperman	hereditary variability; teaching about the world centers of origin of cultivated plants, about the immunity of plants to diseases and pests; collected the world's richest collection (over 350,000) of cultivated plant samples from 68 countries.
	B. The author of the twelve stages of organogenesis of the life cycle of plants, which occur in a certain sequence, which makes it possible 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. The author of the theory of hardening of winter cereals, a researcher of the physiology of plant adaptation to the transfer of low temperatures.

Question 10. Match the crops and the width of the rows when sowing them:

1. 15 cm 2. 45 cm 3. 70 cm 4. 7,5 cm	A. Peas
	B. Rapeseed
	C. Sugar beets
	D. Corn for green fodder
	E. Corn for grain and silage
	F. Sunflower
	G. Flax-long
	H. Buckwheat

	I. Potatoes

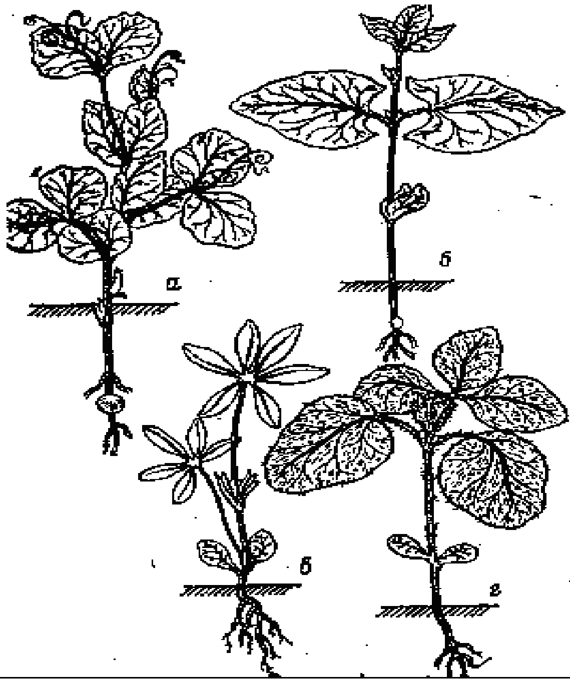
Question 11. Match the recommended stand density of sunflower for the harvest period and the given growing regions

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 sowing rate and crops:

1. 3,5-4,5 million seedlings of seeds / ha	A. Peas
2. 22-23 million seedlings of seeds / ha	B. Wheat
3. 0,9-1,5 million seedlings of seeds / ha	C. Corn for grain
4. 50-60 thousand /ha	D. Sunflower
	E. Flax-long
	F. Buckwheat
	G. Potatoes

Question 13. Indicate with which letters the given cultures are marked in the picture

1 - Soy 2 – Pea 3 – Bean 4 -Lupine	

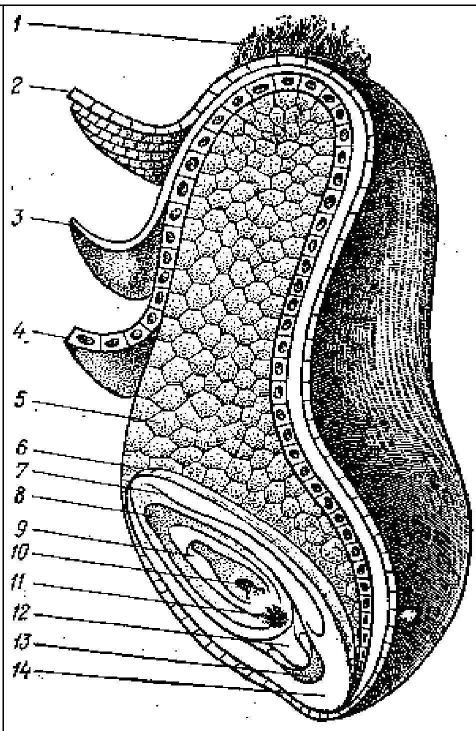
Question 14. Calculate the actual sowing rate, if the recommended sowing rate of winter wheat in the Forest Steppe is 5 million/ha of similar seeds, the weight of 1000 seeds is 45 g. Seed suitability for sowing is 96%.

(in the answer sheet, enter the correct answer with one number)

Question 15. A scientifically based rotation of agricultural crops and a pair in time and on the territory is called

(in the answer sheet, enter the correct answer with one number)

Question 16. Indicate with which numbers the eaten parts of a grain of wheat are marked in the figure

A- rudimentary leaves; B-growth point (growth cone); C- embryonic stem; D - crest; E- fruit shell; F- seed coat; G- aleurone layer; H- endosperm itself; I -coleoptile; J -germinal root; K-root cover.	

Question 17. …. - resistance of plants against a complex of adverse overwintering conditions.

(in the answer sheet, enter the correct answer with one word)

Question 18. Indicate the presence of which organic substance are potato tubers valued for?

1	Protein;
2	Fat;
3	Starch;
4	Sucrose;
5	Клітковини.

Question 19. Indicate which bread culture of group 2 has two types of inflorescences?

1	Millet
2	Sorghum
3	Rice
4	Corn

TERMS AND DEFINITIONS IN CROP PRODUCTION

Agrotechnical method of combating harmful organisms – scientifically based alternation of crops in crop rotation during rotation, the use of healthy seed material, autumn tillage, optimal sowing time, seeding rates, stem density, seeding depth, seeding depth, timing and methods of harvesting.

Agrophytocenosis is an artificial plant grouping created on the basis of agrotechnical measures and constantly supported by man (crops and planting of grain, vegetable, fruit and industrial crops), which has poor dynamic qualities, including weak ecological plasticity, but is characterized by high yields (productivity) of one or more species, plant varieties.

Aeration of the soil is the gas exchange of soil air with the atmosphere, as a result of which the soil air is enriched with oxygen, and the active layer of the atmosphere with carbon dioxide.

Nitrogen fixation is the process of binding molecular nitrogen of air and converting it into organic nitrogenous 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 release of various substances called knees by the previous one.

The bioclimatic potential of productivity is the maximum amount of products that can be obtained per hectare of sowing with the available thermal and water resources of a particular crop growing zone.

Biological yield – the amount of grown main and by-products, which is determined by the method of trial sheaves (before harvesting from the sown area), or calculated – by the balance method (after harvesting.

Biological control – monitoring of morphophysiological and physiological state of plants and phytosanitary situation in crops during the growing season in order to timely adjust the conditions air (carbon) and mineral nutrition of plants, the use of crop protection products to achieve optimal realization of the potential of crop productivity (variety).

The biological method of weed control is the suppression and destruction of weeds with the help of specialized insects, fungi and bacteria.

The biological method of plant protection is the use of living organisms or their waste products in order to reduce the number and harmfulness of harmful organisms and create favourable conditions for the activity of beneficial species in agrocenoses.

Weeds are wild plants that inhabit agricultural land and inhibit the growth and development of a cultivated plant.

Soil buffering is the property of the soil to resist changes in the physical condition and reaction of the soil environment.

Gross yield – conditional total mass of economically useful plant products, collected from the entire area of sowing.

The growing season is part of the period of plant ontogenesis, during which vegetative organs are formed.

The vegetation cycle is a period in plant ontogenesis, during which, under agrometeorological conditions, vital activity and reproduction of one generation of offspring are carried out.

Vegetation is a set of processes of active vital activity of plants with inherent signs of growth and development according to biological properties during the growing season.

Freezing of plants is an unfavourable agrometeorological phenomenon during the winter dormancy period of wintering plants, which is determined by their internal damage or death at temperatures lower than the critical tillering node at the depth.

Soaking is an unfavourable agrometeorological phenomenon of the death of winter crops and perennial grasses from long-term stay under a layer of rain and melt surface water.

Production experiment on technology is a field experiment performed in production conditions in order to check scientific recommendations and assess the effect of technology elements on the crop and its quality.

The loss of winter crops is a phenomenon observed with a sharp and active increase in heat during the recovery of the growing season and at the same time with a lack of moisture in the upper soil layer. At the same time, the secondary root system does not have time to use moisture from the deeper layers of the soil and the plants die. This phenomenon is more common in late spring.

Bulging of plants is the process of displacing tillering nodes of winter crops to the surface of the soil, which is accompanied by rupture of the roots.

Plant ripening is one of the types of plant death at adverse temperatures during the winter dormancy of wintering, mostly overgrown plants, due to intensive breathing under a significant layer of snow and significant costs of nutrient reserves.

Restoration of vegetation – self-restoration of active vital activity of plants under the influence of changes in agrometeorological conditions.

Water consumption is a set of processes of water use by plants in crops of field crops to ensure physiological functions during the growing season.

Total water consumption – the amount of water spent on transpiration and physical evaporation by the soil during the growing season of plants.

Humidity of persistent wilting is the amount of soil moisture at which irreversible signs of wilting of plants begin to appear.

The tillering node is a morphological feature of the development phase, the site of the main maternal shoot, from which the lateral shoots are separated.

Hybridization is the process of obtaining hybrids, which is based on the unification of the genetic material of different cells in one cell.

Herbicides are chemicals to destroy unwanted vegetation.

Heterosis is a phenomenon when the first generation of hybrids obtained as a result of unrelated crossing has increased viability, productivity, growth, resistance to pests, diseases, etc.

Hydrothermal coefficient (GTC) G.T. Selyaninov is an agrometeorological indicator of atmospheric humidification and is determined by the ratio of precipitation for the period with an average daily air temperature above 100C to the sum of average temperatures for the same period, reduced by 10 times.

The depth of seeding is the distance between the field surface and the location of field seeds in the soil.

The 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 strong layer, which gradually passes into the lower loose layers. The thickness of the crust can be from 1-2 mm to 50-80 mm. It complicates the emergence of shoots and respiration of plants.

Soil – climatic potential of productivity – the maximum amount of products that can be obtained per hectare of sowing due to the integrating action of thermal and water resources and the potential fertility of the soil of a particular crop growing zone.

The density of standing plants is the number of plants per $1m^2$ of sowing.

The two-phase method of harvesting is harvesting with the allocation of the main product in two stages.

Determinant varieties – the advantages of this form are increased fertility of flowers, their higher leaf and root supply, a rapid rate of initial fruit formation, separate passage of phases of linear growth of the shoot and fruit filling, increased heat resistance and resistance to lodging.

The ecological feasibility of the technology – the use of agrotechnical measures and chemicalization means, as elements of technology, does not adversely affect the environment.

The economic threshold of harmfulness (harmfulness) is the number of pests or damage to plants, at which crop losses can be > 3-5%, and the use of chemical protection measures increases the profitability of crop production and reduces the cost of harvest.

The economic threshold for weed harm is the number of weeds per $1m^2$ of tilled crops or the ratio as a percentage of the number of cultivated plants and weeds in the sowing of continuous sowing crops.

The elements of technology are interrelated agrotechnical, land reclamation, organizational measures that make up the technologies of cultivation, namely the systems of crop rotation, tillage, fertilization, chemical and biological protection of plants in the agrophytocenosis of sowing and, in general, the system of agriculture.

Epiphytotics is a massive plant disease caused by phytopathogen activity.

Desiccation of crops is a pre-harvest chemical drying of plants on stumps, 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-stimulating substances (pesticides, plant growth regulators, trace elements), which ensures accurate sowing on the final density of plants and protection against harmful organisms.

Effective temperature – agrometeorological indicator, positive temperature of air or soil, reduced by the value of the biological minimum in a certain period of plant development.

Weediness is potential – a possible level of weediness of crops due to the content of viable seeds in the upper soil layer.

Winter drought is the cessation of water supply to the above-ground part of the plant in the absence of snow cover in the fields and the air temperature rises during the day to 0 ° C and above or with intense solar radiation, when there is an increased evaporation of moisture by the leaves and their drying. Due to dehydration of the leaves, the above-ground organs dry out, then the tillering nodes, and the plants die. Winter drought is often accompanied by bulging and blowing of plants.

Winter hardiness of plants is the ability of wintering plants in a state of suspended animation to withstand adverse agrometeorological phenomena of the winter period without significant damage (low temperatures, ice crust, bulging, bulging, soaking, frosts alternating with thaws).

The usual row method of sowing is row sowing with row spacing from 10 to 25 cm.

Liquefaction of sowing – deviation of the sowing density from its optimal value in the direction of reducing the number of plants in the area.

The leaf surface 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 a coating of seeds with an aqueous suspension containing protective-stimulating substances (pesticides, plant growth regulators, trace elements), a film-forming agent and a dye.

An integrated protection system is a complex technological process that is carried out by consistently carrying out a set of measures using chemical and biological methods of pest control, chemical and some special measures to protect plants from diseases and chemical methods of weed control.

The coefficient of water consumption 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 growing season of the crop to its yield.

The efficiency of FAR is a conditional indicator of the ratio of the amount of energy in the phytomass of plants during the growing season to the amount of photosynthetically active radiation received during the same period.

Feed unit – a unit for assessing the nutritional value of feed. For one feed unit taken caloric content of 1 kg of grain of oats.

Rolling is a surface measure of tillage with rollers to compact the top layer, grind blocks and partially level the field surface in order to improve the capillarity of the soil and the contact of seeds with it, create conditions for shallow and uniform seeding, reduce diffuse evaporation, destruction of the soil crust.

The critical period is part of the vegetation cycle of plants, in which the values of agrometeorological factors differ significantly from optimum and are close to the limit of tolerance.

Cultivation is a measure of surface or shallow tillage in order to loosen, partially move, level the top layer of soil, wrap fertilizers and destroy vegetative weeds.

Sowing culture is a field crop that is sown under the cover of another crop, and then grown as the main one.

Steam sowing culture is a crop harvested for green mass or hay until the first half of summer.

Cover culture is a field crop, under the cover of which a sowing crop is grown.

The intermediate post-harvest crop is an intermediate crop that is grown this year after harvesting the main grain products.

Intermediate post-harvest crop is an intermediate crop that is grown this year after harvesting the main crops for green fodder, silage or hay.

Tilled culture is a field crop sown by dotted or tape methods with a width of row spacing or inter-strip distances, which make it possible to cultivate the soil for inter-row care of crops.

The culture of continuous sowing is a field crop sown in a spreading or row way with a row spacing of 7.5 to 25 cm.

Ice crust (ground) is a layer of ice that is formed due to the alternation of thaws and frosts and fits snugly to the soil surface. The death of plants from suffocation occurs during a long stay under the ground ice crust (for 30-40 days or more) due to a violation of gas exchange – an increase in the concentration of carbon dioxide, lack of oxygen. Damage to plants from the ice crust also occurs due to direct mechanical action – rupture of roots, tillering nodes.

Frost resistance of plants is a sign of biological adaptation, genetically determined property of wintering plants to withstand the effects of negative temperatures while maintaining the ability to grow reproduction.

Mulching – coating the soil surface with various materials to reduce moisture evaporation, regulate the temperature regime, prevent the destruction of the structure, weed control.

Seeding rate – the number or mass of seeds sown per hectare, taking into account their economic suitability.

Tillage is a mechanical effect on the soil by the working bodies of machines and tools in order to create the best conditions for growing plants.

A single-phase method of harvesting is harvesting with the allocation of the main product in one stage.

Ontogenesis of plants is the process of individual development of a plant organism according to the hereditary code from the moment of its inception to natural death.

Carrion is a plant that grows in the field from seeds lost during ripening and harvesting of the previous crop.

Cross-sowing method – row sowing in two cross directions.

Field experiment on technology is an experiment carried out in the field in order to determine the effect of technology elements on crop yields, its quality, as well as on soil fertility.

The predecessor is a field crop or pure steam that occupied the field before sowing the next crop.

Sowing is a field planted with seeds of agricultural crops.

Potential yield – the maximum amount of products that can be obtained per hectare of sowing with the full realization of the genetic potential of crop productivity, varieties in specific soil and climatic conditions.

Crop programming is a purposeful formation of conditions for the development of crops in order to obtain the planned harvest.

The productivity of photosynthesis is the intensity of biomass accumulation by plant cenosis per unit area for a certain period.

Weed resistance is a trait acquired during the selection process and characterizes the resistance of certain types of weeds to certain herbicides when they are systematically applied.

Retardants are synthetic substances of various chemical nature that inhibit the growth of stems and give plants resistance to lodging.

Plant growth is an irreversible increase in the size and mass of plants during their development in the growing season.

Plant development is the process of forming habitus, organs and descendants from the birth of a plant to the cessation of its individual existence.

A spreading method of sowing is sowing seeds without rows.

Crop production is a complex of interrelated agrotechnical, land reclamation and organizational measures aimed at the effective use of land, preservation and increase of soil fertility, obtaining high and sustainable yields of crops.

Rotation of crop rotation is the interval of time during which crops and steam pass through each field in the sequence, which is provided for by the scheme of alternation of crop rotation.

Siderat is a predominantly high-protein green mass grown on the field, which is ploughed into the soil to enrich it with organic matter and nitrogen.

Symbiosis is a form of long-term cohabitation of organisms of different species, in which both organisms (symbiotes) benefit from cohabitation.

The system of crop protection is a complex of interrelated agrotechnical, chemical and biological measures, methods aimed at protecting agricultural plants in the agrophytocenosis of sowing from harmful organisms (weeds, diseases, pests) and lodging.

The fertilizer system is a set of scientifically based measures for the use of local, organic, mineral fertilizers and siderats for crop rotation in order to increase soil fertility and crop productivity.

Senitation is a chemical and biological treatment of grain crops for drying stems in order to accelerate ripening and improve the quality of grain. The physiological essence of senication is the effect on plants of ammonium ions that are in the fertilizer, which accelerate the processes of aging and ripening. This action is manifested in the weakening of the synthesis process and the strengthening of the hydrolysis of high-molecular compounds into simple and mobile ones, which contributes to their energetic and fuller outflow into the grain.

Sowing is a technological process in which seeds are sown on an area and wrapped in soil to a certain depth.

Crop rotation is a scientifically based alternation of crops and vapours in time and in the territory, or only in time.

Seed scarification is an artificial surface damage to the seed coat for better absorption of moisture necessary for swelling and germination. Scarify the seeds of clover, alfalfa, clover, etc. plants in which the seed has in the shell a palisade layer of cells that is difficult to penetrate to water and therefore slowly germinates.

Plant variety – a set of plants that are created as a result of breeding and have certain (defined) morphological, physiological, economic characteristics and properties that stably retain their characteristic features in a number of subsequent generations.

Varietal technology is a complex of agrotechnical methods of cultivation with the obligatory consideration of the biological characteristics of not only the crop, but also the variety.

Soil ripeness is the physical condition of the soil surface, which characterizes its readiness for mechanical cultivation.

Stratification is one of the methods of preparing seeds for sowing, in which seeds are placed in a humid, cold environment for a certain time.

The ribbon method of sowing is a string method in which two or more lines that form a ribbon alternate with wider aisles.

Sowing dates are calendar dates of sowing, taking into account the biology of culture and soil and climatic conditions of the growing zone.

The structure of acreage is the ratio of the areas of crops of different field crops and pure vapours, expressed as a percentage of the total area of 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 transition through 100C 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 in interphase periods or during the growing season. It is determined by the sum of the daily differences between the average daily air temperature and the biological minimum temperature.

Alternative technology – a set of agrotechnical measures of production, technical means and operations of growing crops, based on the maximum possible use of bioclimatic and soil – climatic potentials and local resources as fertilizers, ameliorants, and do not allow the use of any agrochemicals – mineral fertilizers, pesticides.

Basic technology – a system of agrotechnical measures that are developed and recommended for a specific zone in order to obtain sustainable yields, taking into account their economic and environmental feasibility.

The technology of growing crops is a system of organizational, economic, agrochemical and agrotechnical measures based on knowledge of the laws of crop formation in the relationship with agrometeorological and soil-climatic conditions in order to manage the processes of formation of elements of plant productivity in sowing and obtaining high sustainable yields of agricultural crops and reducing the gap between potential and real productivity of plants.

Zonal technology is a basic varietal technology, taking into account the bioclimatic potential of the growing zone, the biological characteristics of the variety, the level of soil fertility, the predecessor.

The technology is intensive – a dynamic system of agrotechnical measures, the basis of which is biological control over the formation of potential, biological yields of individual plants and agrophytocenosis in general, the introduction of high-yielding varieties, the development of a new fertilizer system that ensures high efficiency of fertilizer nutrients based on reliable information about the reserves of nutrients in the soil and conditions plant nutrition, an effective differentiated system of plant protection from weeds, pests, diseases, lodging, aimed at maximizing the realization of the genetic potential of a plant variety in an economic crop.

Resource-saving technology is a zonal technology that is to some extent adjusted by the technical and energy capabilities of production and manufacturer.

Transpiration is the physiological process of evaporation of vaporous moisture by plants into the atmosphere during their life.

Biological harvest – crop production, which is on the field for the period of onset of timely harvesting time.

Yield is a conditional indicator of the mass of products of the economic useful body of a grown plant species per unit area.

The chemical method of plant protection is the use of pesticides of chemical synthesis, which can cause the death of various types of harmful organisms or disrupt their development.

A wide-row sowing method is row sowing with a row spacing of at least 45 cm.

The density of the stem is the number of stems per $1m^2$ of sowing.

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