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Growing Technologies of Perennial Legumes

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The monograph presents the results of research, analyzes and solves a new scientific problem to substantiate the biological and organic bases of perennial legumes, developed new technological measures for the Forest-Steppe and Steppe of Ukraine based on the existing patterns of climatic and meteorological factors. Regularities of conditions of growth, development and formation of productivity of alfalfa, clover and sainfoin are established, theoretical and practical bases of modern technologies of cultivation of perennial legumes are developed.

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INTRODUCTION

National scientists point out to the urgency of the problems of the nitrogen cycle in agroecosystems as the most important factor in the formation of organic plant mass. Currently, due to low culture of agriculture conduction, 4 million tons of nitrogen are lost from the cycle every year. This is 139 kg/ha of arable land in cultivation, or 12 million tons of ammonium nitrate, or in the amount of money it is 11 billion UAH. Energy-intensive production of mineral nitrogen fertilizers does not allow to use them in the quantities, which are required to obtain high and sustainable yields. It should be mentioned that artificial fertilizers cause increased nitrogen migration, groundwater pollution, soil degradation. It is known that the source of mineral and biological nitrogen is atmospheric nitrogen. Therefore, biological nitrogen can be used in agriculture only through the stabilization of land use, sown areas optimization. In addition, the urgent issue is creation and implementation of highly efficient resource-saving technologies, which ensure the realization of the natural potential of agroecosystems. As they are mainly based on the effective use of the biological capabilities of the latter.

The relevance of the study is approved by the need to substantiate and develop agrobiological bases for intensifying the cultivation of perennial legumes, the formation and functioning of the zones of sustainable production, taking into account the biological requirements of plants to climatic factors and weather conditions of regions; the need to improve agronomic techniques and optimize their integrated action in the technological cycles in the cultivation of perennial legumes; development of effective technologies based on the principles of adaptive crop production, the application of which would ensure the stabilization of the production of high-quality green mass of alfalfa, clover, sainfoin in the Forest-Steppe and Steppe zones of Ukraine.

In recent years, Ukrainian agriculture has undergone quite positive changes. For example, there is a certain stabilization in production processes and the growth and production of agricultural products. Currently, the formation of the actual structure of production, as well as the system of its organization in the process of agrarian and land reforms is being completed.

Further development of the industry, which is one of the most important in the economy of Ukraine, requires qualitative changes that can increase the competitiveness of agricultural production and strengthen food security. The key issue is the need to create in the nearest future an innovative model of agricultural development in of Ukraine, which will be able to ensure its sustainable and speeded up growth.

The identified strategic directions require the determination of quantitative and qualitative parameters of agricultural development in the country by 2020, as well as the main measures through which such parameters will be achieved. The outlined directions are formed by the results of the conducted scientific studies, the analysis and generalization of the available practical achievements, an estimation and modeling of a social and industrial situation, the ongoing processes, etc.

Strategic directions can be used for the development of legal documents in the field of agriculture, as well as a program and current documents for government bodies and local governments at all levels regarding their development in the relevant period. Also, these areas should be considered when coordinating measures to modernize the economy and agriculture of the country, the development of effective mechanisms for implementing reforms.

The need to address these and other urgent issues has led to the choice of the study direction with alfalfa, the results of which are covered in this monograph.

CHAPTER 1

AGROBIOLOGICAL AND TECHNOLOGICAL SUBSTANTIATION OF THE PROCESS OF FORMATION SUSTAINABLE PERENNIAL LEGUMES PRODUCTIVITY (literature review)

1.1. Perennial legumes as the basis for strengthening forage base at the biologization of crop production

In the structure of production, crop production is 58.4%, livestock – 41.6%. The largest share in production falls on potatoes, vegetables, and melons – 23.8%, slightly less on livestock and poultry – 23.1, on cereals and legumes – 16.3, on industrial crops – 11.7%.

The main direction of achieving strategic goals is to increase the crop production and animal husbandry by ensuring the rational conduction of agricultural production and the introduction of scientific principles in land use and animal husbandry, considering regional peculiarities.

In recent years, the situation regarding the profitability of animal husbandry has drastically changed. Dairy and meat production are highly profitable, given the high productivity of farm animals. In its turn, the further development and productivity of livestock depends on the stability of the forage base. This is confirmed by the share of forage costs in the overall structure of production costs – on average for livestock, it is 55-65%. That is why the production of a sufficient number of highly nutritious balanced forages with a low unit cost is an important precondition for the successful development of animal husbandry.

The creation of a balanced forage base for livestock, as it is testified by the indices of development, should take place by bringing the production of forage crops in 2016 to 24.0 million tons, in 2020 – up to

32.0 million tons of fodder units, which is 5 times higher than 6.2 million tons in 2010.

However, to achieve the milestones, it is necessary to implement the following priority tasks: increasing the economic potential of agroecosystems through the use of major system-forming factors, including increasing soil fertility, reducing chemical and anthropogenic load on ecocenoses, strengthening the adaptive properties of the latter, using only such plant varieties and cultivation technologies that can provide the highest out pay of the resources.

Current and future agricultural production should be mainly environmentally friendly, biological, natural and to a lesser extent artificial and industrial.

Different terms – biological, ecological, organic, or alternative agriculture – include systems of crops cultivation using almost the same techniques. Under the conditions of biological agriculture, the following factors are obligatory: agricultural activity should be performed considering the natural factors of soil formation, restoration of its fertility, formation of the ecosystem; inclusion in the structure of sown areas of annual and perennial legumes for the purpose of biological fixation of nitrogen by their nodules and other bacteria, to ensure their need and enrich the soil without the use of chemical synthetic mineral nitrogen fertilizers; biological loosening and structuring of the soil by the root system of the crops, soil microorganisms and small animals without the use of heavy machinery with high energy consumption for technical and mechanical loosening; control of weeds using biological methods (agronomic techniques) by crops alteration in a crop rotation.

The more active biological processes are, the more biological elements are accumulated, and favorable conditions are created for existing and new generations of living organisms. So, in this way the real existence of the life-organizing regularity of nature is demonstrated – the regularity of increasing soil fertility. At the same time, the general regulation of nature that is increasing soil fertility is manifested in agriculture, ensuring the observation of other regularities in agriculture, especially the one of return, because much of the created organic mass is taken out with the harvest. The most important tasks of agriculture can be solved by the targeted use of agricultural regulations while designing and development of agricultural systems, focusing on the increase in soil fertility and obtaining high yields.

The main source of organic matter is crop residues. The content of organic matter in the soil is especially affected by perennial legumes. They are the cheapest and most affordable way to enrich the soil with nitrogen by fixing it from the air with nodule bacteria. The decomposition of organic matter in the soil is enhanced using modern methods of its cultivation, the introduction of row crops in the rotations. Organic matter comes into the soil not only after the death of plants, but also during their life, due to the continuous process of senescence of various parts of the roots, especially after flowering and early ripening stages. The roots of plants during active life, in contact with soil particles, contribute to the uniform distribution of organic matter and the formation of soil structure particles.

Soil fertility enhancement is provided at the expense of introduction of the complex of organization-technological measures including:

- structure of sown areas adapted to soil and landscape components and scientifically substantiated crop rotations;

- expansion of works on chemical reclamation of acidified and saline soils;

- improving the efficiency of the use of available meliorated lands on an innovative basis;

- anti-erosion measures of permanent action – hydrotechnical, agrotechnical, agricultural and forest reclamation;

- conservation of medium and heavily eroded lands with their subsequent siltation or afforestation;

- focus on organic fertilizer systems, significant growth in production and application of manure;

- increasing the efficiency of mineral fertilizers by optimizing the doses, terms of use and methods of their application into the soil;

- replacement of conventional tillage systems with soil-protective ones, adapted to zonal peculiarities.

Priority in the implementation of this set of measures will be given to:

- maximum biologization of the fertilization system through the rational use and production of organic fertilizers;

- application of 57.9 million tons of manure in 2016 will ensure the increase of 2606 thousand tons of humus and income of 1186 thousand tons, in 2020 – 105 million tons, 4725 thousand tons and 2098 thousand tons of NPK, respectively;

- introduction of scientifically substantiated crop rotations, extension of the area under perennial grasses in 2016 to 1.8 million hectares and in 2020 to 1.9 million hectares, legumes to 2.8 million hectares will promote annual formation of humus in the amount of 3680 and 3760 thousand tons and input into the soil as a result of symbiotic fixation from the atmosphere of 496 and 502 thousand tons of biological nitrogen, which will lead to savings for agricultural enterprises of the costs for purchasing mineral fertilizers in the amount of 4960 and 5020 million UAH;

- increasing the production of green manure, when the expansion of green manure crops in 2016 to 1.5 million hectares, in 2020 to 2 million hectares, will increase the formation of humus, respectively, by 1350 and 1800 thousand tons, and the income of NPK into the soil – in the amount of 251 and 342 thousand tons. Savings on the purchase of an equivalent number of mineral fertilizers will reach to 1960 and 2620 million UAH;

- use of crop by-products for fertilization: for example, by bringing the volume of biomass crops by-products in 2016 to 28.8 million tons and in 2020 to 37.5 million tons, will lead to the formation of humus at 4246 and 5513 thousand tons, and NPK inputs into the soil of 630 and 820 thousand tons.

The use of reserves to increase the fertility of arable land by increasing manure production, enlarging the areas under perennial grasses, legumes and greens, the introduction of by-products of crop production will ensure the inputs of 2568 and 3762 thousand tons of NPK in 2016 and 2020, respectively. To achieve the forecasted indices of crop production, it is necessary to apply into the soil at least 6.6 million tons of active substance of the main nutrients.

Currently the work on the introduction into agriculture of a highly efficient gene pool of varieties and hybrids of crops due to increased potential productivity of varieties and hybrids (with higher efficiency of photosynthesis and payback of fertilizers and irrigation water), as well as strengthening their ecological tolerance to unregulated (frost, drought) and regulated (phytosanitary conditions, increase in acidity and salinization of soils) factors of production, the optimization of which is impossible or requires significant resource costs, is performed.

Increasing the productivity potential of existing varieties and hybrids, which are currently used by 30-40%, overcoming the unacceptably large gap between crop yields by years, considering a significant proportion of agricultural land belonging to the areas of risky agriculture, will be carried out by:

- concentration of all possible resources on plant breeding programs to create more adaptive varieties, which in stressful environmental conditions react less by the yield's reduction and poor product quality;
- accelerated introduction of new, more efficient varieties and hybrids into agriculture of Ukraine through the organization of an improved system of crops seed production;
- use of high-quality seeds not lower than the II reproduction of varieties and the first generation of hybrids in commercial crops. In this case, the share of elite and hybrids of the first generation of new varieties and hybrids must be in the structure of seed crops at least on the level of 20%;
- improving the quality, as well as reproductive and varietal nomenclature of seeds, which are usually used by small farms and private farms.

Considering the relatively high level of national plant breeding for a number of crops, Ukraine has the opportunity to sell on the world market and, first of all, in neighboring countries, up to 2 million tons of seeds of varieties and hybrids of national breeding. Today, the intensive work is conducted for a set of necessary regulatory, organizational, and marketing measures to allow the joining of Ukraine to the global market of varietal seeds. At the same time, it is necessary to complete the accreditation of the state seed laboratory in the system of the International Seed Transit Association (ISTA), which will allow national producers to integrate into the European and global seed market network on equal terms.

At the same time, the application of existing post-industrial systems of resource-saving environmentally friendly technologies for crop production based on the growth of economic potential of agricultural systems, a significant increase in productivity and adaptability of the latter by transferring crop production to new development models foresees the following:

- development and widespread introduction of resource-saving technologies in crop production. The use of such technologies will allow at the expense of rational use of available labor, material and energy resources to significantly reduce the cost of the received unit of production and on this basis to increase the competitiveness of the latter;

- development and widespread implementation of effective methods for optimizing the processes of the plant's growth and development, taking into account rapid changes in climatic conditions, which will significantly increase yields and stabilize crop production;

- a significant increase in the payback of the mineral fertilizers' application if the optimization of doses and ratios of nutrients, as well as the terms and methods of their application into the soil, will be observed. The mineral fertilizers and chemical ameliorants application should be carried out primarily in the fields with an unfavorable balance of plant nutrients and in critical periods of the crops development;

- introduction of an integrated plant protection system, focused primarily on the use of agronomic and biological methods; bringing the index of biologization of plant protection to 30% of the total rational amount of certain protective measures; shift to the use of biological crop technologies on 3.5 million hectares of available agricultural land; introduction of crop biologization technologies with restriction of no more than 75% of the use of chemical pesticides on the area of almost 5 million hectares;

- extending the use of soil-protective, adaptive to zonal peculiarities, tillage technologies that will rationally combine plowing, plowless and chisel loosening, surface and zero tillage; development of the general tendency in the direction of increase in specific weight of surface and zero tillage, first of all in the zones of insufficient humidification; minimum tillage methods should be used on two thirds of arable land. So, the economic effect from their implementation in 2016 will reach 2950 million UAH, in 2020 – 6292.5 million UAH;

- development and forced implementation of innovative systems for regulating the growth and development of plants based on the elements of precision agriculture and nanotechnology; special attention must be paid in this direction to the development of technological methods of regulation physiologically active substances on the functioning of the cellular components of the plant, as well as methods of genetic engineering in the plant breeding process.

To create sustainable forage basis for satisfying the needs of livestock and animal husbandry it is required to:

- increase the areas under the forage crops. The area under grain corn should be increased to 4 million hectares;

- achieve balanced forages by the protein at the expense of increasing protein crops areas to 2.8 million hectares, with the share of soybean – 2.2. million hectares, and perennial legumes – 1.9 million hectares (Table 1.1).

1.1. The efficiency of expanding the volume of biological nitrogen fixation by perennial grasses and legumes

Index	2016			2020		
	by perennial grasses	by legumes and soybean	total	by perennial grasses	by legumes and soybean	total
Sown area, million hectares	1.8	2.8	4.6	1.9	2.8	4.7
Humus receives, thousand tons	-	-	3680	-	-	3760
Volume of symbiotic nitrogen fixation from the atmosphere, thousand tons	216	280	496	222	280	502
The costs for alternative amounts of mineral fertilizers, million UAH	2160	2800	4960	2220	2800	5020

Note: market price for 1 ton of NPK – 10.0 thousand UAH

Creation of a highly efficient raw material base for bioenergy requires:

- increasing the area under rapeseed for biodiesel to 2.6 million hectares, sugar beet for bioethanol production – up to 800 thousand hectares;

- biofuel production from crops, the products of which are not directed for food and forage purposes, which will increase the food and energy security of the country, increase its export potential.

However, it is necessary that the development of organic production occurs by natural potential of plants and soil, their harmonization with the environment by banning, or significant limitation of the use of chemically synthesized fertilizers, pesticides, growth regulators. It should be the norm to prevent or exclude from the use of genetically modified organisms and products of their processing. Priority should be given to preserving and reproducing soil fertility using methods that optimize their biological activity, ensuring increased plants resistance by choosing the appropriate species and varieties.

Considering the existing soil and climatic conditions of the country, a significant expansion of organic farming is an indisputable powerful factor in the successful and efficient development of the industry. According to the expert estimates, its share could reach 5% of agricultural land in 2016 and 7% in 2020.

For the accelerated development of organic agricultural production, a number of organizational and legal problems must be solved in the nearest future. Thus, the adoption of the Law of Ukraine "About Organic Production", the development and implementation of an effective mechanism for certification of enterprises and products, the creation of infrastructure for organic products and their effective promotion on the market.

Achieving the goal and strategy of crop production is possible through the restructuration of the fodder base, improvement, and enhancement of the system of meadow forage production, increase in the area of cultivated irrigated pastures. An important role in this should be played by the expansion of crops of high-yielding perennial legumes, among which we can point out alfalfa, clover, sainfoin.

Hence, the questions related to the study of these crops in general and individual elements of their cultivation technologies are relevant and require further thorough study.

Perennial legumes, as well as annual legumes, have been known in agriculture for at least 6,000 years. They represent a group of plants of the greatest value. Legumes were used in agriculture by the ancient Egyptians and Romans. The inhabitants of the settlements on the lakes of

Switzerland used legumes in 4000 BC. Nowadays, legumes are cultivated everywhere as an important source of forages and protein.

The following perennial legumes are common in field and meadow forage production: alfalfa, knap, sainfoin (sativus, viceous), white and yellow melilot, common bird's-foot trefoil, and others. The importance of legumes in agriculture and crop production is extremely high: they are high yielding, contain a lot of protein, vitamins, minerals, are unbelievably valuable food for all species of animals. At the same time, they are also of great agro-technical importance: they enrich the soil with organic matter, biological nitrogen (nodule bacteria can accumulate it under alfalfa – up to 300 kg/ha, clover – 250, sainfoin – 170-190 kg/ha), use nutrients from hardly soluble forms and deeper horizons. They are a good previous crop for all crops, reduce erosion and soil degradation. Their long-term cultivation in crop rotations and on natural forage lands improves physical, agrochemical, biological properties, and phytosanitary condition of soils. Alternation of legumes with crops that consume nitrogen is important for the increase in soil fertility.

The problem of feed protein today is solved by the production of vegetable protein (cultivation of forage and other crops), as well as animal (fish, meat and bone meal and proteins of microbiological synthesis (fodder yeast) one. Vegetable feed protein has a much lower price. However, both these areas of production should be developed simultaneously and must complement each other.

Literary sources emphasize that alfalfa is a promising forage crop. There are data that the enrichment of soil with nitrogen can reach 300 kg/ha for each year of alfalfa cultivation.

Thus, according to the observations in some farms of Kyiv region, alfalfa crops can be used for 5-6 years against 3-4 in other regions of Ukraine with the appropriate cultivation technology. This means that the need for alfalfa seeds is reduced by 2-3 times compared to that in clover seeds, the period of use of which is 1-2 years.

The yield of alfalfa in the farms that cultivate it for a long period of time not only is inferior in yield to the yield of clover, but even exceeds it. At the same time, in the Forest-Steppe zone of Ukraine until recently there were small areas under alfalfa. Only in recent years, its crops have begun to increase due to the general attention paid to this crop in Ukraine, the experiments of the Institute of Forages and Agriculture of Podillia of NAAS, which is working on the improvement of technology and plant breeding of this crop, also for the Forest-Steppe zone. Many agricultural research stations and other institutions work quite successfully with this crop. However, many issues need to be researched, and the results of the researched issues should be implemented.

Insufficient study of the efficiency of technological methods of alfalfa cultivation restrains further increase in its yield, which rarely exceeds 340-360 kg/ha. The second important factor is the need to expand the sown area for this crop in those regions of the Forest-Steppe zone, where the yield of alfalfa significantly exceeds the yield of other perennial grasses. Clover, which is certainly one of the leading forage crops in the region, occupies just about 86 thousand hectares, that is twice more than alfalfa, or 53.5% of the total area under perennial grasses. Alfalfa's share is only 23%. At the same time, at least 35-40% of the area under perennial grasses can already be set aside for this crop.

In general, in Ukraine for 2014, according to the Ministry of Agriculture and Food of Ukraine (Zadorozhny K.I.) the area of alfalfa crops reached 1.8 million hectares, or 48% in the structure of crops of perennial grasses, including 1229 thousand hectares in the Steppe zone (69%), 453 (26%) – in the Forest-Steppe zone, and 86 thousand hectares (5%) in the zone of Polissia. Thus, the crops of alfalfa are mainly concentrated in the Steppe zone. In the Forest-Steppe zone, as well as in the zone of Polissia, the area under the crop is slowly increasing.

We should note that the total area of alfalfa crops in the CIS countries is 8-9 million hectares, in the United States – more than 10, in Argentina – 7, worldwide – more than 35 million hectares.

The experience of many farms shows that alfalfa in the Forest-Steppe zone could and should be the leading perennial fodder crop in all farms. But no matter how valuable it is, it is impossible to create a highly efficient forage area only at its expense.

The harmonious combination of alfalfa and corn is the basis for the increase in forage production and livestock productivity. In the regions where the organization of high-productive pastures is impossible, a special attention, along with alfalfa, should be paid to annual fodder crops – rapeseed, fodder cabbage, interim winter crops, early spring fodder mixtures, etc. All this will make it possible to organize a highly efficient spring-summer-autumn fodder conveyor of cheap and full-value forages, in which alfalfa should have an important place in June, July, August and September.

Knap is one of the most common fodder legumes. According to the analysis of available data, there are almost 20 million hectares of knap in the world. It is cultivated on large areas in France, England, USA, Canada, Russia. In Ukraine, clover crops are concentrated mainly in the Forest-Steppe zone and in the zone of Polissia. Besides, it is quite common in the foothills and mountainous regions of the Carpathians.

In Ukraine, clover has been known since the first half of the XVIII century. High-yielding local varieties of clover were usually used. Varieties, which are cultivated in Podillia, Volyn and other regions, are worth attention. First, they are adapted to local soil and climatic conditions, have good winter tolerance, provide high yields.

As it was established by the results of research and practice, the varieties imported from the South to the North quickly lose their stability and fall out with the grass due to significant disease, and in winter because of frost. Depending on the existing soil and climatic conditions and agricultural techniques, the yield of knap hay (from two moves) ranges between 40-100 cwt/ha.

However, in the areas with temperate and humid climates, knap is the main perennial herb in the meadow grass cultivation.

Protein of perennial legumes is characterized by high indices. Clover protein contains the essential amino acids lysine and tryptophan 1.5 times more than fishmeal protein, corresponds to the protein content of meat and bone meal and is close to their content in animal protein.

The value of clover fodder is also increased by the fact that per feed unit it contains 1.5 times more digestible protein than provided by zootechnical standards for quality fattening of animals.

Perennial legumes prevent water and wind erosion of soils, promote the accumulation of organic matter in the soil, as well as reduce leaching of nutrients outside the root layer of the soil, enrich the latter with nitrogen. Thus, knap, because of mineralization of root residues, accumulates more than 150 kg/ha of nitrogen in the soil and improves its physical and chemical properties. It is also the most acceptable fore crop for many crops, especially for winter wheat. Nodule bacteria, which are in the rhizosphere of knap, absorb molecular nitrogen from the air, and plants use it to form yields. The use of nitrogen from the air makes it possible to reduce the number of mineral fertilizers, which is helpful in solving the environmental problems. Clover is widely used to create high-yielding cultivated pastures.

Clover cultivation is of great agrotechnical importance. After one year of its use (according to D.M. Prianishnikov) 60-100 kg/ha of nitrogen is accumulated in the soil. High amounts of the following cereal, industrial or other crops are obtained by applying additional phosphorus-potassium fertilizers after clover. Clover hay is highly nutritious containing on average 10, and if harvested during budding – almost 16% of protein. The latter contains many essential amino acids. Hence the hay and green mass of clover are a valuable fodder for farm animals. At the same time, 100 kg of clover hay corresponds to 51 forage units. Clover is also used to make flour from hay, which is used as an admixture to concentrate fodder.

The literature provides convincing evidence that sainfoin is a valuable pasture crop. It belongs to the perennial forage crops, which are used mainly for hay, green fodder, as well as for grazing animals, because it does not cause them tympani. Sainfoin hay has a slightly higher content of digestible protein than clover. Thus, 100 kg of sainfoin hay corresponds to 53 forage units, and each forage unit has 200 g of digestible protein.

Sainfoin is a cross-pollinated plant that is a good honey plant.
Sainfoin yields exceed alfalfa yields, especially in the North Caucasus and Steppe areas. In the arid regions, sainfoin is a valuable pasture crop.

Sainfoin belongs to the ancient crops, which is known since the IX century BC, primarily for cultivation in the Caucasus. Currently, sainfoin culture is widespread in Ukraine and the Central Chernozem zone, as well as in the North Caucasus, Volga region (Russia). In terms of yield on dry carbonate soils, sainfoin is superior to all perennial legumes. Its sown area in Ukraine is within 400 thousand hectares.

Sainfoin has an important agronomic value. Thus, the use of this crop improves the physical properties of the soil, and its root and post-harvest residues input about 100 kg/ha of nitrogen into the soil. However, as a fallow-occupying crop, sainfoin serves as a good fore-crop for winter wheat and other crops.

One of the factors of further development of animal husbandry in Ukraine, especially dairy farming, is the creation of a high-quality fodder base. The fundament for solving this problem is the presence of highly productive varieties and hybrids of forage crops, adapted to specific soil-climatic conditions and cultivation techniques. Currently, varietal resources of forage crops in Ukraine are represented by 357 varieties and hybrids of 15 species listed in the State Register of Plant Varieties of Ukraine. The largest share among them belongs to perennial legumes and cereals (60%). Most varieties (83%) were created by Ukrainian breeders, which testifies to the high competitiveness of the national plant breeding. Among the representatives of the foreign breeding, the varieties of cereal perennial grasses for lawn use are dominating.

The breeding of forage crops is conducted by 18 state scientific-research institutions of the National Academy of Agrarian Sciences of Ukraine, which are in different soil-climatic zones of Ukraine, which since 1991 have been working by the scientific-technical program "Forage Production". The main coordinator of the program is the Institute of Feed and Agriculture of Podillia of NAAS.

The single-minded work is carried out in the breeding of conventional species, together with an increase of forage and seed productivity, in the direction of the increase in tolerance to abiotic – winter tolerance, acidity, drought and salinity tolerance, soil overwatering and to the biotic factors – insects, pathogens and phytocenotic conditions. The improvement in adaptive features of varieties is achieved at the expense of better use of intro-species potential, widening species pool of forage crops, enhancement of their symbiosis with nodule bacteria, rhizosphere microorganisms and mycorrhizal fungi. The use of methods of heterosis selection is also efficient.

1.2. The role of alfalfa in biologization of agriculture

Alfalfa is the oldest forage crop. It is unsurpassed in terms of fodder and, as it is testified by F. Coburn (1908) and Hugo Werner (1876, 1889), has been known to mankind since ancient times.

According to Professor Usov (1837), alfalfa (blue species) was introduced to Ukraine in Smilyansky district from Europe by count Bobrynsky. Here it is cross-pollinated with yellow alfalfa and is further defined as a hybrid of blue alfalfa with yellow. Of course, this is just one of the ways to spread alfalfa in Ukraine. We are convinced of this by other literary sources. Thus, G. Werner (1976, 1989) reports that in 1847 Chinese (Tibetan) alfalfa (*M. sativa chinensis*, *Chinensis lucerne*) was sent from China to Russia under the name "mu-xu". From Russia it quickly got to Europe, to Germany. In addition, G. Werner showed that blue alfalfa wild forms are found in the Siberia, the Caucasus, southern Russia. We should note that in Russia, Central Asia, the Caucasus there are about 36 species of alfalfa, many of them are natural hybrids.

According to F. Koburn, alfalfa was imported to the New World from Europe in the XVI-XVII centuries. Alfalfa came to Europe before the new era from Asia, where it was cultivated everywhere. Thus, according to O.I. Zinchenko, with reference to I.N. Klingen (1960), alfalfa was cultivated in Central Asia – in the Turanian lowlands by the ancient Turkmen-Turans.

Due to the extensive exchange of seeds (often mutual), the gene pool of alfalfa was constantly replenished. However, this exchange has always been well-based. For example, Zaykevych's alfalfa was once obtained from the United States (in the late 1920s). It was bred by Professor Grimm and improved by Professor Zaikevich. This is a well-known variety of Grimm-Zaikevich. But although it has spread, from the beginning it was not a very valuable variety. Thus, in V.R. Williams (1936) we find (quoted literally in Russian translation: "...generous natural hybrids of yellow and blue (more precisely, blue) alfalfa (M. Mebia), in mass selection give excellent crops".

According to Werner, the name of the crop comes from ancient Greece, where alfalfa came from Media (Persia), and received the Greek name "Medicai", and hence – the ancient Roman "herbamedica". According to Decandol, the name of the crop comes from the name of the Lucerne Valley in Piedmont. However, G. Werner (1876) shows that this name (alfalfa) was first mentioned in Dalishampa in his book "History of Plant Development" in 1587. According to him, in Provence (France) the mussel grass (which the Romans called "herbamedica", which means the mussel grass) was already called alfalfa.

There are other data, of Lobel in 1576, where he calls alfalfa "laserto". It is believed that this name comes from France. However, F. Coburn (1809) claims that the name came from Spain, where alfalfa came from, according to Gallo, to whom Werner refers, in France in 1550. In Spain, it was originally called "uzerdas", "latsuzerda", which in France was transformed into cluserta, luserta, and then – in alfalfa (lucerne). It is easy to recognize the relationship between Lobel's laser and other names. At the same time, the Arabs (Moors) brought to Spain the second name of the crop – Alfalda. So, it is called in English and Arabic.

Alfalfa is the most versatile crop, characterized by high yields and nutritional value, suitability for many cuts, longevity, plasticity to growing conditions. The uniqueness of alfalfa could be put upon its ability to form high yield of leaves and stem mass and biological features that determine its significant distribution.

Alfalfa is saved in crops for 10-25 years or more. The term of economic use is usually within eight years. The yield of green mass during this period can be 400-700 cwt/ha, hay yield is 50-150 cwt/ha and higher.

Owing to the rapid growth alfalfa can form 3-4 cuts during the growing season. The multi-cut use of alfalfa allows to create a raw or green conveyor with its grass for 150 days and virtually abandon the cultivation of other legumes. This is a plant of universal and intensive use, which is most consistent with modern technologies of production and fodder storage.

The high fodder value of alfalfa is determined by the fact that its leaf and stem mass contain more than 200 g of digestible protein per one forage unit. Alfalfa is the main leguminous forage crop in the forage conveyor system, one of the most valuable grasses for meadow grass cultivation. In the stage of the beginning of flowering, its green mass contains more than 25% of dry matter, more than 22% of protein, a full set of essential amino acids, including essential. The high content of nutrients is provided by high share of leaves per plant – more than 50%. Alfalfa is distinguished by high digestibility of fodder. According to these indices, it overcomes all other leguminous perennial grasses and is the most valuable in their list.

Significant agrotechnical role is played by alfalfa in organic farming. The root system of this plant accumulates in the soil, compared to cereals, 3 times more nitrogen, 2-3 times more phosphorus, 2 times more potassium. The formation of the biomass yield of alfalfa is mainly supported by the atmospheric nitrogen, due to the symbiotic activity of nodule bacteria. Three-year use of alfalfa in crop rotations contributes to the accumulation of up to 540 kg/ha of the active substance of nitrogen. According to the research of prof. G.P. Kvitka, alfalfa in the optimal cultivation conditions can cause fixation of up to 600 kg/ha of the atmospheric nitrogen.

In the second or third year of the growing season, alfalfa is equivalent to the application of 40-60 tons of manure by the accumulation of nitrogen in the soil. After decomposition in the soil, alfalfa biomass becomes an organic fertilizer that is easily available for plants, forms humus, thereby enriching the soil with nutrients and improving its structure. The crop favors to reduce soil acidity. Alfalfa has a great influence on increasing soil fertility, enriching it with nitrogen, and helps to create a strong fine-clod structure.

The positive consequences of alfalfa on the yield of subsequent crops in the crop rotations was observed. Depending on the type of soil and the level of moisture supply, this effects of alfalfa in the crop rotation is observed for 3-4 years.

The bioenergetic efficiency of alfalfa cultivation for forage purposes under the minimization of the technology is high. According to O.I. Zinchenko and others (1991), the energy coefficient of alfalfa cultivation in case of nurse, pure spring, and post-harvest sowing for two years of use, considering the year of sowing, was 5.6-6.7, which is a fairly high value.

By the estimates of the Institute of Feed and Agriculture of Podillia of NAAS, the increase in alfalfa crops in agriculture of Ukraine to 1.5 million hectares is equivalent to the use of 350 thousand tons of mineral nitrogen. Therefore, the agro-technical role and economic importance of alfalfa in solving the problem of feed protein and intensification of meadow cultivation and pasture fodder production are now highly valued.

Alfalfa shows soil-forming and soil-protective properties. Powerful, deeply penetrating root system of the plant improves the structure of the soil, increases its water and air permeability, promotes the accumulation of humus. With thick herbage, it cleans the fields from weeds. Alfalfa is used as a phytosanitary crop because it is resistant to various diseases and damage by nematodes.

Phytosanitary qualities are revealed in the improvement of the soil. Alfalfa improves the living conditions of worms and soil microorganisms, and when decomposed, it serves as food for them. This, in its turn, reduces plant infestation and increases yields.

Successful cultivation of alfalfa in Ukraine requires a deep understanding of all aspects of the creation and care of grasslands.

Crop placement is one of the main measures of an ecologically rational alfalfa cultivation system. Proper placement of the crop provides it with an appropriate level of pollination and favorable agrometeorological growing conditions. As growing conditions often limit both yield and potential profits, the producer must pay special attention to the choice of area. Some areas can be improved, or the impact of negative factors might be reduced, but the costs in some cases are too high, directly affecting future profits. If the conditions do not meet the requirements, the cultivation of alfalfa can be unprofitable even under the optimal plant care.

The first step in determining the suitability of an area for alfalfa cultivation is the study of soil types according to the results of soil agrochemical surveys. If the survey indicates that the area plot is prospective, the next step is soil and water analyses.

The availability of nutrients is determined by the pH of the soil solution. The maximum amount of nutrients for most crops becomes available when the pH values are within 6.0-7.0 units. However, slightly higher pH values (from 6.3 to 7.5) are recommended for alfalfa cultivation, as it will promote the activity of nitrogen-fixing bacteria Rhizobium. The soils with the pH below 6.0 units are unsuitable for the crop cultivation, so these soils require lime application in the period before sowing the crop, especially if the pH decreases with the depth. Liming of soils not only causes an increase in the nitrogen-fixing ability of the microflora, but also provides an increase in the nitrification ability of the soil, reduces gaseous nitrogen losses.

Liming improves the phosphate nutrition of plants by converting phosphates of iron and aluminum into more mobile compounds, increases the absorptive capacity of the root system, reduces antagonism between phosphorus and aluminum. At joint use of lime and phosphorite flour, precipitate, phosphate slag conditions of phosphate nutrition of plants worsen. Therefore, lime and the above-mentioned phosphorus fertilizers must be applied separately.

Alfalfa is moderately sensitive to salinity. High salt concentrations can be toxic and significantly reduce water supplies. Visual signs of the excessive salinity are shiny spots, white or black crust on the soil surface; leaf burns, the presence of salt-resistant weeds. For radical improvement of solonetzes and alkaline soils containing more than 10% of Na of the total absorption capacity, it is necessary to carry out gypsum application.

Alfalfa is placed in crop rotations after spring and winter cereals, as well as grain corn, industrial and other crops. In vegetable crop rotations, the most acceptable fore crops for alfalfa are tomatoes, eggplants, peppers, marrows, cucumbers and potatoes.

The system of tillage for alfalfa is determined by the biological requirements of the crop, namely the high demand for moisture in the upper layers of the soil during the periods of sowing and initial growth, as well as weak competitiveness of alfalfa plants in the interphase period (seedlings – the formation of the first trifoliate leaf).

When placing alfalfa after winter grain and annual forage crops for green fodder, tillage should begin with shallow plowing using plow harrow to a depth of 8-10 cm and 10-12 cm. The quality of tillage is achieved by the harrowing, which is conducted at an angle of 45 degrees, or across the fore-crop field. In case of significant weediness of the fore-crop field with perennial weeds to exhaust their root systems, intensive disk tillage is carried out using KPE-3.8, KPS-9. The first tilling is carried out to a depth of 8-10 cm, the second and third ones – as soon as weeds appear, but not later than two weeks before the plowing.

Pre-sowing tillage in the early spring period consists of dragging and tilling. Spring tillage is aimed to create the soil with a good level of loosening, which is thoroughly leveled using a combined unit for the pre-sowing tillage AG-6, Europak or others. To create a dense seedbed, be sure to roll the soil before and after sowing with star-wheeled or Cambridge rollers.

Summer sowing of alfalfa limits the time for conduction of agrotechnical measures, so plowing is performed immediately after harrowing the fore-crop field to a depth of 27-30 cm. Then tilling is carried out using a cultivators to a depth of 5-6 cm before and after sowing.

Placing alfalfa after winter and spring cereals requires conventional tillage, i.e. spinner plows. Preparation begins with scuffing the stubble to a depth of 5-7 cm using disc tools. Repetitive scuffing is performed two to three weeks after the emergence of weed seedlings and “drops”.

Considering the type of soils and the content of mobile phosphorus in them, phosphorus fertilizers are applied under the tilth. Immediately after the application of phosphorus fertilizers plowing is carried out using a spinner plow PNO-4-35 27-30 cm.

Because of the increase in the price of raw materials, which takes place every year, and the reduction of net profit, the rational use of fertilizers is especially important. To obtain high yields, alfalfa must be placed after fertilized fore crops, as well as fertilization should be applied directly under this crop. For the formation of 1 kg of dry matter of the aboveground mass, alfalfa uptakes nitrogen – 2.4 kg, phosphorus – 0.6-0.7, potassium and calcium – 1.5-1.7 and 2.6-2.8 kg, respectively.

Industrial practice has shown that alfalfa is quite sensitive to phosphorus and potassium fertilizers. To obtain high yields of green mass, it is recommended to apply mineral fertilizers directly under this crop in the following norms (kg/ha of the active substance):

- ✓ before tilth: P_2O_5 – 30-40; – K_2O – 30-45;
- ✓ in the rows at the time of sowing: P_2O_5 – 8-10; – K_2O – 0;
- ✓ for additional fertilization: P_2O_5 – 30-40; – K_2O – 30-40.

The requirements of alfalfa to nitrogen is low, because up to 70-72% of it is satisfied by fixing nodule bacteria and only 28-30% of nitrogen is absorbed by alfalfa plants from soil and mineral fertilizers. Therefore, nitrogen fertilizers will work effectively only on poor derno-podzolic, gray podzolic and other soils, especially in the case of insufficient watering of the fore-crops at the rate of 30-40 kg/ha of the active substance. At the same time, in case of non-compliance with the norms of ammonium fertilizers and urea application, the nitrogen losses of the mentioned fertilizers increase to 20–36%.

It is advisable to apply well-soluble phosphorus and potassium fertilizers – superphosphate, potassium magnesium, and from nitrogen –

ammonium and calcium nitrate. However, on saline and alkaline soils, potash fertilizers are not used at all.

Additional nutrition of alfalfa should be carried out in the spring and in subsequent years during regrowth and after each cut (at a plant height of 10-15 cm) with complex organo-mineral fertilizer “Furor” (5 L/ha). The mentioned agricultural measure allows to increase crop yields by 15-20% and increase protein content by 1-2%.

To ensure uniform full germination and intensive development of alfalfa herbage, it is necessary to treat the seeds with “Furor” (3 L/t), in combination with an inoculant containing nodule bacteria.

There are three ways to determine the nutrient supply of the soil: according to soil analysis, analysis and interpretation of visual symptoms that occur during the growing season and through laboratory analysis of collected plant samples.

Soil analysis is the most convenient and cost-effective way to determine the level of nutrient supply. This is only a diagnostic method that predicts the level of plant nutrition before sowing.

Visual observations are made during the growing season of plants, but nutrition problems can be too critical, leading to significant yield losses (Table 1.2).

Laboratory analysis of collected plant samples can determine the state of nutrition of herbage before the appearance of any visual signs. For the elements such as sulfur and most trace elements, this is the most acceptable method of determining the demand. For a broader understanding of the nutrition system, soil and laboratory analyzes of plants are combined.

1.2. Visual signs of nutrient deficiency

Element	Visual signs
N	Stunting, elongated and thin stems; plants color from light green to yellow
P	Blue-green or dark green color of the leaves, especially clearly manifested on acidic soils; young leaves are often twisted, and their reverse side and stem become red or crimson
K	White spots on the edge of the leaf blade. The spots appear on the lower leaves but become more noticeable on the apical ones. Developed leaves turn yellow and fall off
Ca	Weakened rooting, depletion of petioles in young leaves
Mg	Manifestation of chlorosis on the lower leaves, the edge of the leaf blade initially remains green
S	Completely light green color of the plant, partial resemblance to nitrogen deficiency, elongated stems, impaired growth
B	Yellow or reddish-yellow color of the upper leaves. In strong deficiency cases, the leaves turn bronze, and the point of growth dies
Mn	Manifestation of chlorosis on young leaves
Fe	Manifestation of chlorosis on young leaves, loss of color by the leaf blade
Zn	Small, young leaves are twisted towards the top
Cu	Significant curvature of petioles, grayish spots on the central leaves
Mo	Pale green and elongated stems, looks like nitrogen deficiency

Usually, alfalfa of zonal varieties is used for sowing. The seeds must be free of weeds, especially quarantine ones. If the batch has 20% of hard seeds or more, it should be scarified on special machines SS-0.5, SKS-1, SKS-2 for 10-12 days before sowing or immediately before sowing.

For seeds, alfalfa is sown as a nurse crop or single crop by ordinary row – with a row spacing of 15 cm, or wide-row method with a row spacing of 45-60 cm, using grain and grass drills SZT-5.4, pneumatic universal one SPU-6, and vegetable drills “KLEN-2,8”, SON-4,2. The depth of seed placing is particularly important and depends on the type of soil. Therefore, often the failure in creation of herbage is mostly connected with too deep placing of the seeds while sowing. So, the depth of placing should not exceed 1-2 cm on heavy clay soils and 3-4 cm on chernozems, chestnut, quick-drying ones.

An important agricultural measure is rolling the soil after sowing. This ensures that the alfalfa seeds come into contact with the soil and this is necessary to prevent the seedlings from drying out.

The factors, which should be considered when sowing time is settled, are weather (primarily temperature and precipitation probability), sowing structure, fore-crop harvest date, moisture supply, irrigation method, weeds, and time of year when environmental conditions are optimal for emergence and seedling development. No sowing date meets all the criteria. The advantages and disadvantages of each time must be weighed in order to choose the optimal date. Actual sowing dates depend on the region of cultivation

The main measure for the care of alfalfa for the second and subsequent years of use is harrowing. The latter helps to improve aeration, moisture supply, enhance the activity of aerobic bacteria and the formation in the soil of readily available nutrients for the plants. In case of prolonged drought and consequently, drying of the land, harrowing is not carried out.

Special attention should be paid to weed control during the plant care for alfalfa crops. If weeds are not eliminated, it can result not only in the reduction of the yield and quality of forage, but also into complete loss of the herbage.

The most wide-spread dicotyledonous weeds in the alfalfa crops are frost-blite (*Chenopodium album* L.), wormwood (*Artemisia absinthium* L.), Canada thistle (*Cirsium arvense*), milkweed (*Euphorbia virgata)*, knot-grass (*Polygonum aviculare* L.), field sowthistle (*Sonchus arvensis* L.), horse sorrel (*Rumex confertus* Willd. L.), daisy wheel (*Tripleurospermum inodorum* L.), goose-grass (*Plantago lanceolata),* shepherd's purse (*Capsella bursa pastoris* L.), penny cress (*Thlaspi arvense* L.), etc. Among the monocotyledonous weeds the most prevalent ones are foxtail species (*Setaria viridis* L., *Setaria glauca* L., *Setaria pumila*), bluegrass (*Elytrigia repens* L.), barnyard grass (*Echinochloa crus-galli* L.).

In alfalfa crops of the first year as a single crop, it is effective to cut the young herbage after the weeds reach the height of 20-25 cm, when they have not yet formed full-fledged seeds. Alfalfa is sensitive to herbicides, so it is reasonable, if possible, to minimize their use.

According to the Institute of Feed and Agriculture of Podillia of NAAS, the most effective method of weed control is the use of a tank mixture of herbicides Eptam 6E (4 kg/ha) and Lenacil beta (0.8 kg/ha), which is applied under pre-sowing cultivation (2012). In this case, it must be immediately wrapped in the soil, because it evaporates fast. This combined application allows to destroy 90-98% of annual cereals and dicotyledonous weeds at the beginning of alfalfa development. Bazagran (2 L/ha) is applied during the growing season if the crops are polluted with annual dicotyledonous weeds. In case of annual and perennial cereals, it is effective to spray the crops with Targa Super (annual – 1.0-1.75 L/ ha; perennial – 2.0-2.5 L/ha) at the weeds height of 10-15 cm.

More than 172 species of insects have been registered in alfalfa, among which about 40 cause significant damage: alfalfa beetle larvae, weevils, wireworms, *Scarabaeidae* larvae, alfalfa sawyer, bean fly larvae, *Opatrum sabulosum*, caterpillars of moths, leafhoppers, aphids, etc.

The most harmful species that damage the generative organs are alfalfa moth, alfalfa, beet and grass bugs, alfalfa weevil, yellow tihius, alfalfa seed chalcid, alfalfa flower fly, phytonomus larvae. Harmfulness of the insects complex and their number increase depending on from which sowing and cut of alfalfa is used for the seeds.

1.3. Economic value and role of knap in energy-saving technologies

The cultivation of knap started in the XIV century in northern Italy, from where the crop was transported to Holland and then to Germany. In 1633 knap was brought to England. In Ukraine and Russia, it has been cultivated since the middle of the XVIII century. Since then, knap is the most important crop of grassland crop rotations, where it usually occupies three fields out of 7-10 in a mixture with timothy grass.

Cultivated knap has undergone a serious evolution compared to wild forms. Its productivity has increased significantly due to increased growth (shoots reached a height of 1 m) and due to more intensive branching and good leafage. But in contrast to durable, resistant to grazing and haymaking wild clover, the cultivars have less longevity (up to three years) and they are less resistant to adverse effects – more often suffer from spring frosts, are worse in winter tolerance, especially in severe winters, fall faster during droughts. But the yield of knap, of course, cannot be compared with the products of even excellent natural meadows – for two cuts you can get 4-6 t/ha of clover hay.

Knap in the former USSR was distributed in Western and Eastern Siberia, in the European part of Russia, the Caucasus and Central Asia. Knap grows in meadows in Forest and Steppe zones, as well as in the forest and subalpine mountain belts. In addition, it develops on meadows, edges, among shrubs, in roadside lanes. It is a part of many polydomain meadow associations, especially on meadows.

The crop is cultivated throughout Europe, in the North Africa (Algeria, Morocco, Tunisia). Nowadays, the main areas of clover cultivation are Ukraine, the Central Non-Chernozem Zone of Russia, Belarus, and the Baltic States. Knap is also cultivated in the Urals, Western Siberia, Primorsky Krai and other regions. The natural areas of clover was significantly expanded because of human economic activities.

The first experiments with knap were conducted by the famous Russian agronomist A.T. Bolotov in the middle of the XVIII century. Later, knap started to be sown systematically by the peasants in Yaroslavl, Perm and other provinces of the Non-Chernozem zone. The famous Yaroslavl and Permian local varieties of knap have not lost their significance. At the same time, the famous Ukrainian breeder V.L. Lykhatsky (1926-2001) improved the technology of knap cultivation for seeds and worked hard to introduce it into production. The varieties of knap bred under his scientific guidance, including Nosivska-4, Nosivska-5, Atlas, Agros-12, became widespread in Ukraine and abroad.

Breeding and research work on clover is carried out today at the Institute of Feed and Agriculture of Podillia of NAAS, Ternopil State Agricultural Research Station, Kyiv Research Station, Nosiv Breeding and Research Station of the Chernihiv Institute of Agricultural Production of NAAS, Carpathian Branch of the Institute of Agriculture and Animal Husbandry of Western Region of NAAS, Uladovo-Liulynetsk Research Station, and other institutions. Knap (red clover), shamrock (white clover) and hybrid clover (pink) are cultivated for forage purposes in Ukraine. The most common species is knap, which is mostly used for hay and haylage.

Nowadays, knap – together with alfalfa, is the major leguminous forage crop in Ukraine and the main crop in field crop rotations. It is cultivated in many regions of the country. The main regions of knap cultivation in Ukraine are moderately humid areas. These are Polissia and Forest-Steppe zone, where it forms the highest yields of herbage mass. In the zone of Steppe, it is less common due to the lack of humidification. The sown area of knap in Ukraine is more than 25% of the total sown area of perennial grasses, or more than 300 thousand hectares (2010).

Shamrock and hybrid clover are cultivated mainly in the western regions of Ukraine, but they are also common in the Forest-steppe zone. Shamrock is used to create cultivated pastures, and hybrid clover – to improve drained meadows and swamps.

Knap is one of the most valuable forage grasses in terms of nutrition: it contains vitamins E, B1, B2, B3, C, D, K, it is characterized by a high content of provitamin A (carotene), and microelements – molybdenum, copper, manganese, cobalt, boron. Nowadays, knap and its mixtures with cereal perennial grasses occupy rather considerable areas in Ukraine. In terms of protein and vitamin content, knap herbage outperforms all other perennial and annual grasses. There are 52 forage units per 100 kg of clover, and 21 forage units per the same mass of its herbage. One forage unit of clover is supported by 160-175 grams of digestible protein. 1 kg of knap hay contains up to 12-13% of protein and up to 75 mg of carotene. Knap is cultivated for hay and green forage. Green forage is used to prepare haylage, pellets, briquettes, and high-protein grass flour. Thus, 100 kg of haylage contain 38-42 forage units, 4.5-5.5 kg of digestible protein, 500-520 g of calcium, 4.1 g of carotene. Grass flour is characterized by high nutrition. 100 kg of grass flour contains double amount of digestible protein compared to hay.

Inflorescences and leaves have the highest forage value. Dried clover leaves contain protein – 23.4%, minerals – 12.8, fiber – 17.3, nitrogen-free extractives - 43.5%. Dried stems contain protein - 11.4%, minerals – 9.5, fiber – 40, nitrogen-free extractives – 40.7%. The content of carotene in the leaves is also many times higher than in the stems (24.8 mg in the leaves and 4.6 mg in the stems). According to scientific research of the Institute of Agriculture and Animal Husbandry in

Western Regions of Ukraine, in the soil layer of 0-30 cm knap leaves 60.2 cwt of air-dry residuals per 1 hectare. They contain 124.1 kg of nitrogen, 24.9 kg of phosphorus, and 3.1 kg of potassium. The main source of vegetable protein in forages, prepared for the winter, and in summer rations is red clover. The latter contains up to 200 g per 1 forage unit of digestible protein, and a lot of phosphorus, calcium and other ash elements. Gross production of juicy and rough forages generally satisfies the demand for them.

During the budding stage, the clover leaf contains a protein that is not inferior to the quality of one from chicken eggs. Per the unit of area, red clover provides the highest amount of protein. For example, with a red clover harvest of 500 cwt/ha, 1500 kg/ha of high-quality digestible protein is obtained, while with a grain harvest of 30 cwt/ha of peas – about 600 kg/ha (900 kg/ha with straw), and the yield of soybean at the level of 25 cwt/ha provides 800 kg/ha of digestible protein. Thus, it can be stated that the use of herbs in fresh form (as green forage), together with haylage, allows to obtain 1.5-2 times more protein than if they were harvested for hay.

Cultivation technology is one of the important components of the process of cultivating knap in the areas with temperate and humid climate, where it is the main perennial grass in the grass growing.

Knap is a perennial crop that grows for 2-3 years. Due to this feature, it is cultivated in a field crop rotation. The standard knap cultivation technology in a field crop rotation consists of nurse sowing (the cover crop is spring barley for grain) – one-year use of the herbage for one or two cuts, followed by plowing for sowing winter wheat. It is possible to use the herbage for two years, saving the costs for seeds, but in the second year the yield of the leaf mass significantly decreases.

Knap is not susceptible to fore-crops, on the contrary – it prepares the soil for other crops. The fore crop must provide a supply of nutrients to the soil and clear the soil of weeds. Choosing a fore crop for knap the requirements of cover crops should be considered, because knap is cultivated as a nurse crop mainly. Among the best fore-crops for knap are winter and spring cereals, weed-free and fertilized row crops – sugar beets, corn, potatoes. The main requirement for the fore crop is the correct selection of herbicides taking into account their aftereffects.

Knap has a positive reaction on manure and peat-manure composts in the amount of 20 to 40 t/ha. When applying organic fertilizers, it is necessary to consider their effect on the cover crop, so as not to result in a large vegetative mass and lodging. Therefore, manure is applied under the fore crop.

Among the mineral fertilizers the prevalence is mostly given to phosphorus-potassium, and if necessary – nitrogen ones. Phosphorus and potassium fertilizers of $P_{60\text{-}90}K_{60\text{-}90}$ are applied before plowing. They are applied for both cover crops and knap. The rate of nitrogen fertilizers for barley should not exceed $N_{30\text{-}60}$ to prevent lodging of crops. In the second year of the growing season, the need for nitrogen fertilizers disappears. They are applied only on weakened crops, low-fertile soils in small doses of up to 30-45 kg/ha. In the autumn or spring, knap is fertilized with phosphorus and potassium in the dose of $P_{30\text{-}60}K_{30\text{-}60}$.

Knap belongs to the crops that grow well with acidic and neutral reaction of the soil solution, at pH of 5.5-7.0. Therefore, acidic soils are limed if necessary. The dose of lime depends on the hydrolytic acidity of the soil. Lime is applied in the full dose considering the hydrolytic acidity before plowing or in case of lack of limestone materials it is scattered by the surface of the field before sowing at the dose of 1-2 t/ha. At pH 4.5, the activity of nodule bacteria is almost ceased. Ways of basic tillage depend on the fore-crop and cover crop. After harvesting the stubble fore-crop, disk harrowing is performed. Plowing is carried out in mid-September to the depth of 25-27 cm. The plots of row fore-crops, which leave not much plant residuals, are usually plowed immediately. After harvesting corn and other crops leaving many residuals, the field is disked with disc harrows and then plowed. In some cases, plowing is replaced by surface tillage using heavy harrows or other equipment. This option is possible, but in these conditions the root system loses the ability to penetrate to the depth, which can affect the productivity of herbage.

Knap is a cold-tolerant plant, have little requirements for heat. The plant begins to germinate at the temperature of 2°C. At the temperature of 10-15°C knap sprouts appear on the 6-8th day. The optimal temperature for germination is 18-20°C. At this temperature, the sprouts appear on the 5th-6th day. The most favorable temperature for plant growth and development is 17-20°C. During the vegetation period, the sum of the active temperatures for the formation of the crop yields from the growth to the first cut for the single-cut forms of knap is about 950°C, for double-cut ones – 950°C. The high photosynthetic activity of knap fields is observed at the temperature of 25°C.

Knap belongs to winter-tolerant crops, and one-cut forms of knap are more winter-resistant than two-cut ones. The sprouts can withstand long frosts up to 5°C and a short-term decrease in temperature to 6-7°C below zero. Decreasing the temperature during knap germination to 8°C below zero will lead to the death of a third of the seedlings. Knap will tolerate the first winter better than the second. Well-developed plants of the first year of cultivation can withstand a decrease in the temperature to 16-17°C below zero, and from the second to the third year – only to 10-12°C. Decrease in the soil temperature at the level of the root neck to 15-20°C below zero is detrimental to the crop. The varieties with a well-developed root system are distinguished by the greatest winter tolerance. Knap can withstand prolonged severe frosts due to the stored nutrients found in the root neck, which were accumulated in the autumn. The frost resistance of knap plants is affected by the storage of nutrients in the soil and its moisture.

Knap is a wet crop that has difficulties in drought tolerance. The optimum soil moisture for its growth is 70-80% of the field capacity before the flowering stage, 60% – during flowering and 40% – during ripening. High and sustainable yields are obtained with an annual rainfall of not less than 400-500 mm. The transpiration coefficient of the single-cut knap ranges between 500-600, and of double-cut – 400-500. It does not resist prolonged, more than 15 days, flooding with water and stagnant water. In Northern regions, soils with the groundwaters closer than 1.5 m from the soil surface are not suitable, in the South – 75 cm.

Knap plants require high soil moisture in the first year of the growing season, when they are nurse crops. During the germination, the seeds absorb water, the mass of which is 130-140% of the mass of the seed. If the soil moisture does not exceed 10% of the field capacity, the seeds of knap do not germinate.

With sufficient humidification, the plants grow well, and the sprouts almost never die. In case of lack of moisture, well-rooted cover crops absorb moisture, creating unfavorable conditions for the herbage. As a rule, young plants, in which the root system is poorly developed, die. The experiments have shown that drying during the first 20 days of knap vegetation leads to the death of 50-60% of plants that have formed 1-2 true leaves. If, by the time the shoot occurs, the knap has four true leaves, up to 20% of the plants die in 20 days.

Knap requires a lot of water after harvesting the cover crop, when it is intensively developed in the root system, especially in the neck of the plants, accumulating food.

During the years of knap herbage use, the demand for moisture increases due to the formation of a large vegetative mass. In the second and subsequent years of knap use, the greatest demand for moisture occurs during the period of the maximum accumulation of dry matter, i.e., from the end of the flowering stage. After cutting the knap, the demand for moisture increases, but to a lesser extent than during the formation of the first cut. Knap reacts positively to irrigation. In case of the lack of moisture and reduction of relative humidity of air to 40-50%, vegetation of the plants slows down or almost stops. In knap cultivation for seeds it is necessary to consider that the greatest yield of the seeds is formed under sufficient accumulation of moisture in the soil before the beginning of flowering of the plants. Due to the lack of moisture currently, the plants dry up and almost do not form sets. With an excess of moisture during the flowering stage and until the harvesting, knap yields are also reduced. If the humidity is high, the herbage shows excessive growth, development of fruit-bearing bodies worsens, many sets die. The highest yields of the seeds are obtained in the years when during the flowering of knap there is enough rainfall and there is dry sunny weather during flowering and seeds ripening.

Knap is a relatively shade-tolerant crop, but it develops well in conditions of sufficient enlightenment. Knap is most sensitive to the lack of light in the budding stage, especially in the year of cultivation. As a result of shade tolerance, it tolerates shading well and develops under the cover of barley or other crops. High yields of green mass could be obtained due to the optimal combination of such natural factors as heat, light, and nutrients content in the soil. However, in general, knap is less sensitive to deterioration of light, so it can easily withstand shading under cover. Knap is a long-day plant. Mono-cut forms of knap are more sensitive to changes in the length of the day – a longer day accelerates their development, while its reduction, on the contrary, delays ripening. When the length of the internode is shortened in the late ripening forms of knap, the height of the stems is noticeably decreased. Knap needs 14-15 hours of light per day – only under such conditions generative organs are formed. A short day accelerates the growth of knap, especially the roots, enhances tillering and increases the leafage. In the conditions of Ukraine, summer knap crops develop unsatisfactorily. This is explained by an excessive amount of light in the initial period of vegetation, high air and soil temperatures, and a decrease in the relative humidity of the air.

Knap is not demanding for the soil. The most suitable soils for it are those with moderate water regime and neutral reaction. At the same time, it is demanding for the content of nutrients in the soil, especially phosphorus and potassium. Due to the activity of nodule bacteria, the plants intensively assimilate atmospheric nitrogen. Knap grows well on podzolic soils and leached chernozems, dark-gray and gray forest soils with a mild or neutral reaction. If irrigated, it could be cultivated on chestnut, gray, and other soils. On clay sands and sands knap yields fluctuate greatly – depending on the moisture content of the soil and the content of nutrients in it. On the soils with a low content of humus knap grows poorly, and on strongly acidic and coniferous it dies. The crop negatively reacts on flooding, as well as deterioration of soil aeration due to the soil compaction, waterlogging. In the case of increasing acidity, the activity of nodule bacteria is suppressed, because of which the nutrition of the plants with nitrogen is disturbed. At the pH of the soil solution below 4.5 it, as a rule, dies.

Knap is sown in the early spring under spring or winter crops. It grows best when planted under spring crops. Valuable cover crops for knap are spring barley and wheat, annual grasses. For two-year use, knap could be sown in a mixture with alfalfa. Such mixtures are more productive than grasses in single crops. It is possible to return knap on the same field after 6-7 years as far as knap plants are infested by fungal diseases due to the knap exhaustion of the soil. Red clover in the Forest-Steppe zone of Ukraine is a good fore-crop for winter wheat, millet, corn, and some technical crops. Nitrogen fertilizers are not applied under clover, and phosphorus and potassium fertilizers significantly increase its yield. On chernozems and gray podzolic soils, application of 40 kg/ha of phosphorus-potassium fertilizers increases clover yield by 20-30%. Clover grows poorly on acidic soils, so it is necessary to carry out liming on podzolic soils. Lime fertilizers are applied in the dose of 10-20 cwt/ha depending on soil acidity. Ground limestone is used on light soils, and slaked lime is used on heavy soils. After liming, the yield increases by 8-10 cwt/ha. The seeds used for sowing must be free from dodder, which parasitizes on clover, with a germination rate of not less than 90%.

Knap seeds are sown in the inter-rows of the cover crop or across the direction of the rows, to the depth of 1-2 cm, and on light soils the seeds are wrapped to the depth of 3 cm. In the first year of the growing season, knap requires special care. When harvesting the cover crop, knap is sown on the sparse places. For the fuller development and increase of winter tolerance of knap, an important feature is the timely harvesting of the cover crop. When harvesting the latter, leave a stubble height of at least 13-15 cm. The high stubble retains snow well, which reduces the risk of plant death from freezing. After harrowing, it is recommended to rake the residuals of the cover crop with a tractor rake. On the thinned crops of knap during the winter, spring, annual ryegrass is sown. This grass grows quickly, equalizes the herbage before the first cut, and provides a high yield from the second cut. Harrowing and rolling are used after the sowing.

Knap for hay is harvested at the beginning of flowering stage. During this period, it forms the main mass of the crop with a high content of protein, minerals, and vitamins. Delay in harvesting leads to the thickening of the plant stems, falling off the leaves, the protein content in them decreases and the amount of fiber increases, because of which forage qualities are deteriorated. Knap should be dried quickly so that the leaves do not over dry and fall off. To speed up the drying of the herbage, KPV-3 roll crushers and GVK-6.0 rakes are used. The period of drying of the cut herbage in math and rolls in 2-4 times shortens crushing of the herbage. Although, the loss of protein, using such a method of drying, increases in comparison with the conventional drying. Also, to speed up the drying, the herbage brought to 35-45% of humidity is dried in the haystack by the method of active ventilation. The hay is stored under the simultaneous pressure of the rolls.

To obtain high yields of forage grasses, it is important to prepare and comply with the requirements for sowing seeds. Before sowing, knap seeds are scarified on a scarifier. In the case when the solid content exceeds 25%, inoculation with rhizotorphin is carried out, enriched with microelements (boron, molybdenum), and treated with fungicides. Heating and electromagnetic irradiation of the seeds is also efficient.

1.4. Agrotechnical substantiation of getting high yields of sainfoin

The historical aspects of the distribution of sainfoin seem to be quite interesting and informative. So, in France, sainfoin first appeared in the fields in 1567. In England it started to be used as forage plant in the middle of the XVII, and in Germany – in the early XVIII century. To the South of Russia and in Ukraine the crop of sainfoin came from France in the second half of the XIX century. Based on this, a number of authors noted that regardless of Western European origin, there was an Eastern or Asian area of sainfoin origin.

The geographic range of the genus *Onobrychis* is only a part of the range of the genus *Hedysarum* and seems to flow into it. The genus *Onobrychis* appeared from the genus *Hedysarum* due to the slow changes in mostly generative parts: a decrease in the number of bean joints to single-seeded beans, which makes it clear that the changes occurred along the lines of the reduction revolution.

In the late XVIII to early XIX century sainfoin was imported to Russia under the name of European sainfoin. But only from the middle of the XIX century it spread in single landed estates, mainly in Ukraine. From the middle of the XIX century, and mainly from the 1920s, for the first time in Ukraine, wild local sand sainfoin was introduced as the crop, which turned out to be more productive and winter-tolerant than the common one.

There are eight species of sainfoin in the wild in Ukraine, and only three of them are in the crop: common, or as it is often called, vetch-leafy (*Onobrychis vicifolia*), sandy (*Onobrychis arenaria*) and Transcaucasian (*Onobrychis transducacia*).

Common sainfoin (*Onobrychis vicifolia*) is now the most common species in agriculture. There is every reason to believe that this sainfoin comes from the wild. However, it should be noted that completely similar forms were not found in the wild. This indicates that under the influence of many years of cultivation in the crop conditions, sainfoin has changed greatly and acquired new features, which it is fundamentally different from its wild ancestors. In its turn, the wild forms from which common sainfoin originates, has also changed, acquiring in the process of natural formation of new features that became the basis for botanists to attribute them to certain types of sainfoin.

Simultaneously with the plant breeding work, a significant number of scientific institutions of Ukraine begin to study the biological and morphological properties of different types of sainfoin. According to the obtained results, sainfoin turned out to be a valuable forage crop, especially for the Forest-Steppe and Steppe of Ukraine, first for sowing on slopes and in sown fallows, as well as in grass mixtures with other perennial grasses in forage crop rotations.

Sainfoin is now spreading rapidly in field and forage crop rotations, as well as in non-crop rotation areas, on hills and slopes. The crop is successfully introduced into agricultural production in Ukraine in such areas as: Vinnytsia, Kyiv, Zhytomyr, Poltava, Chernihiv, Kharkiv, Kirovohrad, Dnipropetrovsk, Zaporizhia, Mykolaiv, Odessa, Lviv, Ternopil and other regions.

The economic value of sainfoin crop is determined not only by high yields and forage properties of the herbage and hay, but also by low demands of this plant for soil conditions, the ability to form valuable high-protein forage on unproductive lands, including slopes.

Herbage and hay of sainfoin are regarded as excellent, nutrient-rich forage for all species of farm animals. Although sainfoin is slightly inferior to alfalfa in protein content, its herbage and hay have high fodder properties (Fig. 1.1).It was determined that the content of forage units per 100 kg of herbage is: alfalfa – 17.8 kg, sainfoin – 17.3, knap – 17 kg, and digestible protein – respectively, 3.9; 2.8 and 2.7 kg. Per each forage unit in alfalfa grass there are 219 g of digestible protein, sainfoin has 162 and knap – 159 g.

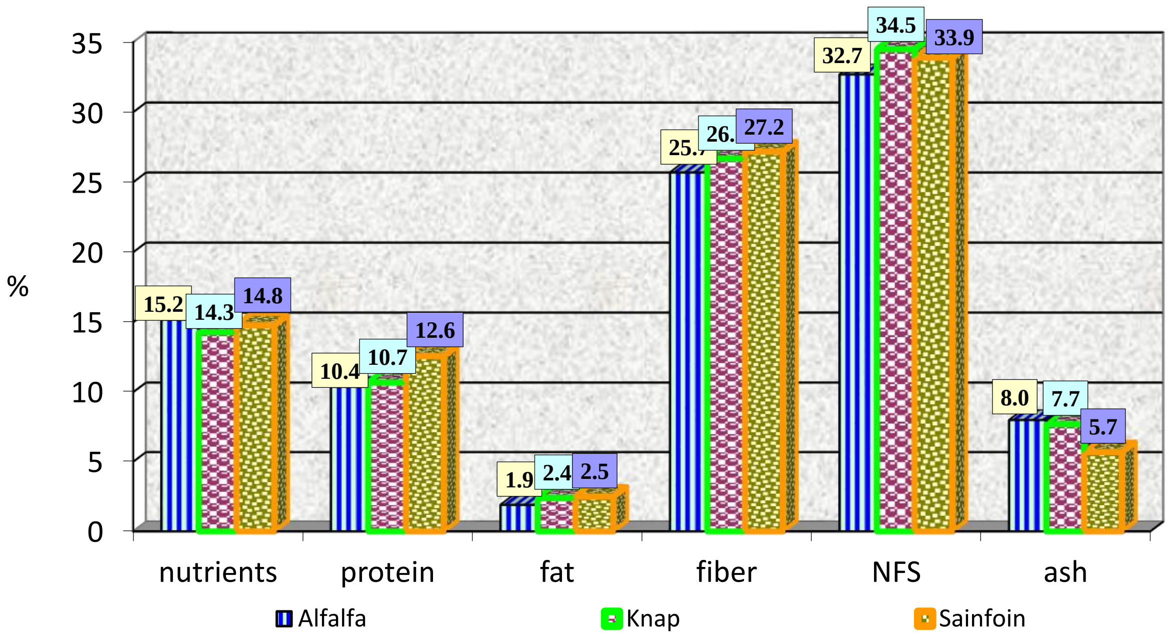
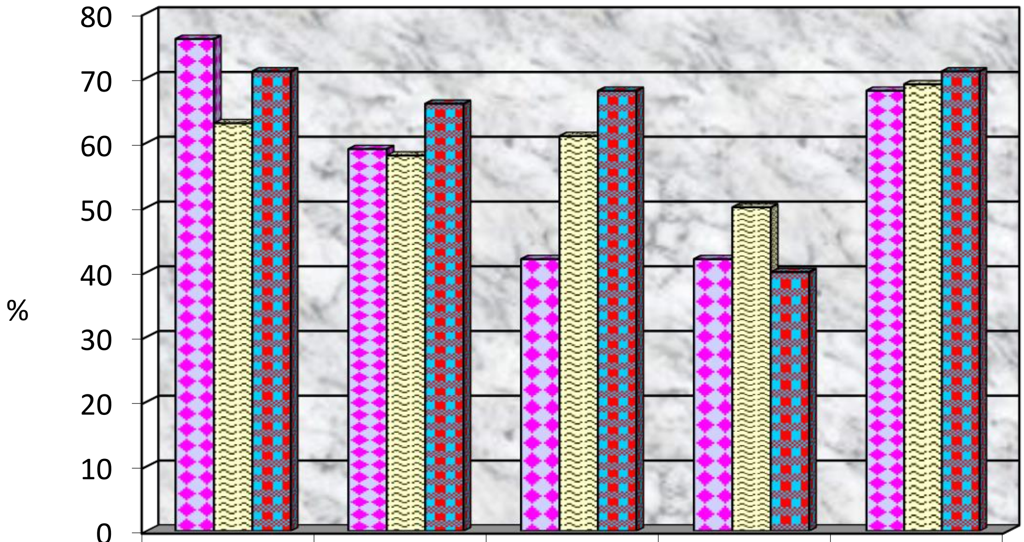


Fig. 1.1. The content of digestible nutrients in hay of perennial grasses, %

Nutrients of sainfoin hay, as well as other legumes, have a high coefficient of digestibility (Fig. 1.2).

The studies have determined that sainfoin is not inferior to alfalfa and knap in terms of forage value. The quality of herbage depends on the stage of its use: the protein content during regrowth in spring is 20.1%, in the tillering phase – 22, budding – 18, flowering – 16.8, fruit formation – 15.3%. 100 kg of herbage contains 20 forage units, digestible protein – 3.3 kg, calcium – 0.25 kg, phosphorus – 0.07 kg, carotene - 5.6 g, one cwt of hay contains 53 forage units, each of which 145-155 g of digestible protein.



	nutrients	protein	fat	fiber	NFS
Alfalfa	76	59	42	42	68
Knap	63	58	61	50	69
Sainfoin	71	66	68	40	71

Fig. 1.2. The coefficient of digestibility of nutrients in the hay of leguminous grasses

Straw and chaff of sainfoin, which are obtained during threshing of seed crops, also have high forage properties. If 100 kg of alfalfa straw contain 19.7 forage units and 3.5 kg of digestible protein, then this amount of sainfoin straw corresponds to 37.5 forage units and 4.8 kg of digestible protein. Sainfoin straw and flour made of it are readily eaten by all kinds of animals and poultry.

Vitamin content is essential in the evaluation of the forage quality. The absence or lack of vitamins in forage inevitably leads to metabolic disorders in the body, reduces its resistance to diseases, delays the growth of young animals, reduces productivity. Vitamin A is the most important one in animal husbandry.

In plant forages there is not this vitamin, or there is a meager amount. However, the herbage, as well as properly prepared fodder hay always contains provitamin A (carotene), which in the body of animals is converted into the vitamin A. According to zootechnical requirements, at least 30 mg of carotene should be per 100 kg of live weight of animals. The studies have shown that sainfoin forage contains more of it than alfalfa. Thus, alfalfa hay contains 21.2 and sainfoin one – 33.6 mg/kg of carotene.

Sainfoin plants have a taproot. However, it does not branch in the upper soil layer, as in knap and alfalfa, but mainly at the depth of 30-70 cm. In the second and third years of the growing season, the roots penetrate to the depth of 3-4 m or more, forming new branches. The root system can absorb sparingly soluble phosphorus and calcium compounds of soil and subsoil. Therefore, sainfoin responds poorly to the application of organic and mineral fertilizers and soil fertility, and therefore grows better than other legumes on low-fertile soils.

The crop of sainfoin, like other legumes, with a high yield of herbage and strong development of the root system enriches the soil with organic matter, nitrogen, and other easily digestible elements, improves its physicochemical and biological properties and, as a result, increases the yield of subsequent crops.

The studies have determined that the root system of sainfoin, as well as its herbage, develop most intensively during the first two years of the growing season. In the third year (second year of use) under such conditions there is a decrease in the rate of formation of new roots, as well as significant extinction and decomposition of old ones. The accumulation of organic residues in the soil is directly dependent on the yield of herbage. The varieties of sainfoin, from which the highest yields of hay are obtained, as a rule, provide more accumulation of dry nutrients and root residues.

According to the chemical analysis of dry organic residues accumulated by sainfoin in the arable soil horizon at the end of the third year of vegetation, they contain from 1.51 to 2.01% of nitrogen and from 0.48 to 0.59% of phosphorus. If recalculated to 1 ha, after two years of use, sainfoin crops in the soil remain from 63.4 to 84.6 kg/ha of nitrogen and from 19.7 to 26.1 kg/ha of phosphorus. The amount of nitrogen accumulated in the soil by sainfoin can reach up to 140-200 kg/ha.

Due to the accumulation of large amounts of organic residues in the soil and the presence of nodule bacteria colonies on the roots, which fix molecular nitrogen from the air, sainfoin enriches the soil with humus and easily digestible nutrients and improves the structure and water-air regime of the latter.

It should be noted that the root necks and roots of sainfoin do not grow after plowing and, unlike alfalfa, weeds will never be formed.

Considering the above-mentioned features of sainfoin, it could be stated that it is a good fore-crop for all crops. At the same time, its use as a fore-crop for winter wheat is of practical interest. The yield of winter wheat sown after sainfoin fallow averaged 76.5% of the yield, which was formed on the clear fallow field.

As a result of these experiments, it was found that sainfoin fallow in terms of reserves of productive moisture in a meter layer of soil, moist arable and sowing horizons is almost not inferior to clear fallow, and the accumulation of nitrate nitrogen is much higher than on the latter. This favors for friendly timely germination of winter crops and normal plant development.

Sainfoin is also a valuable honey plant. It turned out that bees without prior “training” even in the driest years are more willing to visit sainfoin than other honey plants.

In the midst of flowering sainfoin in its flowers concentrates up to 95% of summer bees and only 5% of them visit other honey plants. This is due to the high nectar-bearing capacity of its flowers and the presence of a large amount of pollen (perga). The studies have shown that the average nectar content in one flower ranges from 0.07 to 0.42 mg. The concentration of sugar in the sainfoin nectar, according to the Ukrainian Research Station of Beekeeping, is 37.2-55.6%.

Sainfoin honey has a light amber transparent color, pleasant flavor and taste. A valuable feature of it is that it crystallizes little, and in crystallized form it is a white delicate mass with a creamy tinge.

To master a cultivation technology of any crop it is necessary to be acquainted with biological and morphological features of its seeds. Sainfoin has different definitions for economic and biological term of seed. From an economic point of view, seeds are usually defined as those used for sowing. In sainfoin, in fact, we do not sow seeds (in the botanical sense), but fruits, which are mono-seed beans. Seeds in the botanical sense are what is contained in the middle of the bean and is formed from the seed germ. The weight of 1000 seeds with fruits reaches 15-18 g. Unlike seeds of other crops, sainfoin beans after ripening do not require a long period of dormancy and create friendly sprouts, when sown, in 3-7 days after harvesting. This biological feature of freshly harvested sainfoin seeds is important for accelerated crop propagation.

Sainfoin seeds absorb from the soil the water required for germination for 3-5 days. The amount of water used for germination reaches an average of 133.6% of the weight of dry seeds, i.e., approximately 38% less than alfalfa uses.

The temperature minimum for germination of sainfoin is above 4°C. The water is absorbed by the seeds and the whole process of germination is the fastest at the temperature of 18-30°C. During the bean’s germination, the germinal root is the first to start the growth, which, having passed through the seed coat, pierces the bud in one of the leaves of the bean and penetrates into the soil. After the root, as a result of intensive cell division, the subcotyledonary knee begins to grow, bringing the cotyledons to the earth's surface. The appearance of cotyledons on the soil surface is considered to be the beginning of germination.

The whole process of sainfoin germination from sowing to the appearance of cotyledons on the soil surface lasts from 7 to 15 days, depending on the variety, seed quality and weather conditions.

It is determined that the root system of sainfoin is represented by the main taproot, well developed to the depth of 1.5 m, and has no lateral skeletal roots. Small lateral branches are concentrated in the upper (0-30 cm) soil horizon. The thickness of the root neck for 2-3 years of vegetation reaches 3.4-3.9 cm, and its depth does not exceed 2.3-3.1 cm. During the studies, the regularities between the length and strength pf the root system with the vegetation period and drought resistance were determined: the longer and stronger the root system of sainfoin is, the longer their growing season and the greater the drought resistance are.

Sainfoin flowers blooming occurs all day long. The first flowers open around 7 am, most – between 10-13 hours, the rest – until 18 hours. In good weather and enough number of pollinators, the flowers that bloom in the morning wither in the evening of the very day. This course of sainfoin flowering and its most abundant flowering in the middle of the day, i.e., during the most intense flight of insects, is an important biological feature of this plant, acquired during long-term evolution, as a precaution against self-pollination.

The main requirements for the conditions of sainfoin cultivation consist of considering the biological characteristics of the crop and the necessity to ensure the optimal conditions for growth and development. Sainfoin belongs to the group of photophilous plants. The leaves of these plants are usually coarser and thicker than those of shade-tolerant plants, with many stomata per the unit of leaf area. This is a characteristic feature of photophilous plants. Moisture factor consists of three elements: precipitation, air humidity and soil moisture, which determine the impact of moisture as an environmental factor.

Sainfoin requires great amounts of soil moisture for seeds (fruits) upswelling, and then during the formation of flowering organs. Sainfoin requires the minimum amount of moisture, especially atmospheric, at the fruiting stage. At this time, they can use those moisture reserves that have accumulated in a well-developed root system from other soil layers.

Owing to the well-developed root system, sainfoin does not experience a lack of moisture, which occurs in the upper horizons of the soil during drought and drop in air temperatures, when plant roots are almost unable to absorb water due to the increased viscosity and increased water absorption capacity of the soil.

Sainfoin reaction to moisture was established by studying the evaporation capacity of the leaves by their stomata, the number of which was calculated on a certain area of the leaf surface according to the current methodology.

The number of stomata and their location are a kind of adaptation factor that determines the reaction of the plant to the water regime. Thus, the drier the air is, the higher the need for evaporation and the greater the number of stomata per unit of the leaf area is. Using the quantitative-anatomical method, a similar pattern in the structure and function of leaves on the tiers of the same plant was observed. As it turned out, the higher the leaves are, the more stomata on them per the unit area are, the more successfully they are adapted to combating drought.

Sainfoin each year ends the growing season by the formation of recovery buds located on the basal part of the shoots and on the root neck. On warm autumn days, part of the buds of recovery in some species of sainfoin has time to open before the onset of cold weather and forms a summer-autumn ‘rosette’ of leaves, while the main part of them comes into the winter.

The period of overwintering of the plants is biologically connected with many characteristic features of their vegetation of the summer-autumn period and it represents the continuation of it in various forms. Overwintering takes place in different ways and depends on the stage in which the plant enters the winter. Sainfoin with a well-developed root system is more winter-tolerant than those in which it is poorly developed.

It has been determined that the winter resistance of plants is affected by the structure of the rosette: the species of plants with a well-developed, close to the ground, rosette have higher winter resistance than those with an upright rosette. The results of sainfoin overwintering also depend on the location of the recovery buds that were set in the summer-autumn period.

In the production conditions, the question of how to sow perennial grasses – as a nurse or major crop – is of a great importance. Thus, in the experiments of the Kharkiv Breeding and Research Station, sowing of sainfoin as a major crop for two years of its use provided a higher yield than the nurse crop variant, where oat was the cover crop. The main reason for the negative impact of oats, as a cover crop, on the yield of sainfoin hay was the formation of a significant amount of vegetative mass, which dries the soil and suppresses sainfoin seedlings through their shading. Besides, the root system of oats is located deeper in the soil than in spring wheat and barley, which also adversely affects the development of sainfoin. Therefore, sainfoin is better to be sown under barley or spring wheat.

It should be noted that the yield of sainfoin is affected not only by cover crops, but also those ones that grew in this field in the previous year. The most suitable fore crop for sainfoin are the crops that leave significant reserves of moisture in the deep layers of the soil.

For sowing sainfoin and sainfoin-cereal grass mixtures in fodder and soil-protective crop rotations, soil preparation should begin with harrowing to the depth of 6-8 cm with simultaneous harvesting of the previous crop or immediately after its completion. In the fields that have been infested with thistles or other root weeds, skimming is more effective if it is carried out with plowshare tools instead of discs. The depth of tillage should be increased to 10-12 cm. In case of significant weeding of the field, the second skimming is carried out two or three weeks after the first.

The use of plows with plowshares to the depth of 27-30 cm is justified for plowing the fields under sainfoin. According to the results obtained in the experiments, in arid Steppe areas such plowing makes it possible to increase soil moisture by 1.4-4.5% compared to the conventional one. Deepening the arable horizon to 40 cm contributes to a significant increase in herbage yields.

As in conventional fields, pre-sowing soil preparation in fodder and soil-protective crop rotations begins with the closure of moisture by harrowing with spring-tooth harrows in 1-2 tracks. This measure should be carried out as the soil matures and within one day. Delay in harrowing or its conduction in the extended time leads to the loss of large amounts of moisture. In the case of coverless sowing and sowing of sainfoin under the cover of early cereals in the dry spring years in weed-free fields with not clay soil, pre-sowing cultivation is not used, and seeds are sown immediately after harrowing. In wet spring, as well as in the case of weedy fields or flooding of the soil after harrowing, be sure to perform pre-sowing cultivation to the depth of sowing.

After sowing sainfoin with a cover crop as well as in major crop and especially in mixtures with perennial grasses and knap and alfalfa, care must be taken to ensure that no crust forms on the surface after rain. In heavy rain on the second or third day after sowing, as soon as the soil dries, preventing the formation of crusts, you can harrow with a light harrow across the rows. At this time, sainfoin seeds do not germinate, and harrowing will not damage it. However, when germination has begun and the cotyledons reach the soil surface, harrowing is abandoned because it can significantly damage the seedlings.

You can also destroy the crust at the beginning of the emergence of sprouts with the help of an edgy roller. But such tillage will be effective only if it is carried out in a timely manner, i.e., immediately after the soil dries, which will not stick to the roller in this case. The edges of the roller destroy the crust, which begins to form on the surface.

After harvesting the cover crop, do not allow cops to stand for a long time in the field where the sainfoin is sown. When harvesting cover crops with combine harvesters, straw must be removed from the field immediately and haystacked. If the sainfoin stays under the sheaves or under the straw for even 5-7 days, it will just fall out.

Often, for one reason or another, crops of sainfoin after harvesting cover crops are thinned. In such cases, sainfoin should be sown with freshly harvested seeds. It is performed as soon as possible, immediately after harvesting the cover crop, and is completed no later than August 1. The sowing rate is set each time depending on the degree of thinning the herbage.

Spring loosening of sainfoin crops is carried out in the early and short terms as soon as the soil dries and becomes suitable for cultivation with tillage tools.

Among perennial legumes, sainfoin is distinguished for its originality in relation to the soil. The studies confirming the low requirements of sainfoin to the soil, revealed a feature that for its successful growth and high productivity it must be present in the soil and, especially, in the subsoil, at least 0.5% of calcium oxide (lime). Sainfoin provides the highest yields on chernozem soils, which occur on carbonate rocks. More intensively than other perennial grasses, it grows on sandy and loamy soils. Podzolic, solonets and saline soils are somewhat less suitable for sainfoin cultivation. Acidic soils, which are flooded or have a close groundwater level, as well as areas in the floodplains, are completely unsuitable for it. Here sainfoin develops poorly and falls out quickly, because the root system cannot penetrate the deep horizons of the soil to get nutrients from there.

It was found that sainfoin, compared to other legumes, improves soil fertility and its properties the most. The effect of sainfoin on increasing soil fertility is: first, that it enriches the latter with organic matter due to the large mass of roots and post-harvest residues that remain in the soil after harvesting the herbage; secondly, sainfoin saturates the soil with nitrogen due to its fixation from the air by bacteria; thirdly, sainfoin enriches the soil with lime, phosphorus, which is absorbed by the root system from the lower deep layers, and then accumulates in the post-harvest residues and the root mass of the arable layer.

Bacteria specific for sainfoin can form nodules in size and weight much larger than those in alfalfa and knap. A characteristic feature of sainfoin nodule bacteria is their high resistance to drought. Unlike other legumes, sainfoin has a vigorous continuous formation of nodules – on average, one plant has 15-30 pieces with a total weight of 0.15-0.40 g, which is 300-600 kg/ha.

Yield, quality of crops depends on many factors. It is known that the most influential element in the cultivation technology is fertilization. However, experiments with fertilization on sainfoin crops have not been conducted in the necessary volume, and the data obtained are contradictory.

The studies have shown that sainfoin, unlike alfalfa and other legumes, reacts weakly, and in some cases even negatively, to the application of organic and mineral fertilizers.

The requirements of plants for fertilizers depends on the ability of their root system to absorb insoluble compounds. Sainfoin in this respect differs from many other crops. There is no effect from the application of nitrogen, phosphorus, and potassium fertilizers under sainfoin. This was explained by the characteristic feature of sainfoin to absorb insoluble phosphorus and potassium compounds from the soil.

The comparative effect of manure and superphosphate on the yield of sainfoin and alfalfa was also studied. In these experiments, fertilizers were applied before fallow plowing directly under sainfoin and alfalfa, which were sown without cover crops. It was found that the manure had almost no effect on the yield of sainfoin. At the same time, the yield of alfalfa under the influence of manure was almost doubled. Superphosphate not only did not increase the yield of sainfoin, but even reduced it.

According to some researchers, sainfoin does not react to fertilizer due to the presence of the bulk of small roots that can absorb nutrients from the soil at a considerable depth, which does not get nutrients applied with fertilizers. The reason for the decrease in the yield of sainfoin from superphosphate is the property of this fertilizer to acidify the soil, and sainfoin reacts very negatively to the increased acidity of the soil.

It is determined that the fertilization of sainfoin with superphosphate inhibits the development of nodule bacteria, as a result of which the nutrition of the plants with nitrogen deteriorates. Also, the reason for the weak effect of superphosphate and manure on sainfoin indicate that it needs primarily nitrogen fertilizers. Since sainfoin nodules are formed later than other herbs, with the simultaneous application of nitrogen and phosphorus fertilizers, it reacts positively to superphosphate. Nodule bacteria belong to one species. Therefore, it is unlikely that organisms belonging to the same species, in symbiosis with knap and alfalfa reacted positively, and in case of sainfoin – reacted incredibly negatively to the application of superphosphate.

Based on these data, it can be concluded that sainfoin, unlike knap, alfalfa and other crops, has a high ability to absorb insoluble nutrients present in the soil and is poorly responsive to fertilizers. Therefore, in conventional crops, sainfoin is unreasonable to be fertilized directly, and it is more appropriate to apply fertilizers for other crops of the crop rotations.

Due to the contradiction in the data on the reaction of sainfoin to fertilizers, the latter are not applied when it is cultivated as a major crop (on humus-rich soils) or used at low rates ($N_{30}P_{30\text{-}45}K_{30\text{-}45}$) after harvesting cover crops.

According to the Ukrainian Research Institute of Plant Breeding, Selection and Genetics, the application of $N_{30}P_{45}K_{45}$ led to a decrease in the yield of sainfoin, and under the application of phosphorus-potassium ($P_{45}K_{45}$) it remained the same as in the control without fertilizers. It is proved that sainfoin, unlike many other crops in certain soil and climatic conditions, provides high yields without fertilizers.

The studies conducted at the Drabiv Agricultural Research Station for three years there were examined the effects of manure on sainfoin yields. In these experiments, fertilizers were applied before fallow plowing directly under the sainfoin. On average, in three years with the application of 20 t/ha of manure, the yield of sainfoin hay increased by 48%.

The studies conducted in the experimental field of Bila Tserkva Agricultural Institute found that the application of fully-fledged mineral fertilizer at the rate of 60, 120, 108 kg/ha of active substance on low-humus chernozems of the Right Bank Forest-Steppe of Ukraine did not increase sainfoin yield.

Thus, the studies conducted in different times have testified a weak effect, and sometimes even a negative reaction of sainfoin not only to mineral but also to organic fertilizers. The weak reaction of sainfoin to fertilizers is explained mainly by the ability of a powerful deep-penetrating root system of the plants to uptake nutrients from insoluble compounds of soil and subsoil. In addition to these features of the root system, the reasons for this reaction to fertilizers are acidification of the soil, which causes their application. As a result, unfavorable conditions are created for the successful life of nodule bacteria. An obvious reason for the controversy is that a major part of the sainfoin root system is far beyond the fertilizer application zone, and the studies have been conducted in different soil-climatic zones and on soils that differ in their fertility. The studies have shown that the optimal rate of sowing seeds of sainfoin when cultivating it for hay both as a nurse or major crop is in the range of 75-80 kg of germinating seeds per 1 ha.

According to the results of the research, the most intense cut mass of sainfoin is accumulated in the period from the beginning of budding to the beginning of flowering of its plants. During this time, the growth of stems reaches in different varieties from 30 to 50 cm, which is more than 60% of the total height of the herbage. Later, i.e., in the period from the beginning of flowering to its end, the intensity of plant growth, and with it the accumulation of the yield significantly decreases.

It should be mentioned that immediately after flowering sainfoin stalks are very coarse, their composition significantly reduces the proportion of digestible protein and nitrogen-free extractive substances (NFS) and increases the amount of indigestible fiber. Besides, after the stage of flowering sainfoin leaves begin to dry and crumble. Therefore, when harvested at the end of flowering, there are exceptionally large losses, resulting in reduced hay yield and deterioration of its quality. At the same time, it is also unreasonable to start mass harvesting of sainfoin for hay before the stage of flowering, because in this case there will be a significant loss of dry matter and basic nutrients.

Hence, to prevent crop losses, hay should be harvested at the beginning of flowering, it should be carried out in a short time span in order to finish no later than in the middle stage of flowering. Sainfoin hay can be skirted only when the humidity of the latter will not exceed 15-17% to absolute dry weight. Dry sainfoin hay is that one, which is easily broken in hands.

The time of sainfoin harvesting is determined by the understanding that it is necessary not only to obtain a high yield, but also to get as much nutrients as possible per the unit of area, especially protein. Changes in the chemical composition of sainfoin hay, depending on the stage of the plant development, could be assessed by the results of the research by the former Ukrainian branch of the All-Union Institute of Feed named after

V.R. Williams. Thus, it was found that in the period from the beginning of budding to the stage of full flowering of the plants, i.e., within one decade, the content of crude protein in their composition decreased by 7.2%, while the content of fiber increased by 5.9%.

The decrease in the content of sainfoin protein and other nutrients in the plants in the later stages of development is a consequence not only of the aging of the plants themselves, but also a significant reduction in the proportion of the most valuable and nutritious parts – leaves.

The height of sainfoin cutting is also especially important for increasing the yield of sainfoin. At a high cut there is a significant loss of herbage, and at too low – the conditions of shoot formation worsen, resulting in reduced yields. Therefore, the first cut should be carried out at the height of 6 cm from the soil surface, the second one – at the higher cut (8-10 cm).

At this height of stubble, the plants have more storage and plastic compounds, the process of formation of buds and shoots on the root neck is more intensive, snow is better retained in the field, which increases the resistance of sainfoin against harsh winter conditions and promotes friendly regrowth in the spring next year. Almost the same measures and preparations, as in the cultivation of alfalfa and knap, are used to control weeds.

1.5. Ecological substantiation and optimization of formation of high productivity by perennial leguminous grasses in the conditions of crop production biologization

The presented work investigates the cultivation of perennial grasses mainly in the field crop rotations, so the main attention is paid to the crop of leguminous grasses. In addition, the cultivation technology is considered, where the basis is perennial legumes. In Ukraine, this is a group of grasses that includes alfalfa, knap, sainfoin, melilot, bird's foot and is cultivated on an area exceeding 2.3 million hectares, or more than 7% of arable land. Nowadays, the largest areas are under alfalfa crops – 1.8 million hectares, knap – up to 300 thousand hectares and sainfoin – about 343 thousand hectares.

Sainfoin is much inferior to the sown area under knap and alfalfa, but they are also quite large. Knap crops in Ukraine are concentrated mainly in Polissia and the Forest-Steppe, alfalfa – mostly in the Steppe, sainfoin – in the Forest-Steppe and Steppe. At the same time, it should be noted that in recent years it has become widespread on low-cultivated lands, especially on saline soils and sloping lands in the South, to use melilot, and in the mountain regions and foothills of the Carpathians – bird's foot.

Among the sown grasses, perennial legumes are the most valuable group of forage plants. First, the latter largely determine the stability and continuity of the green conveyor, as they grow intensively throughout the growing season.

In addition to green fodder, they provide livestock with hay, haylage, silage, are used in the form of briquettes, granulated fodder, grass meal.

Perennial legumes have a high content of almost all amino acids, including the most essential - lysine, methionine, tryptophan, arginine. According to the Poltava Agricultural Research Station, perennial legumes in the budding stage contain an average of 11.4-14.2 g of lysine, 1.7-2.2 of methionine and 1.2-2.2 g of tryptophan per 1 kg of dry matter (Fig. 1.3).

To understand how high the figures are, as an example, we give a comparison: alfalfa grass in the budding stage contains 6.2% of lysine (to crude protein), 5.4% of arginine, while corn grain – just about 2.9-4.1, barley grain – 4.5 and 3.8%, respectively.

The advantage of legumes, and especially alfalfa, is obvious. One more thing is to be added: the protein of alfalfa herbage in terms of lysine and tryptophan content is equal to the protein of meat flour.

Perennial leguminous grasses are the main source of carotene in animal diets. In addition, the hay obtained from them is also richer than the hay of cereal grasses by the content of the vitamins C, D, E and others. The green mass and hay of these herbs contain many minerals, including calcium – an average of 18.3-25.6 g, phosphorus – 4.7-5.8 g; 1 kg of clover hay contains, respectively, 15, 15 and 6.3 g of the mentioned minerals. Leguminous grasses have high productivity. Under the appropriate agrotechnology and favorable cultivation conditions, they provide 300-500, and when irrigated (or in wet years) – 500 and even 600-900 kg/ha of herbage, or 75-90 and 150-200 kg/ha of hay. The content of forage units in the yield reaches 100-150, of protein – up to 20 kg/ha and more. At the same time, the cost of 1 cwt of forage units of digestible protein of perennial legumes herbage in all the areas of their cultivation is much lower than of other forages. Perennial grasses provide higher yield than annuals, which is also their advantage. Thus, in 2001-2007, the average yield of hay of annual grasses in Ukraine was 27.7 cwt/ha, of perennial ones – 32 cwt/ha, or 4.3 cwt/ha greater. At the same time, such average hay yields of both annual and perennial grasses cannot be considered high, as it is testified by the data of varietal plots of Ukraine, the practical experience of individual regions, districts and farms.

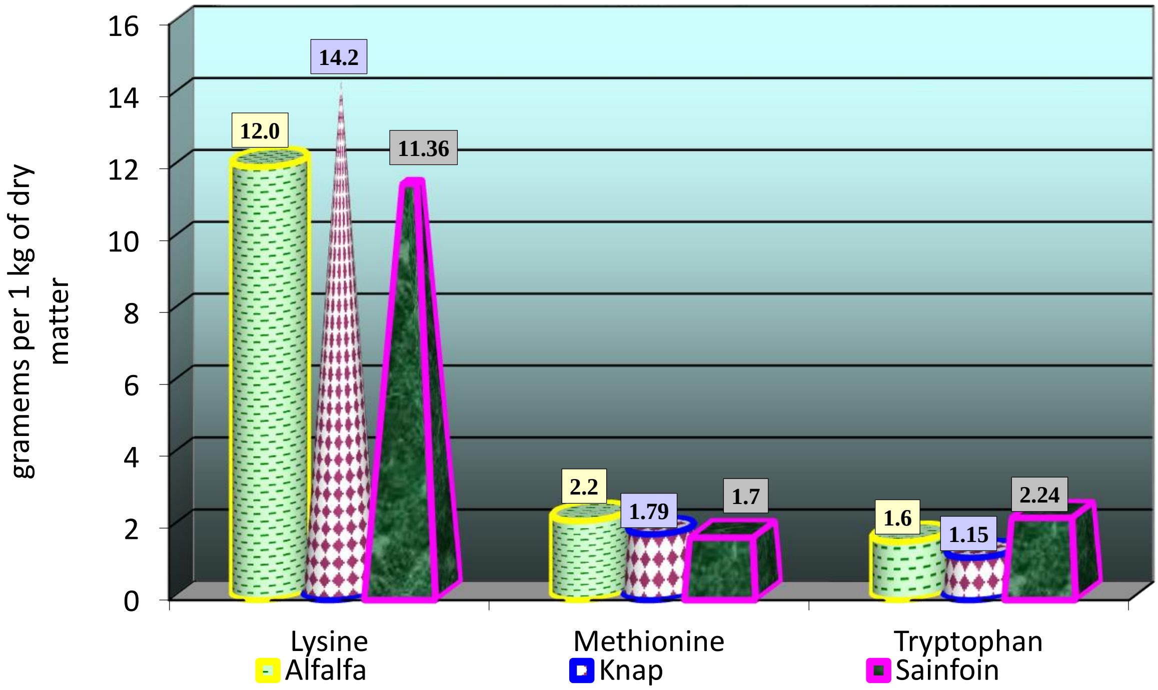


Fig. 1.3. The average content of essential amino acids (g/kg of absolutely dry matter) in the biomass of perennial legumes at the budding stage

According to the analysis of yield data of varietal stations of Ukraine for 2005-2010, it could be concluded that the yield of herbage and hay of leguminous grasses in different soil and climatic zones of Ukraine varies in a wide range from 307 cwt/ha (77.3 cwt/ha of hay) for knap in the Forest-Steppe conditions to 174 cwt/ha (52.7 cwt/ha of hay) – in the Steppe zone (Table 1.3). According to these indices, varietal stations provide hay harvest 2-2.5 times higher than the average in Ukraine.

The investigations of scientific institutions and the experience of successful farms show that the introduction of advanced technologies for harvesting and storage of forages increases their production by 30-35%, and significantly improves their quality. Considering this fact, there is now a trend towards positive changes in increasing the production of grass meal, pellets, briquettes, as well as haylage and hay produced by pressing and active ventilation.

1.3. Yields of herbage and hay of leguminous grasses in different soil and climatic zones of Ukraine, cwt/ha (average for 2005-2010)

Zone	Crop / product type					
	alfalfa		knap		sainfoin	
	herbage	hay	herbage	hay	herbage	hay
Steppe	210	69.5	–	–	174	52.7
Forest-Steppe	289	83.2	307	77.3	235	62.4
Polissia	217	65.7	296	62.2	238	73.6

All these facts testify that perennial leguminous grasses are not only a source of useful and cheap forage for animals, but also are no less effective and powerful means of improving the physical and chemical properties of the soil, increasing its fertility. In addition, leguminous grasses are one of the best fore crops for many crops in a crop rotation, especially for such as winter and spring wheat, flax, etc.

To increase the production of these cheap and nutritious forages, it is necessary to sow high-yielding species and varieties of cereals and legumes, improve the productivity of natural meadows, apply proper agrotechnologies and regimes of use of herbage, as was proposed by a number of well-known scientists, namely: V.G. Kurhak, P.S. Makarenko, A.V. Bohovin, M.T. Yarmoliuk, etc.

Thus, based on the analysis of literature sources and generalization of the research conducted by national and foreign scientists, it is determined that the enlargement of the areas under perennial leguminous grasses will help solve the problem of providing valuable fodder to the domestic livestock industry, and conduction of planned scientific studies in different soil-climatic conditions will allow to provide recommendations on the cultivation technology of forage crops for the purpose of rational use of arable lands, increase of productivity and quality of production, receiving the maximum possible economic efficiency.

In the conditions of the Forest-Steppe of the Right Bank, the basic elements of the cultivation technology of perennial leguminous grasses, which would consider modern varietal structure, biological properties of crops, change in climatic conditions, necessity of introduction of resource-saving technologies, etc. are insufficiently studied and not developed.

Considering the peculiarities of perennial legumes as those that require optimization of basic agricultural measures, one of the ways to an increase in the plant productivity and improvement in the product quality is the use of scientifically sound doses of mineral fertilizers.

The main task of tillage for perennial leguminous grasses is to destroy weeds, accumulate and maintain optimal reserves of productive moisture, which leads to obtaining friendly sprouts. For small-seeded crops it is necessary to form the optimal leveling of the field, as well as fine-grained soil structure, to ensure high humidity and compacted seed bed of the field at the depth of wrapping.

Until now, no technologically sound research has been conducted and some of the conducted ones are out of date and cannot be used to optimize the cultivation technology of perennial leguminous grasses (alfalfa, knap, sainfoin), including the following agricultural measures: varietal composition, tillage, fertilization rates, sowing rates, seed treatment efficiency with bacterial preparations, methods of crop production, the number of cuts, the height of cutting, which confirms the relevance of the topic of the monograph and prompted the inclusion of these factors in the research program.

CHAPTER 2

SOIL AND CLIMATE CONDITIONS, MATERIAL AND METHODOLOGY OF RESEARCH

2.1. Analysis of changes and forecast of climatic resources of Ukraine and their importance in increasing the productivity of perennial legumes

In the world, the area of meadows is twice the area of arable land, while in Ukraine, on the contrary, the area of arable land exceeds the area of meadows with a significant figure – 5 times. At the same time, it is the forest and meadows that are the climate control factors that mitigate adverse weather anomalies.

The negative impact of the activation of humus decomposition can be reduced by saturating the soil with organic matter. This will be the most important source of replenishment of nutrients, a powerful factor in increasing the biological activity of soils, improving their water and physical parameters, as the water holding capacity of organic matter is 5-10 times greater than the mineral fraction of the soil. Therefore, all organic by-products must be used for fertilizer.

It is noteworthy that in ancient times the peasants cared about the concentration of energy on arable land. Using fodder from meadows, forest glades, and other natural lands for animal husbandry, inedible vegetation was sent to animal litter. All this, returning to the field with organic food, provided an increase in crop yields. Therefore, in order to save fuel and plant protection products from weeds in farms with developed livestock, half-rotted manure should be applied to the soil (its weight is reduced by 20%, and the weed seeds present in it completely lose germination). Application rates – from 40 to 80 t/ha.

The importance of the use of sidereal crops is also growing. They not only enrich the soil with nutrients, but also contribute to its phytosanitary recovery.

It is necessary to restore and expand the area of perennial legumes. Thus, the area of 1.8 million hectares under alfalfa crops in Ukraine is equivalent to the introduction of 45 million tons of manure and 1.0 million tons of technical nitrogen.

Nowadays, the issue of chemical land reclamation is becoming increasingly important. After all, in Ukraine in the 80s of the twentieth century the area of acid soils in the forest-steppe increased by 1.8 million hectares. Over the past 180 years, the acidity of atmospheric moisture has increased 100 times.

It is known that the crop and its quality are formed under the constant influence of meteorological factors, primarily light, heat, moisture. All of these factors are highly variable and interrelated.

Different forage crops show the highest productive potential under appropriate optimal conditions. In order to properly select crops for growing in a particular soil-climatic zone, it is necessary to take into account both agro-climatic resources and the needs of plants in the main factors of growth and development.

When assessing climatic resources should take into account the intensity of solar radiation. It is estimated that on average 75% of the solar radiation that hits the leaves is absorbed last, 25% is reflected or passes through it. Most of the absorbed energy is spent on water evaporation.

The amount of solar radiation that penetrates the grass depends on the density of crops and baldness of plants. Both the lack and excess of radiation adversely affect the formation and quantity of the crop. Its high intensity causes the decomposition of chlorophyll, as a result of which the leaves turn yellow and fall off. In the absence of photosynthesis is significantly slowed down, the yield is reduced. In the study region, the duration of sunshine during the growing season is 1400-1550 hours (1743 hours) per year. The amount of HEADLIGHTS (photosynthetically active radiation) here reaches 2126 mJ/m² per year, respectively, for the period with temperatures above 5°C and 1467 mJ/m² – for the period with temperatures above 10°C. Perennial legumes are light-loving and form high yields with sufficient intensity of solar radiation.

Regarding the growth and development and accumulation of green mass, the length of the growing season from germination to forage harvesting and the need of plants for heat and solar radiation are important. The period with the temperature at which early spring crops grow in the Forest-Steppe averages 190-210 days. For those crops that ripen later, i.e., for late crops, for green fodder – from 140 to 170 days. Theoretically, you can grow for green fodder three or four harvests of annual early crops, or two or three late.

In a particular farm, when selecting forage crops, it is necessary to take into account the peculiarities of the change in the sum of temperatures, which are significantly dependent on the microrelief. According to long-term indicators, the sum of active temperatures for the period with a temperature f 5°C reaches 2980°C, for the period with t 10°C – 2645°C (Forest-steppe). The sum of effective temperatures above 5°C is at the level of 1955°C, and above 10°C – 1035°C.

An important climatic factor is moisture supply. The gross need of fodder crops for moisture in different zones, as well as within one zone, is different. This is due to its dependence on the deficit of humidity during the growing season. The amount of precipitation (norm) in the study area is 562 mm per year, including 320-450 mm during the growing season. However, during the growing season they are distributed quite unevenly.

Most rains fall in June and July (64 and 83 mm, respectively), and they are crucial in the formation of the crop and its quality, especially for late crops. After all, most forage crops reach oblique maturity in 50-90 days after sowing. That is, moisture, which significantly affects the formation of the crop and its quality, they use for 2-3 months.

When selecting a crop for certain conditions, you should use the coefficient of moisture supply of the crop (K), which is the ratio of rainfall during the growing season to its need for moisture in a particular area. If K = I, the zone is considered to be provided with moisture of summer precipitation, for K = 0.7-I – sufficiently provided, K = 0.4-0.7 – moderately provided, K = 0.3-0.4 – zone of insufficient provision. The vast majority of perennial grasses are mesophytes, i.e., crops of medium moisture. They grow best at a value of 70-75% HB.

Under the conditions of moisture supply, the Forest-Steppe zone is suitable for obtaining high yields of both early and late fodder crops.

Thus, data on agro-climatic resources and specific terrain conditions make it possible to reasonably determine the set of forage crops and place them on the terrain. Thus, in the western Forest-Steppe in the upper part of the gentle slopes of narrow valleys, in floodplains, on the banks of reservoirs, where warmer than on the plains are better heat-loving crops – corn, Sudanese grass, soybeans, etc. You can start sowing them in these areas 2-3 days earlier than in the open field. Winter and spring crops – rapeseed, pea-oat mixtures – are often grown in such areas, especially to provide the existing livestock with early green mass. Here they reach oblique maturity 2-4 days earlier. After harvesting, you can get a second crop of green fodder – corn.

In places where the sum of temperatures is lower, ie in damp lowlands, closed valleys, moisture-loving and cold-loving crops should be sown (fodder beans, vetch, vetch-oat and vyko-ryegrass mixtures).

In the conditions of the Central Forest-Steppe in forages where the sum of temperatures is 100-200°C higher in comparison with the open terrain, fodder varieties of sorghum, alfalfa, Sudan grass, sainfoin, corn are grown. In the area with a smaller amount of temperatures it is advisable to sow fodder beans, white lupine, winter for green fodder, mustard, rape.

Drought-resistant crops should be grown on the cut relief forms typical of the Eastern Forest-Steppe: corn, Sudanese grass, sorghum, pea-oat mixtures, rank, rye, triticale, alfalfa, sainfoin, boneless stalk, clover, rye. Under irrigated conditions, high yields of such moisture-loving crops as meadow clover, fodder cabbage, mustard, and rapeseed are obtained.

In addition to meteorological factors, soil conditions are taken into account when selecting crops. The quality of the crop is influenced by soil fertility, mechanical composition, reaction of soil solution, its water and temperature regimes.

Long-term studies of the chemical composition of legumes, in particular alfalfa, depending on weather conditions, convincingly show significant fluctuations in nutrient content when harvested in the same phase of development over the years. The protein content in the dry matter varies depending on the weather from 15.4 to 20.3%. The protein content is especially reduced at a hydrothermal coefficient of 0.52-0.82. In the case of a decrease in precipitation and an increase in temperature in the crop, the mineral content decreases sharply. At the same time, there is a tendency to increase the fat content. Changes in carotene content are similar to changes in the amount of protein. These patterns make it possible to predict the quality of the crop before harvest depending on the conditions of humidity and temperature, which is important, for example, in the manufacture of high-protein grass meal.

In cereals, the content of protein, carotene and ash elements in the case of insufficient moisture is significantly reduced, although these crops are quite drought-resistant.

In the Forest-Steppe, the content of protein, carotene and ash elements in the early spring crops depends less on the moisture supply than in the late ones. Due to the fact that these crops are sown in early spring, their growing season is short, they are better provided with moisture. If there is not enough precipitation in the spring, then the soil remains moisture reserves accumulated in the autumn-winter period.

With excessive soil moisture and low temperatures in this area, nitrification processes are often delayed, due to which plants lack the available forms of nitrogen, and hence its reduced content in plants.

The green mass of early spring is of slightly higher quality, if formed at elevated temperatures. This may explain, for example, the increased protein content in the crop of oatmeal mixture, when the intense increase in temperature contributes to the intensive process of nitrification. However, late sowing of early spring due to elevated temperatures and reduced rainfall has a negative effect on the accumulation of nitrogen and phosphorus in their crops.

Numerous experiments conducted on irrigated lands testify to the positive effect of sufficient supply of plants with moisture and increase of protein, carotene and ash elements content. Especially increases the content of protein and carotene in legumes.

Thus, the formation of forage crops, its level and quality depend on meteorological factors, especially on the conditions of humidity and temperature. Therefore, a promising area in crop production is to identify quantitative relationships between weather elements and indicators of yield and quality of forage crops.

It is known that the crop and its quality are formed under the constant influence of meteorological factors, primarily light, heat, moisture. All of these factors are highly variable and interrelated. Different forage crops realize their potential only under certain optimal conditions. In order to properly select crops for growing in a particular soil-climatic zone, it is necessary to take into account both agro-climatic resources and the needs of plants in the main factors of growth and development.

The climate of the Forest-Steppe of Ukraine is temperate--continental. The average daily air temperature is 6-8°C, the sum of active temperatures during the growing season of certain crops is in the range of 2100-2500°C. In April and May, the average monthly temperature according to long-term data reaches 8.4°C and 15.3°C. This air temperature promotes sowing at an earlier date, friendly germination of seeds, the appearance of friendly and full seedlings. The duration of the period with a temperature above 5°C averages 210-215 days, and with a temperature above 10°C – 150-189 days. The average long-term norm of the sum of active temperatures over 10°C during the growing season is at the level of 3078°C.

The average cessation dates of the last spring and the beginning of the first autumn frosts are April 14-21 and October 7-10, respectively. Deviation from the average dates of the beginning of the first autumn frosts sometimes reaches 10-20 days.

The average annual value of headlights for the growing season in the Forest-Steppe zone is 1676 MJ/m^2. This amount is quite enough to form a high crop yield.

According to the meteorological post of the Separeted Subdivision of National University of Life and Environmental Sciences of Ukraine “Agronomic Research Station”, the average annual precipitation is

562 mm and during the growing season – 354 mm of precipitation (63% per annum). During the year, they are distributed unevenly: in spring it is 126 mm (22.4% of the annual amount), in summer – 204 (36.3%), in autumn – 106 (18.9%) and in winter – 126 mm (22.4%).

During the period with an average daily temperature above 10°C, 310-330 mm of precipitation falls. Vysotsky's hydrothermal coefficient is 1.3.

During the growing season, the greatest variability is characterized by the sum of precipitation and temperatures above 10°C. Humidity is the most stable (coefficient of variation 2.8%).

Geographically, the territory of Ukraine is divided into main zones: Polissya, Forest-Steppe, Steppe. The Forest-Steppe zone stretches from the Carpathians to the eastern borders of Ukraine in a strip that exceeds 1 thousand km. Its area is over 20.1 million hectares, or 33.6% of the total territory of Ukraine. The Forest-Steppe zone covers Cherkasy, Poltava, Vinnytsia, Ternopil, most of Khmelnytsky, Sumy, eastern districts of Lviv, Ivano-Frankivsk, Chernivtsi, southern districts of Volyn, Rivne, Zhytomyr, Kyiv and Chernihiv, northern districts of Kharkiv and Mykolaiv.

With relatively mild winters, moderately humid and warm summers and available fertile soils, the most favorable conditions in Ukraine for growing high and stable yields of almost all heat- and moisture-loving forage crops are noted here.

37.2% of the sown area of grain crops is concentrated in the Forest--Steppe. In addition, large areas of farms are set aside for fodder crops, which provide fodder for available meat and dairy livestock, pigs and poultry. At the same time, as the mentioned zone crosses the territory of Ukraine from west to east between Polissya in the north and the Steppe in the south, it is characterized by heterogeneity of soil-climatic and weather conditions.

Plant life, growth and development are the result of constant interaction between the plant and the environment. These processes are most successful in favorable conditions with the optimal amount. Hence, the existing patterns of growth, development and formation of crops in the system “soil-plant-atmosphere” need a comprehensive study, taking into account the quantitative and qualitative assessment of the impact of meteorological conditions. After all, as is known, the highest productivity of crops is always formed by a certain combination of meteorological elements and optimal indicators of the latter, which are determined by the biological properties of plants.

Nowadays, with the rapid intensification of agricultural production, the climate and weather should be considered not only as natural factors, but also as economic and social. Therefore, an important condition for the economic activity of specialists, as well as their search for possible means to reduce the impact of climate change and weather anomalies on the crop is the annual accounting and objective analysis of temperature, rainfall, soil moisture and other similar factors.

2.2. The influence of daylight duration and light quality on the rate and volume of crop production

Solar energy is an indispensable, mandatory environmental factor in the existence of plants and living organisms. Light is the main component of photosynthesis in plants, and solar radiation is the main energy resource of the earth. The radiation factor is determined by the heat input from the sun. It depends on the length of the day and the height of the sun above the horizon. Its level is influenced by cloudiness, transparency of the atmosphere and the state of the earth’s surface.

On the territory of Ukraine during the year the noon altitudes of the sun vary considerably: in winter from 25°C in the north to 23° in the south; in summer from 60° in the north to 6° in the south. Due to this, the length of the day also varies: in winter from 7.4 to 8.6 hours, in summer from 15.3 to 16.0 hours, respectively.

The duration of sunshine should be indicated as an important indicator of the radiation regime. The latter is the time during which direct sunlight falls on the earth's surface. In the Forest-Steppe zone, according to long-term observations, the total annual duration of sunshine exceeds 2000 hours. At the same time, monthly figures in winter are 15-30 percent, in summer – 60 percent of the possible amount.

The minimum value of the duration of sunshine is observed in December (33-45 hours). In January, the duration of sunshine increases slightly, while in February its rate increases by 2 times compared to December (55-70 hours).

From March, the duration of sunshine increases rapidly and reaches 120-155 hours, in April – 160-170, in May – 240-260 hours. During June, the number of hours of sunshine remains almost unchanged. This is a consequence of the increase in cloudiness compared to May, because the rate of sunshine in June exceeds May by only 10-30 hours. In July, it reaches the highest values of the year and is at the level of 260-300 hours. In the following months, the duration of sunshine decreases and is: in August – 230-250 hours, September – 170-180, October – 100-140, in November – 45-50 hours.

The main amount of heat the green mass of plants receives due to solar radiation. In the Forest-Steppe zone, the total radiation per year varies from 95 to 107 kcal per 1 cm^2. The total value of photosynthetic active radiation of HEADLIGHTS for the period with temperatures above plus 5°C and plus 10°C is 1600-1750 and 1460-1470 MJ/m^2, respectively. Most of this heat reaches the earth's surface in the spring and summer.

The cultivation of many major crops depends on a certain amount of solar radiation. However, during photosynthesis, plants do not use the entire spectrum, but only the part that is in the wavelength range of 0.38-0.71 μm. It is called photosynthetic active radiation (PHARE). HEADLIGHTS are one of the important factors that ensure the productivity of agricultural plants. To accumulate organic matter in the latter, it is necessary that the energy illumination created by solar radiation exceeds the so-called compensation point. For crops, this value should be within the intensity of HEADLIGHTS 20-35 W/m^2. At lower values, the consumption of organic matter for respiration is observed, the intensity of photosynthesis decreases, and hence the future yield.

Solar energy is used by plants throughout their lives. The sun affects plants not only directly, but also through the heating of the environment, ie air and soil. The efficiency of radiant energy use by plants is determined by the efficiency. Thus, the efficiency of photosynthesis of vegetation of cultivated plants is in the range of 0.5-1.0%. However, it is estimated that theoretically the efficiency can reach 5-10 percent or more. Thus, the development of plants, possible yields, as well as the chemical composition of the crop depend on the length of daylight and the size of the headlights.

Light affects the formation of plastic substances. Without light, life processes in the vast majority of plants are impossible, and it matters not only the intensity but also the composition of light. Today, in response to light, plants are conventionally divided into groups: those that require long daylight (long-day plants – wheat, rye, oats, barley, peas, flax, poppy, clover, alfalfa, beets, carrots); those that require short daylight (short-day plants – millet, corn, beans, soybeans, sorghum);

intermediate and neutral plants. Distinctive feature of intermediates crops – they do not bloom or bear fruit, while neutral plants – do not respond to the length of the day.

Plants grown in low light conditions contain little chlorophyll. They are characterized by poorly developed mechanical tissue, there is a lack of valuable nutrients, especially sugars. In the case of shading, the plants stretch upwards, which weakens the tillering, reduces the mass of aboveground organs. The development of the root system also deteriorates. In years when cloudy weather prevails, insufficient light causes poor differentiation of plant tissue. This often leads to lodging of cereals under the influence of wind and rain. Green mass of fodder crops in sufficient light contains more protein, gluten, fat and other valuable substances.

In the process of evolution, plants have adapted to the conditions of receipt of a certain amount of solar energy, which they are able to accumulate. Establishing the amount of energy and heat from the Sun, as well as forecasting these indicators allows you to adjust the elements of technology for growing legumes in order to form the highest level of yield and minimize the anthropogenic impact on the environment. The intensity of solar energy absorption processes largely depends on the spectral composition of sunshine, energy balance between energy absorbed and the cost of photosynthesis, photooxidation, evaporation, heat and moisture exchange, the presence of nutrients in the soil and so on.

In agriculture, a number of scientifically sound agronomic measures are used to regulate the amount of solar radiation obtained for an individual plant. Among such measures the most common should be: creating the optimal density of plants, changing the direction of sowing relative to the sides of the horizon, compatible crops, creating a multi-tiered grass in crops, the formation of optimal leaf surface.

Using the method of taking into account the inflow of solar radiation during the study, the coefficients of photosynthetically active radiation by crops of the studied crops depending on technological schemes of cultivation and the potential level of this indicator under full use of natural and agrotechnical potential of the Forest-Steppe zone of Ukraine.

The maximum coefficient for the existing and optimized cultivation technology in the range of 1.63-2.87% was observed in the cultivation of alfalfa, which is more than 7.9-23.5 and 20.1-35.4 relative percent compared to clover and sainfoin.

Correlation-regression analysis allowed to establish a high potential level of KFAR with maximum use of natural and technological factors. Under such conditions, when growing alfalfa, this figure will be 3.71%, and clover and sainfoin – 3.28-3.52%.

2.3. Temperature regime and its influence on the growth and development of legumes

Along with light, heat is also one of the main factors of plant life, without which biological, chemical and physical processes are impossible. Thus, the thermal regime of the surface layer of air and soil determines not only the rate of plant development, but also the level of yield in general.

In the Forest-Steppe zone, the average annual air temperature is 7-8°C warm. At the same time, the lowest average January air temperatures are observed in the eastern Forest-Steppe (minus 7-8°C); in the west they rise to minus 4-6°C. Summer in the Forest-Steppe is usually warm.

During the year, the average monthly air temperature reaches its highest values in July and in the west of the zone it is 18-19°, in the east – 19-21°C.

The third decade of January – the first decade of February is the coldest period of the year, while the second or third decade of July – the warmest.

Air temperature of 30°C and above, which can negatively affect the growth and development of crops, happens in periods (within 10-80 hours), mainly in July-August. The average duration of the period per year with a minimum temperature of minus 20°C and below is in January-February and is 5-9 days.

The duration of the period with an air temperature of minus 30°C and below does not exceed one day.

An important characteristic of the thermal regime for the cultivation of various crops is the duration of the warm period of the year in general and the growing season in particular. Thus, the longer the warm period in conditions of sufficient supply of other factors, the more diverse the set of crops grown and the better the quality of agricultural products obtained from them.

In meteorology, the transition of the average daily air temperature through 0°C in the direction of warming is considered to be the beginning of spring, and its transition in the autumn in the direction of cooling – for the beginning of winter.

The growing season of the vast majority of crops is limited to the number of days with average daily air temperatures above 5°C, heat-loving at 10°C and quite heat-loving above 15°C.

Dates of stable transition of the average daily air temperature through 5°C fall on the period of snow cover rise and the beginning of rapid development of spring processes. This temperature period (end of

March – first half of April) is the beginning of the vegetation process of field crops – intensive restoration of winter vegetation and sowing of early spring.

Autumn transition of the average daily air temperature through 5°C in the direction of decrease in the Forest-Steppe zone is observed in the end of October.

The dates of stable transition of the average daily air temperature through 10°C in the spring determine the terms of sowing of thermophilic crops. Active growth and development of the latter occurs at an average daily air temperature above 10°C, so the period with this temperature is called the period of active vegetation of thermophilic crops. Throughout the Forest-Steppe zone, the transition of the average daily air temperature through 10°C begins on average in the third decade of April.

In autumn, the transition of the average daily air temperature through 10°C in the downward direction occurs in the first decade of October and indicates the cessation of active vegetation of thermophilic crops.

The dates of steady transition of the average daily air temperature through 15°C in the direction of decrease and increase are limited to the summer season.

In the Forest-Steppe, temperatures above 15°C are set on average in May.

The autumn transition of the average daily temperature through 15°C in the direction of decrease, which is accepted for the end of summer and the beginning of autumn, is usually observed in the first decade of September.

The most optimal terms of the beginning and end of field works and zoning of agricultural crops are determined by the duration of the periods between the dates of stable transition through 5, 10 and 15°C. The duration of the mentioned periods on the territory of the Forest-Steppe averages 201, 158 and 109 days, respectively.

The possible period of vegetation of agricultural crops of the district is significantly adjusted by frosts. The average date of the last spring frosts is fixed on April 17 (the earliest on March 22 and the latest on May 24), the first autumn frosts – on October 16 (the earliest on September 20 and the latest on November 12). According to available data, the duration of the frost-free period is 160-170 days.

The duration of the warm period in the Forest-Steppe zone ranges from 230 to 275 days; duration of the growing season – is within 190-210 days; period of active vegetation – 150-180 days.

In practice, the sum of active and effective temperatures is most often used to assess the thermal resources of an area in relation to the cultivation of different crops or the development of pests. In the Forest-Steppe zone, the sums of active temperatures are as follows: over 5° – 2980°C, 10° – 2645°C and 15° – 2005°C. The sums of effective air temperatures above these limits are 1955, 1035 and 340°C, respectively. The average minimum soil temperature at the depth of the winter tillering site is 11°C with the absolute minimum in February – 21°C.

The average depth of soil freezing is 50-70 cm (maximum – 150 cm, minimum – 10-15 cm). The formation of aboveground organs, as well as plant development increasingly depend on air temperature. However, in different periods of growth and development of plants are equally demanding of heat. In addition, some crops need more heat during the growing season, others – less. For example, such a crop as oats from the beginning of growth to ripening requires a sum of positive temperatures above 10° – 1300°C, corn of different hybrids –

1500-2000°C, barley – 1100-1200°C, winter wheat – 1300-1600°C, peas – 900-1200°C, sugar beets – 1600-2000°C, potatoes - 1000-1200°C.

The minimum ripening temperature for cereals, legumes – 10-13°C, root crops – 6-10°C. At the same time low temperatures cause a decrease in the yield of reproductive organs (grain), but under such conditions the total mass of straw and roots increases. Harmful to the vegetation of plants are frosts. According to the reaction to them, plants are divided into appropriate groups: very resistant (spring wheat, oats, barley, peas, lentils, rank, poppy); resistant (lupine, beans, sunflower, flax, fodder and sugar beets, carrots, cabbage); low-resistant (soybeans, corn, potatoes, millet, sorghum); not stable (buckwheat, beans, melons, cucumbers, tomatoes).

At both low and excessive temperatures, plants slow down physiological functions, such as photosynthesis, respiration, transpiration, and so on. In the case of excessively high temperatures (above the optimum), the decomposition of substances increases and the synthesis weakens, there are deep violations of the vital functions of plant organs, resulting in the death of the latter or the death of the entire plant.

2.4. Moisture supply as one of the main factors in obtaining stable yields

An important condition for obtaining high, stable and high-quality crops is the full supply of moisture. Moisture is required for plants from the beginning of seed germination to the onset of the ripening phase. However, in most parts of Ukraine, crops suffer from a lack of moisture, which negatively affects their growth and production efficiency. Precipitation is the main source of moisture for plants. The month with the highest precipitation in Ukraine is March.

Starting from April, there is a gradual increase in precipitation, which continues in May and July.

In the Forest-Steppe, for the most part, the maximum annual rainfall falls in July. The amount of precipitation in August and September decreases.

October is characterized by a slight increase in monthly precipitation compared to September. In November, the amount of precipitation, compared to October, decreases throughout the territory.

In December, less precipitation falls than in November.

In the summer and winter months, the monthly minimums of precipitation in the zone do not exceed 10 mm, and in the Forest-Steppe zone there are rainless periods. Rains are periods when there is no precipitation for more than 10 days. They usually cause damage to agriculture, causing significant disturbances in the processes of plant life.

According to research, the frequency of rainy periods increases from northwest to southeast. However, rainy periods lasting more than 20 days are not celebrated every year. For most crops, the provision of the growing season with moisture is estimated by its presence in the soil layer 0-20, 0-50, 0-100 cm.

According to the level of humidity, the Forest-Steppe zone is divided into three agroclimatic subzones – sufficient, unstable and insufficient moisture.

The subzone of sufficient moisture is formed by Volyn, Rivne, Lviv, Ivano-Frankivsk, Ternopil, Chernivtsi (except eastern districts), Khmelnytsky and Zhytomyr regions, north-western districts of Vinnytsia and northern forest-steppe districts of Chernihiv and Sumy regions. In this area, the average annual rainfall is 570-600, during the growing season – 380-450 mm. Towards the southeast, precipitation decreases, but prolonged droughts are almost non-existent. For the vast majority of years, the water regime of the soil was favorable, droughts were rare and short-lived, and water reserves were rapidly restored.

Unstable humidification subzone is a transitional subzone of sufficient moisture from the north and west, and insufficient moisture from the south and east. This line covers Mohyliv-Podilskyi, Uman, Yahotyn, Romny, Sumy, Kharkiv.

This location determines the significant diversity of areas in terms of soil differences, as well as the supply of plants with water, temperature and other meteorological conditions. During the year, on average, up to 480-500 mm of precipitation falls here.

To the south of the zone of unstable humidification there is a subzone of insufficient humidification. It covers the southern forest-steppe regions of Odessa, south-western and north-eastern forest--steppe regions of Kirovohrad and southern regions of Poltava regions. During the year 430-480 mm of precipitation falls here, during the growing season – 300-340 mm of precipitation.

Precipitation is fairly unevenly distributed throughout the year. The main number of them falls in the warm period of the year (70-75%).

In the forest-steppe zone, snow cover appears in the second or third decade of November (November 15-25). It completely rises on average in late March. The number of days with snow cover varies from 100-110 in the northeast to 70 in the southwest. The average height of snow cover does not exceed 20-30 cm.

As a rule, the largest reserves of productive moisture in the soil are formed in the spring and reach 160-170 mm. The harvest of agricultural crops depends on them. Then, during the growing season, moisture reserves are significantly reduced due to evaporation and use by plants. Under winter at the beginning of ripening its reserves are 80-90 mm; spring cereals – 75-80; corn – 90; beets – 80 mm. At the beginning of winter sowing moisture reserves are in the range of 130-135 mm (black steam) and 100-120 mm (non-steam predecessors).

In order to comprehensively assess the level of humidification of the territory using the hydrothermal coefficient (SCC). It has been established that the most favorable conditions for obtaining high yields of grain crops in the spring sowing period are created when the SCC for the corresponding growing season of the latter range from 1.0 to 1.4. For post-harvest and post-harvest crops, optimal conditions occur at SCC 1.4-1.6. In the study area, the average long-term hydrothermal coefficient for the warm period (April-October) is 1.1-1.2, with the optimal values of SCC in some years 1.3. This allows us to refer it to a slightly arid zone.

As mentioned earlier, to obtain high yields of crops requires full supply of moisture. In this case, the plants use mainly the moisture that comes through the roots from the soil. Therefore, water reserves in the soil, which plants can use during the growing season (productive moisture), are an important indicator and factor in increasing the yield of cultivated plants. As evidenced by scientific and industrial practice, the optimal soil moisture for the vast majority of plants during the growing season is 65-80% of the field moisture content.

According to the results of research, the highest yields of different crops are found in terms of humidity: corn for silage, vegetable crops, perennial grasses – 80% HB, winter wheat, rye, spring cereals, corn for grain, sugar, fodder beets, carrots – 70; sunflower – 60% FMC.

In the period from sowing to the tillering phase in cereals, the condition of plants is determined by the humidity in the upper layer of the soil (0-20 cm). If the moisture content in the specified layer is less than 5 mm, the shoots usually do not appear. For a satisfactory condition of the seedlings it is necessary that the moisture reserves were in the range of 12-15 mm. Friendly stairs are usually with stocks of 25-30 mm. With moisture reserves of 110-125 mm in the soil layer 0-100 cm, the highest yields of winter and spring cereals are obtained.

The highest grain yields of corn plants are formed with a moisture reserve of 70-80 mm in the soil layer 0-50 cm.

It is proved that for many cultivated plants it is important to moisten the arable soil layer (0-20 cm), where the main part of the root system is concentrated. Decrease in the mentioned layer of productive moisture reserves below 20 mm has a negative effect on the yield and sharply reduces it.

In different periods of the growing season the plants' need for moisture changes. At the same time, there are so-called critical periods in which plants are most sensitive to lack of moisture and from which the crop is especially lost. The most important thing is sufficient supply of plants with moisture during the formation of reproductive organs.

For the vast majority of crops, the onset of the critical period is possible in the following phases: in winter and spring ears – out into the tube – pouring grain; in corn – flowering – milk ripeness; in legumes and buckwheat – flowering – pouring grain; in sorghum, millet – earing – pouring grain; in potatoes – budding – mass tuber formation; in tomatoes – tying and fruit growth; cucumbers – fruiting. Root crops need the most moisture during the period of intensive growth of leaves and actually root crops.

At the same time, the reduction of soil moisture by 10-20% HB compared to the optimal is allowed before and after the critical period. This usually does not lead to a significant reduction in yield.

It is known that water is necessary for seed germination, as well as dissolution, movement in the soil and the supply of nutrients to the plant. It is important for maintaining turgor and appropriate temperature in plants and cells. Without it, photosynthesis, transpiration and other physiological processes that take place in the plant body are impossible. It should be noted the crucial role of moisture in the process of photosynthesis. The latter occurs normally when the water content in the cells, tissues and organs of plants is in the range of 75-80%. In the case of lack of moisture in plant tissues, hydrolysis is enhanced and they lose the ability to synthesize. In particular, hydrolysis of hydrocarbons, decomposition of proteins is slowed down and, as a result, yield is reduced.

Today, in need of revival and further development of animal husbandry, the problem of developing agrobiological bases for intensifying the cultivation of perennial legumes in the Forest-Steppe of Ukraine has become timely. Its solution requires studying the degree of variability of weather and climatic conditions, ecological plasticity of perennial legumes, optimizing the location of growing areas, the dependence of their yield and production stability on the action of a set of weather factors based on climatic characteristics and crop yields of all areas of major soil and climatic zones , as well as experimental studies, which were carried out in 11 field experiments to study the effectiveness of individual agronomic techniques and the complex action of elements of cultivation technology on the formation of high-yielding coenoses of perennial legumes during2005-2015.

2.5. Characteristics of soil and weather conditions of research

The forest-steppe zone stretches from west to east for more than 1000 km, and from north to east - more than 350 km. From 28 million hectares to 85% are arable land, about 8.5% – hayfields and 6.3% – pastures and pastures, the rest – other types of land. The natural conditions of the zone are quite heterogeneous, which is significantly reflected, first of all, in the differentiation of soil cover and its quality indicators and determines the need for appropriate zoning by soil and ecological characteristics for further rational use. In terms of soil structure, the Forest-Steppe zone is one of the most difficult. The most common types of soils here are light gray forest (3.8%), gray forest (11.5%), dark gray podzolic (13.2%), chernozem podzolic (23.9%), typical chernozem (37, 2%), meadow-chernozem (2.9%), meadow (3.6%) soils.

The soil of the experimental field is typical low-humus medium-loam chernozem, coarse-grained in the forest. The content of humus in the arable layer according to Tyurin is 4.34–4.68%, the pH of the salt extract is 6.8–7.3, and the absorption capacity is 30.7–32.5 mg-eq. per 100 g of soil. The composition of the mineral solid phase of the soil includes 37% of physical clay, 63% of sand.

The density of the soil in the equilibrium state is at the level of 1.16–1.25 g/cm^3, the humidity of stable wilting is 10.8%. Agrochemical and water-physical properties of soil are given in Tables 2.1 and 2.2.

2.1. Agrochemical characteristics of soil (according to SS NULES of Ukraine "Agronomic Research Station")

Depth of horizon, cm	Humus content, %	pH of salt extract	Carbonate content, %	Absorption capacity, mg-eq. per 100 g of soil
0-10	4.53	6.87	–	31.9
35-45	4.38	7.30	1.66	32.0
70-80	1.36	7.30	9.20	19.1
130-140	0.86	7.30	10.50	15.0
210-220	–	7.30	9.70	–

The soil is characterized by a high content of gross and mobile forms of nutrients: the content of total nitrogen (according to Kjeldahl) is 0.27-0.31%, phosphorus – 0.15-0.25 and potassium – 2.3-2.5%; mobile phosphorus (according to Machigin) – 4.5-5.5 and exchangeable potassium (according to Chirkov) – 9.8-10.3 mg per 100 g of soil. Typical chernozems in the region account for 54.6%, which allows us to recommend the results of field research in the Right Bank Forest-Steppe of Ukraine for widespread implementation.

2.2. Water and physical properties of soil (according to SS NULES of Ukraine "Agronomic Research Station")

Depth of horizon, cm	Density, g/cm³	Total porosity, %	Maximum molecular moisture content, %	Withering moisture, %	Field moisture content, %	Total moisture content, %
5-25	1.25	52	13.6	10.8	28.2	41.6
25-45	1.16	55	13.2	10.7	27.3	47.4
80-100	1.27	52	12.3	9.8	25.6	41.0
135-155	1.20	54	–	–	21.5	45.0
185-205	1.20	56	120	9.6	20.8	48.3
230-250	1.55	42	–	–	22.1	27.1

Within the experimental field, the morphological structure of typical chernozem is as follows:

- H (k) 0-55 – humus horizon – dark gray, coarse-grained medium loamy, granular-lumpy in arable and granular – in subsoil, compacted, many wormholes, the transition to the next horizon is gradual;

- NRK 55-115 – humus transitional – dark gray, coarse-grained, medium-loamy, with a granular-lumpy structure, carbonate "mold", wormholes and moles are observed, the transition to the next horizon is gradual;

- Phk 115-180 – lower transition horizon to rock – gray, light loamy, sparse, has a lumpy-prismatic structure;

- Rk 180-210 is a partially pile carbonate forest.

To characterize the weather conditions in the years of research used the data of meteorological stations: Gogolevo, Shishak district, Poltava region; Holoskiv, Letychiv district, Khmelnytsky region; Vinnytsia.

Over the years of research, weather conditions differed in humidity and temperature, which significantly affected the formation of the crop. To establish the typicality of weather conditions, the coefficients of materiality of deviations were calculated, which allow to visually assess the deviations of certain agrometeorological conditions in comparison with long-term norms. Deviations for which the materiality factor is less than+ 1 are considered insignificant, significant – at a value of + 1-2 and extreme – at a value greater than + 2.

Temperate climatic conditions LLC. Dovzhenko of Shishatsky district of Poltava region; LLC "Poltavazernoproduct", Globino, Poltava region; LLC "Khmilnytske" of Khmilnytskyi district of Vinnytsia region, LLC "Volochysk-Agro", Volochysk of Khmelnytsky region of the Right Bank Forest-Steppe of Ukraine in combination with native rocks and plain relief differ in fertile chernozem soils in these territories, the main part of which is provided by micro- and macroelements that determine soil fertility. In terms of humus content in the soil, the forest-steppe zone occupies a priority place among other regions of Ukraine. These areas have significant agricultural resource potential. The main part of the lands of these regions – about 76%, is in agricultural use.

The climate of the research sites is temperate-continental. The long-term average annual air temperature is 7.5°C. The average long-term temperature in July is 19.6°C, in January – minus 6.9°C. The last spring frosts occur until May 18-20, the first autumn – September 18-20.

Winters in the area are mild. The third decade of November is characterized by the beginning of winter and is determined by the transition of the average daily air temperature through 0°C. In recent years, there has been significant warming in the winter. The average temperature in December is minus 4°C, in January – minus 6°C, in February – from minus 5°C to minus 6°C. In winter there are frequent thaws, the duration of which varies. The snow cover is unstable, its average thickness does not exceed 18-20 cm. The average long-term depth of soil freezing is 42-44 cm (in some years 70-80 cm).

On average, 563 mm of precipitation falls per year, of which 125 mm (22%) in winter, 126 mm (22%) in spring, 204 mm (36%) in summer and 108 mm (20%) in autumn. During the growing season, 333 mm or 59% of annual indicators fall. Their distribution is quite uniform, resulting in satisfactory moisture conditions during the growing season of field crops. The average relative humidity is quite high (79.4%).

The duration of the growing season with an average daily temperature above 5°C is 210-215 days, above 10° – 161 days and above 15°C – 115 days. The transition of average daily temperatures through 5°C is observed at the beginning, and after 10°C – at the end of April.

Intensive growth of most plants begins with the establishment of average daily temperatures above 10°C. The transition of the average daily air temperature above 15°C occurs in the second half of May, below – in early September. June is mostly warm, and July and August are hot; the average air temperature in May and June reaches 18–20°C, in July and August 22-23°C (maximum – 38°C).

An important factor in the cultivation of fodder crops is the length of daylight (Table 2.3).

According to the analysis of meteorological data, it was found that the length of the day, starting from April, increases by 30-40 minutes, and reaches a maximum in June. For all decades of this month there is almost the same duration.

Starting in July, the length of daylight decreases. These indicators must be taken into account in the biological selection of forage crops, growing them in intermediate crops.

In a particular farm when selecting fodder crops should take into account the peculiarities of changes in the sum of temperatures, which largely depend on the microrelief. According to long-term indicators, the sum of active temperatures for the period with a temperature of 5°C reaches 2980°C, and from 10° – 2645°C. The sums of effective temperatures above 5°C are 1955°C, above 10° – 1035°C.

2.3. The length of daylight when growing perennial legumes in the Forest-Steppe zone (according to SS NULES of Ukraine "Agronomic Research Station")

Month	Decade months	The length of the day	
		hours	minutes
January	First	8	15
	Second	8	39
	Third	9	20
February	First	9	24
	Second	10	49
	Third	11	00
March	First	11	05
	Second	11	59
	Third	12	53
April	First	13	9
	Second	13	46
	Third	14	23
May	First	14	56
	Second	15	27
	Third	15	53
June	First	16	15
	Second	16	25
	Third	16	26
July	First	16	17
	Second	15	59
	Third	15	34
August	First	15	06
	Second	14	30
	Third	13	53
September	First	12	48
	Second	12	27
	Third	12	00
October	First	11	37
	Second	10	14
	Third	9	50
November	First	9	45
	Second	9	12
	Third	8	26
December	First	8	22
	Second	8	18
	Third	8	9

An important ecological factor for the normal development of post-harvest crops is the sum of active temperatures during their growing season. Different cultures need different meanings. Thus, for oilseed radish it is 600-700°C, for peas – 800-1000°C, rapeseed – 700-800°C, white mustard – 700-1000°C, oats – 600-1000°C.

The most important environmental factor, which in most cases plays a crucial role in shaping the value of crop yields, is the meteorological conditions that developed during their cultivation.

The analysis of weather conditions of the years of experimental research was carried out according to the hydrometeorological point "p. Wheat", which is located in the area of activity of Separeted Subdivision of NULES of Ukraine "Agronomic Research Station".

The main parameters that characterize the weather conditions of the research years show that the years differed significantly in the main indicators. Thus, for most of them there was an increase in average monthly air temperature and sharp fluctuations in rainfall intensity, when prolonged droughts were replaced by periods of prolonged rains, which negatively affected the growth and development of cabbage crops and the formation of appropriate yields.

Agrometeorological conditions for growth, development and formation of leaf mass of the 2002/2003 growing year were unfavorable, and in general (autumn – winter – spring) these are the most unfavorable conditions for the last 50 years in this area. Sowing, which began in the summer, took place in dry weather, which led to unfriendly seedlings of alfalfa plants. In autumn, especially in September, a large amount of precipitation fell. In general, the weather conditions of October and November did not contribute to the formation of normal winter hardiness of alfalfa plants sown at different sowing dates.

In December-January-February and in March the territory was dominated by a stable winter weather regime with intense frosts, in some periods – with short-term thaws. In terms of temperature conditions, the most unfavorable wintering conditions developed in December. The minimum air temperature decreased to minus 19-21°C. The soil surface in the absence of snow was cooled to minus 23-25°C. Due to the thaw that occurred in late December, rainfall and subsequent cooling, the fields began to form a crushed ice crust, which persisted and increased in thickness during the thaw almost until early March.

In the first – second decades of March, the melting of snow and the destruction of the ice crust was extremely slow, the duration of its occurrence at that time reached 75-85 days (critical period 40-45 days).

Adverse conditions were also observed during the period of restoration of spring vegetation of alfalfa sowing – active increase of heat, advantage of dry weather. Active vegetation of alfalfa plants began at the end of the first decade of April, 1.5-2 weeks later than the average long term. The development of spring processes, which were largely determined by winter conditions (the presence of snow cover and freezing of the soil), occurred with a significant delay compared to the norm.

Due to such meteorological conditions, overwintering alfalfa crops of different sowing dates at the beginning of the vegetation recovery had a different state of development. Spring sowing (April-early May) and summer (July-August) sowing dates had a low level of overwintering, so most of them had to be replanted. Alfalfa plants sown in the spring, sown in the spring, overwintered best. Despite the fact that alfalfa plants sown during this sowing period were also partially liquefied, but later they underwent a full cycle of development in ontogenesis and provided high yields.

Agrometeorological conditions of the 2003-2004 growing year were favorable for growing many perennial legumes, as the average air temperature was 0.2°C higher than the average perennial. This had a positive effect on the growth and development of alfalfa.

The autumn growing season of alfalfa was relatively warm. During the sowing period there were favorable conditions for seedlings. The average monthly temperature in September was 13.2°C, in October – 6.8°C and in November – 3.4°C, while the average long-term temperature was 14.3; 7.8 and 1.9°C. The cessation of vegetation in 2003/2004 took place in the first decade of November. A steady decrease in temperature after 0°C was observed in the first decade of December. The weather in the winter months of 2004 was relatively warm. The average monthly temperature in January, February and March was higher than the long-term average. The resumption of spring alfalfa vegetation this year took place in the middle of the second decade of March. Intensive regrowth of alfalfa sowing began in late March-early April.

The spring months (March and April) of 2003-2004 became relatively warm. Average monthly temperatures exceeded long-term averages by 2.7; 0.1°C. In May, recorded sharp drops in temperature, sometimes before frost.

The summer months this year in terms of air temperature were also close to the average perennial.

2004-2005 vegetation year. The average air temperature in September was 13.4°C; October – 8.7°C; November – 2.0°C, but in November only in the first and second decades the temperature was higher than 0°C – 6.1 and 3.8°C, respectively. The transition through 5°C took place on November 15. The first cessation of autumn vegetation (transition through 0°C) occurred on November 20. From December 3, the average daily temperature again exceeded 0°C and the reverse transition took place only on December 14, and later in December and January the average daily temperatures were lower, but close to it, and on some days in December even slightly above 0°C. The average daily temperature in December was – minus 1.5°C; January – minus 1°C; February – minus 4.8°C; the first decade of March – minus 4.6°C; the second decade of March - minus 0.7°C.

The amount of precipitation in the autumn was insignificant: 46.2 mm fell in September; October – 19.1; November – 26.4 mm. Precipitation, which fell in August (104 mm), became the main source of moisture: the first decade – 67.3 mm; second decade – 10.6; the third decade – 26.3 mm. Due to such conditions, no intensive tillering and overgrowth was observed in the autumn.

The winter period of 2005-2006 turned out to be favorable for sown perennial legumes. December was warm, the temperature transition through 0°C occurred at the beginning of the second decade. The decrease in temperature in January 2006 did not affect the overwintering of alfalfa due to heavy snow cover, which formed at the beginning of the month.

The meteorological conditions of the 2006 growing season differed slightly from the long-term averages. March was cold and the average monthly temperature was minus 2.0°C. The average temperature in April-May exceeded the norm by 1.7-1.2°C. A steady transition of air temperature through 0°C was recorded in the first, and after 5°C – in the second decade of April, which stimulated the supply of nutrients, early terms of vegetation restoration and intensive herbage of alfalfa.

Sufficient rainfall in April-May (152.6 mm) became a favorable basis for the formation of reserves of productive moisture in the active layer of soil in spring and early summer. Favorable meteorological conditions of the spring period had a positive effect on the growth and development of perennial grasses. The average temperatures for April-October were close to the average long-term values. The air temperature in April-May was 1.5-1.2°C higher compared to long-term values, which contributed to the growth and development of grasslands and ensuring high yields of the first mowing. Favorable temperature prevailed in September-October, which ensured the accumulation of sufficient spare plastic substances and overwintering agrophytocenoses. During the growing season, 343.7 mm of precipitation fell, which is 25.5 mm more than the average long-term values, but they fell unevenly. In March-June there was much more precipitation compared to long-term averages.

Sufficient rainfall contributed to the growth, development and formation of high yields. In the second half of summer (July-August) and in the autumn months of 2006, precipitation fell below the long-term average values for the region, which had a negative impact on the yield of forage crops. In July and August, the hydrothermal coefficient reached the lowest value compared to the norm. At the end of the 2006 growing season, it rained. They caused an increase in the hydrothermal coefficient, which had a positive effect on overwintering perennial legumes.

The winter period of 2006-2007 turned out to be relatively warm. Indicators of air temperature in December were characterized by a positive value (close to 0°C at long-term values from minus 5 to minus 7°C). Temperatures in February dropped to minus values – minus 4.5°C at minus 6.5°C. The amount of precipitation in the winter was close to the long-term average values in the study area. The temperature regime of the winter period of 2006-2007 contributed to the successful overwintering of grasslands.

The spring months, in particular March and April 2007, were 1.0-4.2°C warmer in terms of temperature compared to long-term values. Sufficient soil moisture in combination with a favorable temperature regime was ensured by intensive regrowth of grasslands, rapid weight gain and formation of high yields. The spring months were favorable in terms of temperature, while the summer months (June, July, August) were relatively hot. The air temperature in June was 2.0°C higher than the long-term average by 0.8°C in July and by 1.8°C in August. September and October were characterized by its excess by 1.0-1.5°C compared to the long-term norm. December turned out to be much warmer – 1.2°C above the norm. Thus, 2007 with the average annual temperature plus 9.9°C was the warmest.

Precipitation in December was less than normal (by 23 mm). In January they fell 34 mm, and in February 14 mm (norm 38 and 37 mm), in March close to the norm. During the growing season, except in May and June, there was a shortage of moisture, which had a negative impact on the formation of yields of alfalfa and cereal stands. During the growing season, precipitation was distributed unevenly. Their number in May was less than the norm by 14 mm, in September – by 28 mm, which negatively affected the yield of both the first and second slopes. In November, 86 mm of precipitation fell (at a rate of 49 mm), which replenished autumn and winter moisture reserves in the soil. In April-May, the amount of precipitation was significantly lower than the long-term norm – the hydrothermal coefficient was extremely low compared to the long-term norm. Drought periods were recorded in May and September, which affected the yield during the growing season and especially the second slope.

The sum of active temperatures in 2007 significantly exceeded the long-term norm. In general, the weather conditions in 2007 were unfavorable for the region, which was manifested in significant drought, extremely high temperatures and low hydrothermal coefficient.

Thus, the growing season April-October seemed hot and dry, and not favorable for growing perennial legumes. Only elements of technology (selection of intensive grass mixtures, strip crops) taking into account specific weather conditions made it possible to achieve the goal – to obtain a high yield of sown agrophytocenoses.

Meteorological indicators of the winter period of 2007-2008 were favorable for overwintering of sown legumes – almost no snow cover in the winter months, with an average monthly temperature of 1.2°C in December, 1.3°C in January, and in February 3.9°C higher than the long-term norm. Such temperature conditions, although the snow cover was insignificant, contributed to the successful overwintering of grasslands. Autumn 2007 came at a time close to the long-term average (a steady transition of the average daily air temperature through 15°C downwards took place on September 8-9).

In most days of September, moderately warm unstable weather prevailed. The sunshine reached the Earth's surface for almost 199 hours (105% of the lunar norm). The average monthly air temperature was close to normal and in absolute terms was 13.6-15.4°C. The maximum air temperature in the first decade of September rose to 26-29°C. In the second half of the month frosts were recorded, the minimum temperature decreased from 6°C of heat to minus 1°C of frost. Precipitation was observed for 5-10 days. In the vast majority of the region for the month they fell from 38 to 52 mm (87-133% of the monthly norm). In the third decade of September, agrometeorological conditions for sowing and vegetation of winter crops were favorable.

In October, the weather remained warmer than usual for this time of year. Sunlight reached the earth's surface for a month up to 118 hours

(96% of the lunar norm). The average monthly air temperature was 1.0-1.8°C higher than normal and in absolute terms was 8.5-9.8°C. On the warmest days, the maximum air temperature rose to 23-26°C of heat, and the minimum on the coldest nights decreased from 1°C of heat to minus 3°C of frost. The surface of the soil in the warmest days was heated to 33-40°C of heat, at night it was cooled to minus 1-4°C of frost. Rains of varying intensity fell for 3-6 days. In the territory of the region for a month they fell from 16 to 27 mm, or 42-74% of the monthly norm. The average monthly relative humidity was in the range of 74-83%. A steady transition of air temperature through 10°C took place on October 5-10 (a week later than the average long-term terms). From the beginning of September to the end of the third decade of October, the sum of effective temperatures above 5°C in the region was 325-440°C at 345-390°C.

In the third decade of October, agrometeorological conditions for winter growth and development were satisfactory. As of October 28, the reserves of productive moisture in the arable layer of the soil on most sown areas with winter crops are defined as lower than optimal.

In November, the weather was slightly colder than usual with precipitation. The average monthly air temperature was 0.9-1.7°C below normal and in absolute terms was 0.2-1.2°C heat. The maximum air temperature on the warmest days increased to 10-12°C of heat, the minimum on the coldest nights decreased to 7-12°C of frost. The soil surface was cooled to minus 10-15°C of frost. Precipitation was observed for 7-11 days. In the region for the month their number ranged from 66 to 87 mm (151-215% of the monthly norm). The snow cover, which formed at the beginning of the second decade of November, was 1-3 cm high at the end of the month. During the third decade of November, the agrometeorological conditions for overwintering of winter crops were satisfactory. The minimum soil temperature at the depth of the tillering node below minus 1-4°C did not fall, which is much higher than the critical limits of freezing, even for underdeveloped plants. As of November 30, the critical freezing point of winter wheat of medium frost resistance was 13-17°C. The condition of crops was generally assessed as good.

Conditions for hardening winter crops due to warm and cloudy weather were unfavorable.

December seemed warmer than usual. The average air temperature per month was 04-1.3°C, which is 1-3°C above normal. On the coldest nights the frosts reached minus 5-8°C, on the warmest days of the month the maximum air temperature rose to 5-10°C heat. The soil surface was cooled to minus 5-10°C.

In December, there was a shortage of precipitation - for the month their amount in the region was 19-30 mm, or 38-63% of the norm.

During the last decade of December, the wintering of winter crops was satisfactory. Despite the lack of snow cover, the soil temperature at the depth of the winter wheat tillering site, rye below minus 2-4°C did not decrease and did not pose a threat to wintering plants.

During the first decade of January, the weather remained cold without precipitation. In the second and third decades of January it got much warmer and it rained. The average monthly air temperature was minus 2.7-3.5°C below zero, which is 2.3-3.3°C above normal. The maximum air temperature in the third decade rose to 6-8°C heat. The minimum air temperature in the first decade of January decreased to minus 14-17°C of frost. The snow surface on the territory was cooled to minus 17-21°C.

Precipitation was observed for 4-8 days in the form of rain, mist, wet snow and sleet. In most parts of the region they fell from 54 to 69% of the monthly norm.

Overwintering of winter crops during the month took place under satisfactory agrometeorological conditions. Winter crops in most parts of the territory were covered with a small layer of snow 1-4 cm. The minimum soil temperature at the depth of the tillering node below minus 4°C did not fall, which is much higher than the critical freezing limits even for underdeveloped plants.

February was characterized by high temperatures. For almost the whole month, the average daily air temperatures were higher than the norm by 2-8°C, in the third decade – 6-13°C. The average monthly air temperature was 5-6°C higher than normal and in absolute terms ranged from minus 0.1 to plus 1.1°C. The minimum air temperature decreased to minus 13-16°C of frost, the maximum air temperature increased to 13-17°C of heat.

Precipitation in most parts of the region fell from 8 to 22 mm (24-65% of the monthly norm). At the end of the decade, winter crops resumed vegetation throughout the region. The condition was mostly good. In March, the weather remained unstable with precipitation. The average monthly air temperature was 4-5°C higher than normal and in absolute terms was 3.9-4.8°C heat. On the warmest days, the maximum air temperature rose to 15-17°C. The minimum air temperature on the coldest nights dropped to minus 3-6°C. The soil surface was cooled to minus 4-11°C, during the day it was warmed up to 22-32°C. Precipitation in March was observed for 6-13 days in the form of snow, sleet and rain. Their total number for the month was 27-45 mm (88-145% of the monthly norm). The decrease in air temperature at the beginning and on some days of the decade caused a slowdown and temporary cessation of active vegetation of winter crops.

In April, the earth's surface received about 118 hours of sunshine (70% of the lunar norm). The average monthly air temperature was

1.6-2.6°C higher than normal and in absolute terms was 10.0-10.9°C. The maximum air temperature rose to 20-21°C, the minimum – decreased from 4°C heat to minus 2°C frost.

Precipitation was observed for 10-15 days. In most parts of the region for the month the amount of precipitation was 86-123 mm (184-251% of the monthly norm).

Precipitation of 5 mm or more was recorded throughout the region for 4-10 days.

In the third decade of April, the development of agricultural crops (due to the accumulation of heat in March and early April and optimal moisture reserves) was accelerated and was assessed mainly as good.

At the end of April, 154-184°C of effective (above 5°C) heat at the rate of 100-115°C and 31-45°C of effective (above 10°C) heat at the rate of 15-21°C have accumulated in the region since the beginning of spring. In most parts of the region, moisture reserves in the arable soil layer exceeded the norm by 4-20 mm.

In May, there was unstable temperature, on some days with rain, the weather. Sunlight reached the earth's surface for a month about 262 hours (102% of the lunar norm). The average monthly air temperature was 1.0°C below normal and in absolute terms was 13.6-14.6°C. The maximum air temperature rose to 26-29°C, the minimum on the coldest nights decreased to 2-4°C heat.

Precipitation in May was recorded for 5-9 days. The monthly rainfall was 20-38 mm (44-72% of normal). During this period, crops were mainly developed under satisfactory agrometeorological conditions. The rains in the third decade of May replenished the soil's moisture reserves. At the end of May, 425-475°C of effective (above 5°C) temperatures at the norms of 395-425°C, above 10°C – 140-175°C at the norms of 155-180°C have accumulated in the region since the beginning of spring. At the end of the month, the condition of winter and spring crops was assessed mainly as good.

In June, warm weather with precipitation prevailed. Sunlight on the earth's surface for the month received about 314 hours (115% of the lunar norm).

The average monthly air temperature was close to normal and in absolute terms was 17.7-19.3°C. On the warmest days, the maximum air temperature rose to 30-31°C, the minimum on the coldest nights decreased to 3-10°C. The soil surface was heated to 51-59°C during the day and cooled to 1-8°C at night. Precipitation was observed for 4-7 days. In most parts of the region for the month the amount of precipitation reached 5-101 mm (67-138% of the monthly norm). At the end of June, 815-900°C effective air temperatures above 5°C at the norm of 775-820°C, above 10-375-445°C at the norms of 380-420°C have accumulated in the region since the beginning of spring. Conditions for the growth and development of crops were satisfactory. Reserves of productive moisture in most fields of the region were sufficient.

The average monthly air temperature in July was 1-2°C higher than normal and in absolute terms was 20.0-20.1°C. The maximum air temperature increased to 31-33°C, the minimum – decreased to 6-12°C heat.

Precipitation was observed for 7-12 days. The amount of precipitation per month was 82-111 mm (81-148% of the monthly norm). Precipitation of 5 mm and more was observed for 2-7 days.

In July, the earth's surface received up to 294 hours of sunshine (102% of the lunar norm).

Warm and rainy weather in the third decade of July was favorable for the maturing of late crops. As of July 31, since the beginning of spring, the sum of effective air temperatures above 10°C in the region was 680-780°C of heat at the norms of 650-715°C.

The weather was dry and hot on most days of August. At the end of the month it rained and got cold.

Sunlight on the earth's surface for the month received about 336 hours (133% of the lunar norm). The average monthly air temperature was 2-4°C higher than normal and in absolute terms was 20.2-22.1°C. On the warmest days, the maximum air temperature rose to 36-38°C, the minimum on the coldest nights decreased to 6-8°C. The soil surface was heated to 48-59°C during the day and cooled to 4-8°C at night. Precipitation was observed for 2-6 days. In the vast majority of the region for the month they dropped 18-49 mm (31-81% of the monthly norm). The average monthly relative humidity was in the range of 58-68% at 68-73%.

The vegetation period in 2008 lasted more than 200 days with the highest amount of precipitation of 574 mm over the years of research, which significantly exceeded the long-term norm. However, precipitation fell unevenly. In April, June, September they fell much more than normal, and in May and August – only 39 and 27 mm at a rate of 53-57 mm. September seemed rainy. During this month, 152 mm of precipitation fell, which had a positive effect on moisture reserves in autumn and winter. In October, only 14 mm of precipitation fell, which negatively affected soil moisture reserves. In general, the weather conditions were not typical for the region where the research was conducted. The rate of SCC during the growing season averaged 0.6.

In general, the temperature regime in 2008 did not differ much from the long-term average. Slightly high average daily air temperature in April, compared to the average perennial with sufficient moisture, contributed to the rapid germination and development of plants. In May-

June there was a slight decrease in temperature, which did not significantly affect the development of crops.

In the early period of sowing, the moisture supply was higher than the minimum annual average, which contributed to the friendly germination of plants. However, in May the rainfall was three times lower than the long-term average. This negatively affected sowing and initial growth. The amount of precipitation in June was also much lower than the long-term average.

In July, as water demand increased, its inflow increased slightly, but was below long-term averages.

The vegetation period of 2008 in terms of temperature was within the average long-term data. However, the decadal distribution of precipitation in 2008 did not meet the biological requirements of crops. In the period from May to July there was a shortage of moisture, which led to a significant decrease in yield.

Weather conditions of the winter period of 2008-2009 and the vegetation period of 2009 were not typical for the northern part of the Forest-Steppe of Ukraine. The average monthly indicators of the winter period significantly outweighed the perennial ones. The warmest month in winter was February. The average monthly temperature this month was 1.7°C higher than the long-term norm. The beginning of the growing season in 2009 fell on March 30 with a consistent steady rise in air temperature in April. Favorable temperature conditions had a positive effect on regrowth, growth and development of sown perennial legumes.

The average daily temperature during the year exceeded the long-term average. In 2009, the average annual temperature was higher by 1.7°C and amounted to 9.4°C, only in May and August it did not differ from long-term values. September, October and November were warm. The highest amount of precipitation fell in December – 88.8 mm, the lowest in January – 18.4 mm (at a rate of 63.3 mm). In 2009, during the growing season, the lowest amount of precipitation for the years of research was recorded – 226.1 mm. July, August and September were very dry with significant rainfall. In general, the warm period of 2009 set a new record for aridity. The hydrothermal coefficient (SCC) on average during the growing season reached 0.6, which indicates a significant deficit of soil moisture and dryness of the year.

According to the analysis of the results of meteorological observations for 2009, it can be concluded that it turned out to be one of the warmest for the 130-year period of regular meteorological observations in Kyiv region.

The average long-term value (standard climate norm), calculated for the period 1961-1990 (a thirty-year period determined by the WMO, which reliably shows changes in the global climate), for Kyiv is 7.7°C. In 2009, the average annual temperature was exceeded by 1.7°C and reached 9.4°C.

Only in May and December the long-term air temperature was not exceeded. September turned out to be too warm, when the average monthly temperature was almost equal to June (3.4°C higher than normal). January and February also turned out to be warmer than the norm, there was a lot of heat in April and November - in all the mentioned months the air temperature exceeded the norm by 2-2.5°C (Fig. 2.4).

However, the warm period (IV-X) seemed hot and dry. April should be especially distinguished – the amount of precipitation for the whole month was only 4% of the norm.

July, August and September were also very dry, in these months 60-75% of the monthly rainfall was not received. In general, the warm period of 2009 set a new aridity record – 197 mm, lowering the previous 1959 (227 mm) by as much as 30 mm.

Based on the figures in Figs. 2.6-2.7 graphs conclude that both temperature and precipitation in 2010 differed significantly from long-term data. For example, more than 200 mm of rain fell in July. This was more than twice the long-term average and negatively affected the maturation of early spring crops, especially harvesting, and affected the quality of the final product.

Indicators of air temperature in 2010 throughout the growing season exceeded the long-term average. The above affected the duration of the growing season and the fullness of the grain, and together with excessive moisture in July – on the development of diseases and, ultimately, on the quality of grain.

January 2011 was not typical. During its first decade, the weather remained cold and without precipitation. The average monthly air temperature was 1.9°C higher than normal and was minus 2.4°C, normal monthly temperature for January minus 4.3°C.

For March, the weather conditions were not the best and far from normal. The weather was stable throughout the month, without precipitation. The amount of precipitation was only 17% of the norm. There was only 6 mm of precipitation. Precipitation in March was observed for 6-13 days in the form of snow, sleet and rain. The average monthly temperature was within normal limits and was 1.3-1.5°C. On the warmest days, the maximum air temperature rose to 12°C. The soil surface was cooled to minus 3-6°C. The decrease in air temperature at the beginning and on some days of the month caused a slowdown and temporary cessation of active vegetation of winter crops.

April was a little warmer than usual. About 156 hours of sunshine (112% of the lunar norm) arrived on the earth's surface during this month.

The average monthly air temperature was 1.3°C higher than normal and in absolute terms was 10.2°C. The maximum air temperature increased to 20-21°C, the minimum – decreased from 4°C heat to minus 2°C frost. Precipitation was insignificant, observed 5-7 days a month. The rainfall was 23 mm (47% of normal). The development of crops (due to the accumulation of heat in March and early April due to a shortage of moisture) was not the best way and was assessed mainly as sufficient.

At the end of April, 154°C of effective (above 5°C) heat at the norms of 100-115°C and 31°C of effective (above 10°C) heat at the norms of 15-21°C have accumulated in the region since the beginning of spring.

In most parts of the region, moisture reserves in the arable soil layer were 4-10 mm lower than normal.

In May, there was unstable temperature, on some days with rain, the weather. Sunlight reached the Earth's surface for about 265 hours (103% of the lunar norm). The average monthly air temperature was higher than the norm by 1.6°C and in absolute terms was 15.1°C. The maximum air temperature rose to 26-29°C, the minimum on the coldest nights decreased to 2-4°C heat.

Precipitation in May was recorded for 5-8 days. The monthly rainfall was 27 mm (51% of normal).

The development of agricultural crops mainly took place under satisfactory agrometeorological conditions. The rains observed in the third decade of May did not sufficiently replenish the soil's moisture reserves.

At the end of May, 425-475°C of effective (above 5°C) temperatures at 395-425°C, above 10°C - 140-175°C at 155-180°C have accumulated in the region since the beginning of spring.

In June, warm weather with a lot of precipitation prevailed. Sunlight reached the earth's surface for a month about 320 hours (118% of the lunar norm). The average monthly temperature was slightly higher than normal and in absolute terms was 21.1-21.4°C.

On the warmest days, the maximum air temperature rose to 30-31°C, the minimum on the coldest nights decreased to 3-10°C. The soil surface was heated to 51-59°C during the day and cooled to 1-8°C at night.

Precipitation was observed for 4-7 days. In most parts of the region for the month the amount of precipitation was 75 mm (179% of the monthly norm).

At the end of June in the region from the beginning of spring 815-900°C effective air temperatures above 5°C at norms of 775-820°C, above 10°C – 375-445°C at norms of 380-420°C have accumulated.

Conditions for the growth and development of crops were satisfactory. Reserves of productive moisture in most fields of the region are defined as sufficient.

The average monthly air temperature in July was higher than the norm by 2.2°C and in absolute terms was equal to 21.7°C. The maximum air temperature increased to 31-33°C, the minimum decreased to 6-12°C heat.

Precipitation was recorded for 13-16 days. The amount of precipitation per month was 152 mm, or 179% of the norm.

The sunshine in July reached the earth's surface up to 285 hours (101% of the lunar norm).

Warm and rainy weather in the third decade of July was favorable for the maturing of late crops. As of July 31, since the beginning of spring, the sum of effective air temperatures above 10°C in the region was 680-780°C of heat at the norms of 650-715°C.

In most days of August, warm rainy weather persisted.

The average monthly air temperature was 0.4°C higher than normal and in absolute terms was 19.3°C. On the warmest days, the maximum air temperature rose to 36-38°C, the minimum on the coldest nights decreased to 6-8°C. The soil surface was heated to 48-59°C during the day and cooled to 4-8°C at night.

Precipitation was observed for 12 days. In most of the region for the month they dropped 51 mm (91% of the monthly norm). The average monthly relative humidity was in the range of 58-68% at 68-73%.

As of August 31 in the region since the beginning of spring, the sum of effective air temperatures above 10°C was 990-1130°C at a rate of 900-985°C.

In general, the weather conditions for agricultural work were favorable.

The winter period of 2011-2012 turned out to be relatively warm. September in terms of temperature was within normal limits. However, the amount of precipitation differed too much from the norm. The amount of precipitation was 37 mm, or 33% of normal. The average monthly temperature was higher than normal and in absolute terms reached 15.8°C.

October turned out to be somewhat unstable. The average monthly temperature was 0.2 below normal and in absolute terms was 7.7°C.

Precipitation exceeded the norm twice and amounted to 77 mm (208% of the norm).

In November, by contrast, there was very little rainfall. Only 10% of them fell, which could not but affect the yield of winter crops. After all, for the successful development of crops, entering the winter in such agro-climatic conditions is too dangerous.

Conditions in 2012 were favorable for the growth and development and formation of the yield of leaf mass of perennial grasses. March seemed cold, in which frosts were observed in the first and second decades, and warming occurred in the third decade, where the average daily temperature was 5.4°C. Restoration of vegetation of perennial grasses was noted in the first decade of April. Spring was warm, when the average monthly air temperature reached 11.4°C in April and 18.1°C in May, which is 3.0 and 2.8°C higher than normal, respectively. Precipitation was uneven – the total amount was 137.4 mm at a rate of 119 mm.

Summer was hot and rainy. The highest average monthly air temperature was observed in July – 23.2°C, which is 3.6°C above the norm. In June and August it was 20.6-20.8°C, but was also higher than normal 1.7-2.3°C. The driest was July, where only 20.7 mm fell

62.3 mm less, or 24.4% of the long-term average. It was rainy in August. Precipitation was 132.4 mm, or 2.32 times higher than normal.

During 2012-2013, the winter was mild. September and October were warm at an average daily temperature of 16.2 and 10.4°C, respectively. In November, there was a decrease in the average monthly air temperature to 4.2°C. The amount of precipitation for the period September-November was 96.6 mm, or within normal limits.

Thus, the weather conditions in this region were within the norm for growing perennial legumes for fodder purposes.

The conditions of 2013 are defined as favorable for the growth and development and formation of the crop of leaf mass of perennial grasses. The year on average is close to the average long-term data.

During the growing season, the maximum amount of precipitation fell – for April-May-June, respectively 141.8-111.8-73.0 mm, which in combination with the temperature regime led to the optimal increase in green mass. However, with such a high yield of the latter, in turn, there were problems with its collection.

The agrometeorological conditions of the 2013/2014 growing year turned out to be favorable for growing many perennial legumes, as the average air temperature was 1.9°C higher than the average perennial. This had a positive effect on the growth and development of alfalfa.

The winter period of 2013-2014 turned out to be typical for this zone. According to observations, perennial grasses sown in spring overwintered most successfully. Plants underwent a full cycle of development in ontogenesis and provided high yields.

The autumn growing season of alfalfa was relatively warm. During the sowing period there were favorable conditions for the emergence of seedlings. The average monthly temperature in September was 13.4°C, in October – 10.6°C and in November – 4.0°C, while the average long-term temperature was 14.3; 7.8 and 1.9°C. The cessation of vegetation in 2013/2014 took place in the first decade of November. A steady decrease in temperature after 0°C was observed in the first decade of December. The indicators of the winter months of 2014 fluctuated within 0°C, which ensured the successful overwintering of perennial legumes. The average monthly temperature in January, February and March was higher than the long-term average. The resumption of spring alfalfa vegetation this year took place in the middle of the second decade of March. Intensive regrowth of alfalfa sowing began in late March-early April.

Temperature weather conditions in 2014 were the most favorable for the growth and development and formation of the yield of leaf and stem mass of perennial grasses. At the same time, the average precipitation in the spring months was at a minimum: in March – 14.8 mm; April – 16.2; May – 0.4 mm. Although this did not affect the growth and development of vegetative plants.

2014-2015 vegetation year. The average air temperature in September was 12.6°C; October – 6.8°C; November – 3.2°C, but in November only in the first and second decades the temperature was higher than 0°C. The transition through 5°C took place on November 10. The first cessation of autumn vegetation (transition through 0°C) occurred on November 20.

The average daily temperature in December was minus 1.3°C; January – minus 0.1°C; February – plus 0.4°C; March – plus 2.7°C.

The amount of precipitation in the autumn was insignificant: 30.6 mm fell in September; October – 12.0; November – 11.0 mm. Precipitation, which fell in July (144.4 mm), became the main source of moisture. Due to such conditions, no intensive tillering and overgrowth was observed in the autumn.

Conditions in 2015 contributed to the growth and development, the formation of high-quality, high-nutrient leaf mass of perennial grasses to obtain a balanced, highly nutritious livestock feed.

Meteorological conditions of vegetation years differed significantly from the average annual indicators and were atypical.

The analysis of meteorological indicators of 2003-2015 allows to state that meteorological (weather) conditions in years of researches as a whole at application of the corresponding technologies were favorable for formation of high productivity of bean grasses.

During the research, the coefficient of significant deviations from the long-term norm in terms of precipitation during the growing season was calculated. By the value of Ks = +0.30 the amount of precipitation for the growing season of 2006 Ki = 0 - 1; 2007 - Ki = -1.22; 2008 - Ki = -0.11; 2009 - Ki = -1.10 and Ks = -0.53 can be attributed to conditions close to normal.

After analyzing the sum of the temperatures obtained during the growing season by years (2006-2009), we can conclude that the coefficient of significant deviations Ks from the long-term norm in 2006-2009 is from 0.69 to 1.97 and these years are years with conditions which differ significantly from the perennial averages (Ki = 1-2).

2.6. Objects, scheme and methods of research

Long-term research, the results of which are reflected in the monograph, was conducted during 2003-2015, in the Forest-Steppe zone – in crop rotation of the Department of Forage Production, Land Reclamation and Meteorology of the Separate Division of the National University of Life and Environmental Sciences located in the village. Wheat Vasylkiv district of Kyiv region. Also, research was conducted in farms in different regions of Ukraine: LLC. Dovzhenko of Shishatsky district of Poltava region; LLC “Poltavazernoproduct”, Globino, Poltava region; LLC “Khmilnytske” of Khmilnytskyi district of Vinnytsia region, LLC “Volochysk-Agro”, Volochysk of Khmelnytsky region of the Right Bank Forest-Steppe of Ukraine, as well as in the steppe zone of Ukraine – in the conditions of Askania DSDS of the Institute of Irrigated Agriculture When setting up experiments, performing various measurements, observations, analyzes, they used generally accepted modern methods. The following are the main characteristics and conditions of field experiments:

Experiment 1. To determine the potential of ecological substantiation and the influence of fertilizer doses on the productivity of the variety in highly productive grasses of alfalfa varieties in the conditions of SS of NULES of Ukraine “Agronomic Research Station” (average for 2005-2012).

Experiment 2. To investigate the impact of tillage measures on the varietal productivity of alfalfa in Poltava region (average for 2009-2011). Scheme: spring harrowing with spring harrows (control), treatment with needle disks (stars), cutting of cracks on 14-16 cm at restoration of vegetation + harrowing, cutting of cracks on 18-20 cm + harrowing, cutting of cracks on 14-16 cm in autumn + harrowing, cutting cracks by 18-20 cm + harrowing.

Experiment 3. To establish the influence of alfalfa seed treatment with strains of nodule bacteria (rhizotorphin) on productivity and nitrogen-fixing ability in the conditions of SS of NULES of Ukraine “Agronomic Research Station” (average for 2005-2008). Fertilizer dose (factor A) $P_{60}K_{60}$; $N_{30}P_{60}K_{60}$; $N_{60}P_{60}K_{60}$; $N_{90}P_{60}K_{60}$ and seed treatment with bacterial fertilizer (factor B), without rhizotorphin, with rhizotorphin.

Experiment 4. To determine the effect of fertilizers on the content of nitrogen and phosphorus in alfalfa plants in different phases of growth and development in a vegetation experiment close to the field in terms of SS of NULES of Ukraine “Agronomic Research Station” (average for 2009-2011), according to the scheme : variant of the experiment (control; N_{15}; P_{15};), in the phase of the first true leaf (leaves), roots; in the period of 60 days (leaves), roots, the second year of vegetation of alfalfa, flowering phase.

Experiment 5. To determine the leaf surface area and grass yield depending on the share of alfalfa and doses of mineral fertilizers in the conditions of SS of NULES of Ukraine “Agronomic Research Station” (average for 2007-2009). Scheme: without fertilizer (control), $P_{90}K_{120}$, $N_{90}P_{90}K_{120}$; slope first and second.

Experiment 6. To study the formation of the yield of leaf and stem mass of alfalfa sown depending on the sowing rates in terms of SS of NULES of Ukraine “Agronomic Research Station” (average for 2007-2009). Scheme: seeding rate – 6, 8, 10 million units/ha; year of vegetation – the second, third and yield of leaf and stem mass and dry matter.

Experiment 7. To establish the effectiveness of fertilizers (UAM-32) and pesticides in the technology of growing alfalfa in the Vinnytsia region (average for 2005-2015 pp.). Scheme. Technology: common with the use of fertilizers and liquid fertilizers; the effect of urea-ammonia mixture on the yield of alfalfa green mass: control; $P_{60}K_{60}$ + N_{60} (ammonium nitrate); $N_{90}P_{90}$ + K_{120} (ammonium nitrate); $P_{60}K_{60}$ + N_{60} UAM-32; $N_{90}P_{90}K_{120}$ + UAM-32; $N_{90}P_{90}K_{120}$ + N_{10} UAM-32 + N_{10} UAM-32; $P_{60}K_{60}$ + N_{60} UAM-32 + N_{60} UAM-32 + N_{60} UAM-32.

Experiment 8. To determine the productivity potential of meadow clover varieties (Agros-12, Marusya) in the formation of high-yielding grasslands in SS of NULES of Ukraine “Agronomic Research Station” (average 2010-2012). Scheme: Marusya, Agros-12 (factor A); Fertilizers (factor B): without fertilizers (control), inoculation (background); background + $P_{60}K_{90}$; background + $N_{60}P_{60}K_{90}$; Method of sowing (factor C): normal (15 cm), row spacing (30 cm, 45 cm); Sowing rate (factor E): 6.8.10 million units/ha; Slope (factor D): first, second.

Experiment 9. To investigate the complex influence of fertilizer system optimization and its role in forms of productivity of phytomass of meadow clover varieties in SS of NULES of Ukraine “Agronomic Research Station” (average 2010-2012). Scheme: Marusya, Agros-12 (factor A); Fertilizers (factor B): without fertilizers (control), inoculation (background), background + $P_{60}K_{90}$, background + $N_{60}P_{60}K_{90}$; Growing method (factor C): usual method of sowing (15 cm) Slope (factor D): first, second.

Experiment 10. To determine the influence of fertilizers and mowing height on the formation of productivity of sainfoin sowing in the conditions of SS of NULES of Ukraine "Agronomic Research Station" (average 2007-2012). According to the following scheme: Fertilizers (factor A): without fertilizers (control), $P_{60}K_{60}$ (estimated dose), $N_{30}P_{60}K_{60}$, $N_{45}P_{60}K_{60}$. Mowing height (factor B): 6-8 cm, 10-12 cm. Since during the experiment all the work was carried out by conventional equipment, the area was 260 m^2, the estimated 50 m^2. Repeat four times. Alfalfa was harvested by hand and weighed to record yields. Samples were taken for drying.

Experiment 11. To model the production process of alfalfa in different soil and climatic zones of Ukraine (2012-2018). Analysis of productivity formation and establishment of optimal combination of factors and variants, which were revealed during research for Forest-Steppe and Steppe conditions of Ukraine with development of production process models using meteorological indicators, photosynthetically active radiation, soil fertility, etc.

To conduct basic studies to study the impact of individual elements of technology on the formation of yields of alfalfa, clover and sainfoin, simultaneously with studies in a stationary experiment, laid temporary one-three-factor experiments with a plot area of 8 to 15 m^2 for 4-6 times. The placement of options is consistent.

The herbage was mowed in different phases – the beginning of budding, budding, the beginning of flowering and flowering.

Phenological observations were carried out in all variants and replicates of the experiment by examining plants during the main phenophases of development in the experimental area.

The height was determined by measuring 20 plants, taking samples diagonally from two non-adjacent repeats of the experiment before each cut. Analyzing the height data, we calculated the average height of the plants.

Grass density was determined for all variants during the growing season by counting the number of shoots of three types on fixed plots with an area of 0.25 m^2 (50 × 50 cm), then counting the density of grass was transferred to 1 m^2, in three typical places of the plot of two adjacent replicates.

The ratio of leaves and stems was established by sampling (sheaves weighing 1 kg in triplicate in two non-adjacent replicates of the experiment). To do this, 25 plants were selected in triplicate in two non-adjacent replicates of the experiment, the leaves were cut off and, weighing the leaves and stems, their percentage was calculated.

The leaf surface area of the experimental grass was calculated by the weight method (Nichiporovich et al., 1961).

Yield accounting was performed when the bean component reached the budding phase by continuous mowing with simultaneous weighing and sampling to determine the amount of absolutely dry mass and chemical analysis.

Soil samples for agrochemical analysis of soil were taken in accordance with DSTU 4287:2004.

Analytical studies were conducted to determine soil fertility indicators in accordance with the following standards: DSTU ISO 11464:2007 Soil quality. Pre-treatment of samples for physicochemical analysis (ISO 11464:2006). Determination of active acidity – according to

DSTU ISO 10390-2001 Soil quality. Determination of pH. Determination of ammonium and nitrate nitrogen content – according to DSTU 4729:2007 Soil quality. Determination of nitrate and ammonium nitrogen in the modification of NSC IGA. ON Sokolovsky. DSTU 4115-2002 Determination of mobile phosphorus and potassium compounds by the modified Chirikov method. DSTU 4114-2002 Soils. Determination of mobile compounds of phosphorus and potassium by the modified Machigin method.

The experimental part of field research was performed in a stationary experiment, as well as in temporary field experiments in the research fields of the SS of NULES of Ukraine "Agronomic Research Station" and farms of Poltava, Vinnytsia and Khmelnytsky regions.

The scheme of the stationary experiment was to study the effectiveness of fertilizer systems, fertilizer rates, inoculation and protection systems on the productivity of alfalfa, sainfoin and clover varieties, which were placed in crop rotation after one-year forage crops.

Phosphorus and potassium fertilizers (simple granular superphosphate – 19.5% and potassium magnesium – 28.0%) were applied in the fall for the main tillage, nitrogen (ammonium nitrate – 34.5%) – for pre-sowing cultivation.

The main tillage for experimental crops is combined (ploughshare peeling to a depth of 14-16 cm + chiseling).

The experiment studied the effectiveness of the treatment of seeds with nitrogen-fixing strains of nodule bacteria on the growth, development, activity of symbiotic systems, on individual plant productivity and coenosis in general.

The analysis of weather conditions and the level of their variability for the period 2002-2015 compared to long-term averages was carried out on the basis of criteria of coefficient of materiality (significance) of elements of agrometeorological regime of each of the studied years from long-term averages according.

Ecological plasticity of perennial legumes, the dependence of their yield and production stability on weather factors in the main soil and climatic zones was determined by crop yields for the period 2003-2012 on the basis of statistical data and weather conditions for the same period using mathematical analysis using correlation and regression methods.

The leaf surface area was determined by the method of “cuttings”, which is based on determining the area and mass of a certain number (20-50) of cuttings, as well as the leaf surface mass of the entire sample and subsequent calculations of the leaf surface.

Determination of the content of basic nutrients in plants was performed after wet ashing according to Ginzburg – nitrogen, and phosphorus – photometrically, potassium – on a flame photometer. Analysis of crop structure – according to Maisuryan’s method. Harvesting – by direct combining in sections, by the method of continuous accounting.

Determination of chemical and technological quality indicators of alfalfa, clover and sainfoin green mass (protein, fat, fiber, ash, phosphorus and potassium content) – using the method of spectrometry on an infrared analyzer NIR Scanner 4250 with computer software ADI DM 3114.

The economic and energy efficiency of technologies for growing perennial legumes was calculated based on guidelines and technological maps for growing the studied crops. Grass varieties during the test were evaluated by the following indicators: yield of green mass and dry matter content in it, the period of onset of oblique ripeness, baldness, winter hardiness (perennial grasses), resistance to disease and pest damage, resistance to lodging and adverse weather conditions, content and protein yield, fiber, nitrate, alkaloid, eating and feed digestibility.

Winter hardiness of varieties, the state of crops in autumn before winter and spring, after the beginning of vegetation recovery, the general condition of crops with forecasts for the harvest was assessed similarly to the testing of varieties of winter cereals.

Samples of perennial grasses in the winter were taken by the method of monoliths or other methods according to the scheme of experiments.

Resistance to lodging in adverse weather conditions was assessed according to the requirements of the general part of the method on a nine-point scale in each replication, deriving the average score for the variety.

The height of the plants was measured before the first mowing from the soil surface to the tops of the stems (sloping plants are lifted), in five equidistant areas, two non-adjacent repetitions, and the average height of the plants of the variety was derived.

Harvesting and accounting in experiments. During harvesting, varieties of all crops were evaluated for suitability for mechanized harvesting, which depended on many indicators (resistance to lodging, disease, height, stem density, etc.). Used the following scale:

1 – mechanized harvesting is impossible;

3 – mechanized harvesting is possible only in one direction with the use of devices for harvesting fallen crops:

5 – mechanized harvesting is possible in the presence of special devices, probable crop losses;

7 – mechanized harvesting is possible;

9 – variety suitable for mechanized harvesting without losses.

The number of slopes was determined by the biological characteristics of the culture, the conditions of the growing area and the purpose of use of grass. In field grassing experiments, single-slope clover was tested for 1-2-slope use, double-slope clover for 2-3 slopes; alfalfa – depending on the test area and harvesting phase for 2 slopes or more, for testing cereals spend 2-5 slopes. The term of the first mowing was determined by the phase of development (legumes – at the beginning of flowering, legumes by multi-use – at the beginning of budding, cereals – at the beginning of earing (ejection of panicles), and the terms of subsequent mowings – by height of grass and phase of their growth and development after 30-35 days.

Under cover sowing on hay, the green mass began to be mowed from the second year of the growing season. When perennial grasses sown under cover cover the first year of the growing season, this crop was accounted for in sections and added to the total yield, but this year was not considered the year of the cycle.

The yield of the main grass (without weeds) was determined by two samples weighing 2-3 kg each, taken after mowing from areas of two non-adjacent replicates.

The test sheaf consisted of small samples, which were taken evenly in several places of the mown area. Then weighed the green mass from the site to the nearest 0.1 kg. At the same time, the test sheaves were weighed separately. The mass of test sheaves was added to the mass of grass from the plots. Sheaves were disassembled immediately after mowing on the test culture and impurities.

The yield of the main grass in percent was determined by dividing the mass of the main grass of the test sheaf by its weight and multiplying by 100. The yield of green mass of the variety from the plot in t/ha was calculated by dividing the mass of cut grass from the plot in kg to its area in m^2 and multiplying the output of the main herbs in percent.

CHAPTER 3

ECOLOGICAL AND AGROTECHNOLOGICAL FUNDAMENTALS OF FORMATION OF HIGHLY PRODUCTIVE GRASSES OF SOWING ALFALFA

3.1. Ecological substantiation of the variety in the formation of highly productive alfalfa

The catalog of plant varieties suitable for distribution in Ukraine includes 24 varieties of alfalfa. But only 8-12 of them have the largest spectrum of distribution. Interestingly, this includes alfalfa variety Zaykevych, zoned in 1931, and Veselopodolyanska 11 – in 1960. In the research was used alfalfa variety Poltavchanka, included in the catalog of varieties, as the seeds of this variety are used in Separated Subdivision of National University of Life and Environmental Sciences of Ukraine "Agronomic Research Station".

Fig. 3.1. Alfalfa (*Medicago sativa* L.), Poltavchanka variety

Selection of varieties for pasture use. Until now, there are no special pasture varieties of alfalfa, and therefore this theme is considered relevant. Such varieties, along with a high yield of green mass, long-term use, a positive reaction to fertilizer application and irrigation should have a rapid rate of regrowth in spring and after grazing (1.5-2.5 cm per day before budding phase), marked by resistance to trampling (four or five pastures), high competitiveness in grass mixtures. An important feature of grazing varieties is the reaction to the level of soil nutrients: they must provide a sufficiently high yield, even with an average content of nutrients in the soil.

Selection to improve feed quality. In alfalfa, this can be achieved through the following indicators: 1) increasing the content of crude protein and improving its amino acid composition by increasing leavesness and improving the quality of stems; 2) the creation of multi-crop varieties resistant to repeated alienation of green mass in the early stages of vegetation (budding – the beginning of flowering), protein yield per 1 ha should be 20% higher than commercial, with the same or slightly reduced crop yield; 3) reducing the content of fiber and saponin and increase the digestibility of feed.

Breeding to reduce the saponin content of alfalfa is carried out in the United States, Hungary, Germany, the Czech Republic, France due to the widespread use of alfalfa flour as a protein feed, especially for feeding poultry, and the creation of pure alfalfa pastures. It has been found that when chickens are fed alfalfa flour with a high saponin content, their growth is slowed down and the egg-laying period is reduced.

Significant differences in saponin content were found both between varieties and within varieties. No correlation was found between the amount of saponin and protein, which allows selection for both traits simultaneously. The saponin content is determined by hemolytic method.

Increasing the digestibility of alfalfa feed contributes to a significant increase in animal productivity. This figure should be not less than 65-70%, and to a large extent the digestibility of plant mass can be increased by digestibility of stems and reduced fiber content.

The developed method of *in vitro* digestibility assessment by small samples without alienation of the whole plant (on the first flowering stems) with the use of pepsin and cellocandin enzymes allows to significantly expand the evaluation of selection material and more efficiently select forms according to this indicator.

The amount of carotene is taken into account when assessing the quality of feed, in particular grass meal. It is believed that when harvesting alfalfa in the early stages, its content is quite high, and the leaves are 5-7 times larger than in the stem. Plants with green stems are dominated by carotene, where the stems are colored with anthocyanin.

As already mentioned, according to the results of many years of research, scientists have created a number of highly competitive varieties – 24, which are successfully implemented in agricultural production. During the research, four varieties of alfalfa were used – Zaikevycha, Banat VS, Poltavchanka, Plane, and Yaroslavna;

The variety ***Zaikevycha*** (registered in 1931) belongs to the alfalfa crop. In the register since 1931. Medium-ripe variety of hay direction.

Banat VS (2010, Serbia) is an early variety of rapid growth (23.2 cm – 15 days after the spring equinox), characterized by rapid regenerative capacity after mowing (26.4 cm – 14 days after mowing). High speed of regeneration after mowing, as well as resistance to drought and low temperatures (overwintering) cause similarity with the variety of NA Banat OMS II. The height of plants during the mowing period is 67 cm. Part of the leaf mass in yield reaches 50%. The leaves are gray-green. Gray color from a wax plaque on leaves testifies to special drought resistance. The flowers range in color from light to dark purple. The protein content is 20.1%. The colors are dominated by light purple. Forms a fairly high yield on soils with light and medium-heavy mechanical composition. Compared with the variety Banat OMS II plants of the variety Banat VS ripen 2-3 days later.

Poltavchanka (1987) – entered in the State Register of Varieties of Ukraine since 1996. Originator: Poltava State Agricultural Research Station named after M.I. Vavilov, Institute of Pig Breeding and Agroindustrial Production of the National Academy of Agrarian Sciences of Ukraine. Refers to alfalfa variable, blue-hybrid group. Stems reach a height of 100-130 cm, corollas – blue-purple. Flowering is friendly, good fruiting. Winter hardiness and drought resistance are average. Yield of green mass 43.5-50 t/ha, hay – 11 t/ha, seeds 0.5-0.7 t/ha.

Plane (1999) – breeding and seed company "Euro Grass Breeding GmbH & Co. KG" (Germany). 2012 is a year of inclusion of the variety in the State Register.

Alfalfa variety Plane is recommended for growing in the Forest-Steppe and Steppe zone. Diseases were not observed during the years of trials. The Plane is resistant to phomosis and bacterial wilt, which significantly increases the endurance of the variety.

Morphological features: erect shrub, medium height, round stem, medium to long; bushiness is average; leaves green, elliptical, sparsely pubescent, without wax; inflorescence shortened raceme, multifloral, cylindrical, medium density, dark purple flowers; seeds kidney-shaped, yellow or light brown.

Economic and biological characteristic: for the 2009-2011 tests, the average yield of dry matter was 14.1 t/ha, the maximum – 24.3 t/ha, obtained in 2010. The variety is winter hardy, resistance to lodging and drought is high. It grows early in the spring and intensively – after mowing. For vegetation provides 3-4 mowing. Dry matter content: protein – 17.2%, calcium – 1.37, magnesium – 0.22, fiber – 32.3%; protein harvest – 25.6 kg/ha.

Yaroslavna (1987*)* – Originator: "Institute of Agriculture NAAS", a synthetic variety, consists of five components that have an average level of autogamy – self-compatibility reaches 40%, easy flower opening, high combination ability, which provides long-term heterosis. Partial autogamy and early maturity allow obtaining seeds even in the northern regions of Ukraine and in areas with adverse weather conditions. High intensity of regrowth in spring and after mowing provide high yield of fodder mass. Entered into the Register of Plant Varieties of Ukraine and the Russian Federation since 1987.

Distribution area: Forest-Steppe and Polissya of Ukraine, territories of other countries with similar climatic conditions.

Selection for seed productivity must be combined with any other areas of selection. Even the most high-yielding and stable variety, if it does not provide seed production with elite seeds, is not very suitable for production. Currently, the harvest of alfalfa seeds does not fully meet the requirements of seed production. The alfalfa seed system exists in the areas most favorable for growing seeds of this crop. According to available data, when irrigated, the average yield of alfalfa seeds almost does not exceed 2-3 kg/ha in the irrigation zone and on average 1-2 kg/ha – in the area not provided with moisture. However, the biological and genetic potential of alfalfa seed productivity is much higher. In view of this, the task of selection for seed productivity should be to create varieties that would, in compliance with appropriate agricultural techniques to ensure a stable seed yield. Different ecotypes play an important role here.

According to some studies, temperatures below 20°C, heavy rainfall and high humidity during flowering adversely affect the formation of seed yields. In severe drought, when the relative humidity falls below the critical level of 30%, the seed productivity of alfalfa decreases. Temperatures above 20°C and relative humidity in the range of 46-60% contribute to high seed yields.

The yield of alfalfa seeds depends, as a rule, on the individual productivity of its plants, the morphological structure of the seed bush, the number of productive stems, beans, the weight of 1000 seeds.

One of the most important indicators of the variety's adaptability to environmental conditions is the height of plants. So, the height of the plants was measured before mowing (Table 3.1).

The studied F1 population was characterized by a higher height compared to the parental forms. The average height of individual vegetative shoots reached 86 cm, in *Medicago sativa* it was at the level of 66 cm.

Such an indicator of sample evaluation as leavesness is important. Under the conditions of combined use of alfalfa for fodder, as a result of the formation of the harvest of varieties with higher leaf content, it is possible to significantly improve the quality of green mass and hay. In the year of research, the content of leaves in aboveground biomass in the budding phase ranged from 43.9 to 46.6%. In the study population, the proportion of leaves was 44.3%. One of the most important components of the harvest is the number of racemes on one stem. After analyzing the results, we can conclude that this indicator had a slight variation in the samples and was in the range of 9.2-9.7 pieces per stem.

3.1. Some indicators of the structure of alfalfa harvest of the first year of vegetation in the conditions of SU NULES "Agronomic Research Station" (average for 2005-2008)

No	Indicator	*Medicago sativa*	F_1	**V, %**
1	Plant height, cm	65 ±0.9	86 ±0.5	**16.9**
2	Leavesness, %	46.6 ±0.9	44.3 ±0.7	**3.2**
3	The number of tassels on one stem, pcs.	9.5 ±0.3	9.7 ±0.2	**2.7**
4	The number of beans in a bunch, pcs.	7.1 ±0.5	7.7 ±0.7	**12.4**
5	The number of seeds per bean, pcs.	2.75 ±0.03	2.93 ±0.01	**6.7**
6	The number of seeds in the brush, pcs.	19.5 ±1.5	19.7 ±1.4	**6.1**
7	Weight of 1000 seeds, g	2.09 ±0.03	2.13 ±0.02	**1.5**
8	Mass of seeds from a plant, g	21 ±1.7	25 ±1.8	**24.8**

As a rule, the increase in yield is due to an increase in the number of beans in the bunch and the number of seeds per bean. These indicators were the highest in the F1 hybrid population – 7.7 and 2.93 respectively, the lowest in *Medicago falcata* – 6.0 and 2.56 pcs.

There is a slight difference between the studied samples on such an indicator as the weight of 1000 seeds. The amplitude of its oscillation is recorded in the range of 0.02-0.06 g

The results of the variation analysis indicate a very high amplitude of variability of fluctuations in the structure of the alfalfa harvest in the first year of the growing season. Thus, according to indicators, including the weight of 1000 seeds, the number of racemes on one stem and leavesness, the coefficient of variation was in the range of 1.5-3.2%, and in relation to plant height and seed weight per plant, its growth was up to 16.9 24.8%, or 5.3-16.5 times. Thus, the last two indicators fluctuated significantly, which can be explained by the influence of hydrothermal factors and the action and interaction of a set of agronomic factors.

3.2. Biological prerequisites for obtaining high quality feed

The nutritional value of feed depends on the correct choice of mowing dates. Plants are mowed at the stage at which they receive the largest number of feed units and high-quality feed (in terms of protein and other nutrients). For some individual grass species, the mowing dates are set more clearly.

When choosing the timing of mowing mixed crops are usually focused on the bulk of plants. As the stages of plants change rapidly, the plants are mowed in the shortest possible time. The duration of harvesting plants depends on climatic conditions. In the zone with dry and hot climate, where the plants ripen faster, they are collected in a shorter time – 10-12 days, while in humid areas – up to 15 days.

Obtaining high and stable yields of plants for its long-term use depends on the correctly set cutting height. The recommended height of the cut above the ground from 5 to 8 cm. The cut of the plants should be smooth and complete. The deviation of the height of the cut along the entire length of the cutting device should not exceed ±5 mm, and losses during mowing of plants from the increased cut – up to 2%. There should be no uncut plants after the cutting shoe.

In the late stages of mowing plants, the yield remains at the same level or there is some reduction due to drying and death of leaves at the bottom of plant stems.

The growth of grass yield at the end of the formation of the photosynthetic apparatus is carried out only due to the growth of stems. The most significant effect of photosynthetic potential is manifested in mowing the mass during budding and flowering.

The efficiency of the use of photosynthetically active radiation is characterized by large differences in the process of growth and development of plants. The most significant increase in efficiency occurs in the budding stage. Compared with the tillering period, this indicator in the budding stage increases by 2.9-3.1 times, and in the panicle ejection stage relative to the budding period – only 2-2.1 times.

Significant differences between the photosynthetic potential and the utilization rate of photosynthetically active radiation cause different productivity of grasses depending on the mode of use and the level of mineral nutrition of plants. The highest yield of dry matter per season is achieved during harvesting in the budding stage and the beginning of flowering, while the lowest yield is obtained in the tillering stage.

Significant changes are observed in the process of plant growth and development in terms of fodder value. Thus, with aging in plants, the content of the most valuable nutrients, such as protein, carotene and fat, decreases, the content of fiber increases. These changes cause a deterioration in digestibility, reducing the nutritional value of feed that is harvested.

The nitrogen content of plants decreases with each subsequent stage of their development. For example, in meadow clover in the stage of budding the nitrogen content is 3%, in the period of full budding – 2.7, at the beginning of flowering – 2.4, in the stage of full flowering – 1.9%. In cereals, the decrease in nitrogen concentration occurs faster than in legumes. Legumes are much richer than cereals in nitrogen.

However, at a young age, these differences are not so pronounced. As the plants age, during the period of full flowering clover exceeds alfalfa in nitrogen content by 1.9 times.

The leaves of plants are much richer in protein and other essential nutrients than stems. The leaves of legumes, namely clover, contain 1.5-2.7 times more protein than the stems, and 2 times less fiber. The leaves of cereal grasses also contain more nutrients than the stems. Thus, in the leaves 2-2.5 times more protein, 25-30% less fiber than in the stems. In the process of growth and development, the nitrogen content in both the leaves and stems decreases. However, as the plants age, the stems and leaves become coarser and less nutritious, and their nitrogen content decreases. The rate of nitrogen reduction in the leaves is lower than in the stems. For example, the decrease in nitrogen in the leaves of clover in the stage of complete budding compared to its beginning occurs by 13%, in the stems – by 17%, during the beginning of flowering – by 25 and 30%, respectively.

Thus, the reduction of valuable fodder properties of grasses in the process of growth and development is due to two reasons: first, the absolute and relative changes in the mass of leaves and stems, and secondly, changes in the nutritional value of plant organs.

According to calculations, if the total decrease in clover protein content for the period from the stage of budding to the beginning of flowering is taken as 100, then the largest decrease – 37.4%, occurs due to the collection of dry matter of the leaves. The protein content in the stems is reduced by 29.3%, in the leaves – by 20%.

The quality of protein largely depends on its digestibility, which also deteriorates with age. If the content of digestible protein in the stage of tillering is determined by 100%, its amount is reduced on average in the stage of budding to 97.6%, in the stage of ejection of panicles – up to 60.9% and flowering – up to 42.5%.

The predominant form of nitrogen in all periods of growth is protein. However, in the process of growth and development, the ratio between protein and non-protein nitrogen in plants changes.

Most nitrogen enters plants in the early stages of development of the latter. In the later stages there is a decrease in activity. At this time, the processes of redistribution of nitrogen compounds are more pronounced.

The level of fiber content is one of the main indicators of feed quality, taking into account which sets the optimal time for harvesting plants. In cereals, as well as in legumes, in the process of growth and development there is an increase in fiber content.

As the vegetation stage of plants progresses, there are differences in the increase in fiber content – lower rates in legumes and higher – in cereals. Thus, the fiber content in meadow clover from 24.3% in the phase of the beginning of budding increases to 27.3% in the phase of full budding, and at full flowering reaches 33.4%, i.e., compared to young plants increases by 37%.

In mature cereal plants, the fiber content increases compared to young 1.5 times. In the tillering phase for fertilizer application, its rate is 20.3%, during budding – 24.7, ejection of panicles – 27.3 and flowering – 31.4%. The optimal level of fiber content for ruminants is in the range of 22-25%.

Fat is a high-energy part of the diet. Lack of it in the feed causes beriberi in animals, impaired reproduction. Perennial herbs at a young age are richer in fat than in the later stages of development. For example, in clover plants, the fat content decreases from 5.06% at the beginning of budding to 3.45% before full flowering, i.e., almost 1.5 times. The same changes occur with aging in cereals. Thus, in plants of *Dactylis glomerta* the fat content decreases from 5.08% in the tillering phase to 3.39% before the flowering period, i.e., also 1.5 times.

Over time, perennial grasses reduce the content of ash elements. For example, in plants of meadow clover this indicator makes 8.15% in a phase of the beginning of formation of buds, 7.54 – in the period of full budding, then 7.07 – at the beginning of flowering and 6.22% – at full flowering. In cereals, the content of ash elements is reduced in smaller parameters than in legumes.

Mowing times affect the content relative to the norm of individual mineral nutrients. Thus, the calcium content in meadow clover plants from 1.16% during bud formation is reduced to 0.9% at full bloom, phosphorus – from 0.22 to 0.19%, potassium – from 1.69 to 1.43%.

When growing perennial grasses in pure form, such as meadow clover, alfalfa or barberry in fodder crop rotations, the selection of optimal mowing dates is determined by the yield and nutritional value of a particular species. However, in areas with the vast majority of mixed crops of perennial grasses, the optimal mowing time of grass mixtures is usually determined by forage preferences and nutrient yields obtained not from one plant species, but from the grass mixture as a whole.

To ensure the production of high-quality feed from the grass mixture, it is important to use similar in growth and maturation rates of species and varieties of crops. After all, at significantly different rates of growth and development, some of them will suppress others, and the difference in precocity will make it difficult to determine the optimal harvest time.

One of the most common is a mixture of meadow clover with timothy-grass. Among the many advantages inherent in this herb mixture, almost the same rate of development of these crops is important. The grass structure of this mixture does not remain constant, but changes in the process of growth and development, i.e., with the formation of the crop, with the timing of mowing and years of use. As the crop is formed, the share of meadow clover in the grass mixture decreases and the share of timothy-grass increases. These factors must be taken into account when harvesting clover-timothy, and other grass mixtures.

Alfalfa is almost 2 times richer in carotene than *Bromus inermis*. At a young age it is not noticeable, but with the aging of plants the difference increases. Thus, if in the meadow clover, mown in the beginning of bud formation, the carotene content is 17.6 mg%, then timothy-grass in the same phase – 10.6 mg%, and during full flowering – respectively 7.1 and 2.8 mg%.

Herbs, unlike other types of feed, such as wheat bran, fish meal, contain less phosphorus and calcium. Legumes and cereals have different mineral composition, so depending on the composition of the grass mixture, mowing time, the proportion of these feeds in the diet solves the issue of mineral nutrition of animals.

Changes that occur in legumes and cereals with the aging of plants, differences in the rate of their growth and development, affect the structure of grasses and crop formation, lead to a deterioration in the nutritional value of feed. At the stage of the beginning of budding clover in a mixture with timothy-grass in 1 kg of dry matter contains 0.84 feed units, during the period of full budding – 0.72, at the beginning of flowering – 0.59, at full flowering – 0.5 feed units. At the beginning of flowering grasses, the nutritional value of forage decreases by about one third compared to their collection during bud formation. The nutritional value of grasses cut in the phase of full flowering clover is reduced by 40%.

The highest yield of nutrients per unit area is achieved by harvesting clover-timothy grass mixture in the phase of the beginning of budding clover. During the period of complete budding of the latter, the yield of nutrients decreases by only 4.1%. The dry matter yield of clover-timothy grass mixture, which is obtained during harvesting at the stage of budding, is slightly lower than in the stage of complete budding. Therefore, the largest yield of nutrients per unit area in the phase of the beginning of budding is mainly due to the high nutritional value of grasses in this period.

The total yield of nutrients decreases sharply at later dates of harvesting grass. When mowing the grass mixture at the beginning of clover flowering, nutrient yield is reduced by 22-30%, and during full flowering – by 35-40% compared to harvesting grass at the beginning of bud formation. Especially large shortage of nutrients occurs when harvesting the grass mixture in the second year of use, when it contains less clover.

In some cases, perennial grasses are collected in the phase of the beginning of clover flowering and end, depending on the available technical and economic conditions, sometimes in the phase of seed formation. This does not take into account that the total collection of nutrients in herbs decreases before flowering, and insufficient protein content leads to overuse of feed, more expensive milk and meat.

Until recently, clover with timothy was sown on arable lands from perennial grasses. They are the main raw material for the preparation of hay, haylage. The optimal time for harvesting these grasses in the first mowing is 10-12 days and a little more in the second. However, producers do not always invest in the optimal time with the procurement of these herbs for feed, which is one of the main reasons for low feed quality, high nutrient losses, overconsumption of feed per unit of livestock production, rising of price on milk and meat.

Alfalfa, *Bromus inermis*, *Dactylis glomerata* and other high-yielding grasses ripen two to three weeks earlier. This allows to increase the optimal time of their harvesting and to ensure a more even loading of forage harvesting equipment. In addition, a set of herbs that reach for harvest at different times allows you to increase the collection of nutrients and protein by 20% by eliminating the losses associated with a unique set of perennial herbs.

3.3. Optimization of factors of growth and development of alfalfa

The main factors of growth and development of alfalfa are temperature, humidity and lighting of the environment in which the plant is located. In order for alfalfa cultivation to be successful, the soil must be well permeable and fertile. Ordinary, gray, dark gray and forest soils correspond to this most fully.

Alfalfa grows very poorly or almost not on acidic soils, when the pH is less than 4-4.5, as well as at high groundwater levels. However, alfalfa is able to withstand low soil salinity, so such crops are used to combat soil salinity under irrigation.

The temperature that alfalfa tolerates can fluctuate significantly. The minimum temperature at which alfalfa seeds germinate is in the range of 1-2°C, seedlings emerge and develop well at 15°C and above. At a temperature of 5°C and below the vegetation of the plant stops. Seedlings can withstand frosts down to minus 5-6°C.

According to research results, for a full-fledged mowing, the sum of active temperatures in the Forest-Steppe should be 2000-2200°C. Alfalfa seedlings are less resistant to maximum temperatures. On the soil surface in the Southern Forest-Steppe the temperature can reach 4°C. In such extreme conditions, alfalfa seedlings die.

Winter hardiness and frost resistance of the culture are quite high. Thus, during the winter, in the absence of snow cover, plants tolerate frosts down to minus 20-25°C, while with constant snow cover they are able to withstand much lower temperatures. In practice and experiments it has been proven that the last mowing should be carried out 25-30 days before the end of the growing season.

Moisture is necessary for alfalfa, as well as for other plants. At the same time it is not afraid of drought, also responds well to moisture.

High yields of alfalfa green mass are obtained under irrigation conditions, where its productivity increases sharply.

When growing alfalfa for green fodder, it is necessary to maintain the continuity of growth and development of plants, which is achieved by sufficient soil moisture – more than 80-85% of the field moisture resistance of the latter. Excess moisture or the proximity of groundwater to the soil surface adversely affects alfalfa productivity and causes grass damage. Flooding of alfalfa fields in spring with melt water for 10-15 days causes crop losses.

The total use of moisture per unit area in alfalfa is superior to many field crops. This is due to the fact that alfalfa forms a strong aboveground part and root system, as well as a large leaf area, which reaches 50 thousand m^2 per hectare and more. The transpiration coefficient in alfalfa, depending on the growing conditions, as in other field crops is in the range of 180-200.

It should be noted that the higher the soil moisture, the more it gives moisture to plants and the transpiration rate increases. But the transpiration coefficient increases more slowly than soil moisture. By regulating the water regime by watering, it is possible to significantly increase the productivity of alfalfa. Due to this, in the conditions of irrigated agriculture, where it is possible to create favorable light, heat and nutrient regimes, with the necessary moisture regime, the most favorable conditions for growing alfalfa vegetative mass are created.

Alfalfa grows quite intensively on fertile, well-drained, including slightly saline, soils.

Light is one of the important environmental factors throughout the vegetative life of alfalfa and other plants. Alfalfa is a short-day plant and is most sensitive to light in the early period of its development. The best conditions for development are up to 18 hours a day and a sufficient light intensity of 60 thousand suites.

For alfalfa stands, the depth of light penetration to different tiers, which form the overall productivity of photosynthesis, the assimilation surface of the leaf apparatus, is also important. Because of this, in production conditions, cover crops should minimally shade alfalfa.

An important indicator of plant growth is their height. However, in the year of sowing, it can be very dependent on the different dates and the collection of cover crops. Therefore, even in autumn, in general, this figure will not be unambiguously predictable. The same applies to the comparison of the autumn growth of green mass. Although it should be noted that under the conditions of summer sowing in June, sufficient heat and moisture are initial, the initial conditions of alfalfa vegetation are much more favorable than in early spring. They are in many respects more favorable for late spring sowing – from late April to early May.

However, the growing season of summer crops is shorter: therefore, there is a somewhat accelerated phase of development and a certain recession of linear indicators. At the same stage of organogenesis (for example, branching) in summer sowing plants marked slightly lower height. More heat, more intense sunlight contributed to the passage of phases in a shorter time. This phenomenon, confirms O.I. Zinchenko (1985), is called neoteny – when plants, such as weeds (shrews, mice), reach the generative phase in a much shorter time than if their vegetation began in the spring. This is recorded, albeit to a lesser extent, in alfalfa plants.

Observations of the development of alfalfa plants have shown that during uncovered spring sowing they go through the full cycle of vegetation, reach full grain maturity, but under the condition of not mowing, ie without interrupting the growth and development of plants.

Uncovered post-harvest sowing after rye by autumn reached the flowering phase (9th stage of organogenesis). Undercoat crops of alfalfa for barley and oat mixture before removing the cover crop, respectively, were at the 4-5th stages of organogenesis – branching. Covering sowing under corn for green fodder in the spring sowing period for the period of corn harvesting reached the 6-7th stage of organogenesis – the end of the branching phase. Only in places of liquid stalked corn in some plants was marked the beginning of the budding phase.

Alfalfa plants also reached the full branching phase during post-harvest cover sowing before harvesting corn. Some of them were in the budding phase in places with sparse maize stalks.

According to the specified phenological indicators it is possible to compare also autumn otava. However, due to the different timing of cover crops, these data will also not be so objective that reliable conclusions can be drawn. Because this does not take into account the previous growth of the plant. We need an indicator that would “summarize” the overall growth.

To compare the final autumn growth of plants in the year of sowing, a somewhat unconventional indicator was used – the diameter of the root collar of plants. In any case, these data have not been found in the scientific literature. However, this indicator can be considered quite objective. The vegetation of plants of different sowing dates of uncovered and under-cover crops could be interrupted due to harvesting of cover crops or mowing on uncovered crops in order to control weeds. However, the root system functioned, and its size during the growing season increased. One of the indicators of this process is the diameter of the root neck – “crown”, as it is called by G.P. Kvitko (1998). According to observations, as a result of mowing when harvesting cover crops recovery buds are formed not only in the upper part of the root neck and sinuses of the lower internodes of the stem, but also below – at a depth of 2-3 cm from these buds, as well as upper which could not be, if not carried out mowing. The upper part of the root neck as a result thickens slightly.

Its largest diameter was observed in plants of spring and summer (after rye for green fodder) coverless crops. In second place on this indicator were alfalfa plants of spring cover crops for corn for green fodder. Crops of alfalfa uncovered sowing after vetches-oat mixture and undercover under post-harvest corn had almost the same indicators. The least developed was the root collar in the variant with sowing of alfalfa under barley and slightly better in the variant with sowing under vetches-oat mixture. This can probably be explained by better nutritional conditions after the use of vetches-oat mixture. These differences in the formation of the root collar, respectively, affected the formation of recovery buds. They, per capita, were laid much more on coverless spring crops and after winter rye for green fodder, undercover crops for corn for green fodder in spring and post-harvest sowing.

Alfalfa plants had the fewest buds in the variant of sowing it under barley, but the sowing was liquefied mostly under the oat mixture. This adequately determined the density of stems in the first year of use. And although the plants were less developed after the barley than after the mowing, there were more plants left under the barley. Therefore, the density of stalks in the first year of use in this embodiment was slightly higher than when sowing under the oat mixture. For the second year of use, a significant difference in stem density according to the variants of the experiment was no longer observed. It should be noted that the linear growth of alfalfa plants was much more intense during the May sowing period and was 64-67 cm compared to June – 55-42 cm.

Upon receipt of alfalfa seedlings during June, one mowing is formed in the phase of the beginning of flowering in late August and mid-September with a yield of 88-94 kg/ha and a yield of 19.8-21.0 kg/ha of dry matter and 4.2-4.6 c/ha of protein.

In the experiments of 2005-2008 it was established that during the spring sowing period the duration of the germination period – the beginning of flowering primarily depends on the length of the day and the temperature regime (Table 3.2).

3.2. Influence of sowing of alfalfa on the duration of the germination period – the beginning of flowering (according to SS NULES of Ukraine "Agronomic Research Station") (average for 2005-2008)

Average calendar dates			Number of days from germination to flowering	Sum		The average daily indicators for the period of germination – flowering	
sowing	stairs	beginning of flowering		air temp., °C	light hours	air temp., °C	day length, hour
30.04	7.05	21.07	74	1202	1187	16.2	16.0
20.05	28.05	30.07	63	1086	1015	17.2	16.1
9.06	15.06	21.08	65	1148	1049	17.7	16.1
19.06	26.06	10.09	75	1343	1136	17.9	15.1
26.06	1.07	20.09	80	1443	1198	18.0	14.9
20.07	1.08	1.10	60	979	1155	10.9	12.8
V, %			**12.7**	**15.8**	**7.5**	**18.7**	**9.4**

The most favorable conditions for the growth and development of alfalfa during spring sowing are created at an average day length of 16.1-16.2 hours. Under these conditions, alfalfa reaches the beginning of the flowering phase in 55-60 days.

Variation analysis proved that the greatest stability (with coefficients of variation of 7.5-9.4%) is characterized by the amount of light hours and the length of the day for the period "seedlings – flowering". The highest variability (V = 15.8-18.7%) was recorded in relation to fluctuations in the sum of air temperatures and average daily air for the period “seedlings – flowering”, which confirms the importance of temperature on alfalfa plants with changes in sowing dates of the studied crop.

The best time to sow alfalfa should be considered the third decade of April, when the growth and development of this crop occurs in May-June with an average light day of 16 hours.

Given the above, agro-climatic resources of the Forest-Steppe of Ukraine in terms of natural soil fertility, moisture conditions, temperature and light regimes are favorable for maximum realization of the biological potential of forage productivity of alfalfa sown regionalized varieties.

Alfalfa, as already mentioned, depending on environmental conditions, develops in both spring and winter types. In the spring type of development during spring pure sowing alfalfa forms seeds, or two mowing of the vegetative mass in the early flowering phase. In the first year of the growing season, the formation of the “crown” is completed, where a sufficient amount of carbohydrates accumulates, which guarantees maximum overwintering and stem-forming ability of plants in subsequent years of use by grasses.

In the case of sowing alfalfa under the cover of early spring crops with a reduced seeding rate of 20-30%, unfavorable agroecological conditions are created for growth and development in the first year of life. The growth and development of alfalfa is negatively affected by the intensive growth of early spring crops, resulting in a significant decrease in the light of alfalfa plants for 40-45 days. Plants do not pass the light phase of development and for the period of harvesting cover crops are in the phase of 4-7 trifoliate leaves at a height of 10.4-12.1 cm, which characterizes the winter type of development.

At the end of the growing season of the first year of use when sowing under the cover of barley grass liquefies by 25-30%. The root system penetrates to a depth of 60-80 cm (the formation of the “crown” is not complete), which does not always guarantee the successful overwintering of plants.

3.4. Inoculation in the formation of alfalfa crop

Perennial legumes have the ability to enter into symbiotic relationships with nodule bacteria, which belong to the genus *Rhizobium*. Nitrogen fixation in nature is due to a complex process of interaction between the two components of symbiosis – bacteria and plants. Each species of nodule bacteria contains a large number of strains that differ in a set of characteristics, including nitrogen-fixing ability. Strains may differ in the degree of adaptation to a particular species of legumes in the group. This phenomenon is called species specificity. Under the condition of adaptation to the corresponding variety of the same type of legume there is a varietal specificity.

With the formation of an active complex, the *Rhizobium* plant forms a symbiosis, in the process of which solar energy is used to bind atmospheric nitrogen biologically. The process of biological nitrogen fixation is due to the energy of photosynthesis products that enter the root system and rhizosphere of plants.

Bean-rhizobial symbiosis is beneficial for both components and formed in the process of long-term evolution. Although evolutionarily a relatively young nitrogen-fixing system, it uses the ancient and to date the only known method of biological fixation by the enzyme nitrogenase, which in a living cell catalyzes the reductive process of nitrogen binding, i.e., hydrogen bonding.

The productivity of various nitrogen-fixing organisms and their associations depends both on the sources and rates of energy material and on the intensity of its productive use. In addition, it is directly dependent on weather conditions of the year, the level of nutrient supply, biological characteristics of plants, as well as, in most cases, the presence of a highly active specific nitrogen-fixing strain.

Numerous studies have shown that the development of symbiotic systems of legumes, the intensity of fixation of biological nitrogen is effectively regulated by the introduction of appropriate doses of fertilizers, bacterial preparations, which provides a high level of fixation and long-term activity of complex.

Alfalfa absorbs 150-200 kg/ha of nitrogen from the air, which is from 40-60 to 70% of the plant’s need for this element. Nitrogen fixation is improved when special races of nodule bacteria are selected, seeds are treated with them or they are applied directly to the soil. It is especially desirable to do this on poor podzolic soils. On fertile soils, the positive effect of this drug on the improvement of biological nitrogen fixation is not always revealed.

Rhizotorphin is a drug that contains highly effective strains of nodule bacteria grown on peat, to which vitamins, trace elements and minerals are added. It should be noted that according to the Institute of Agricultural Microbiology of NAAS in Chernihiv, the simultaneous introduction of alfalfa rhizotorphin with ammonium nitrate provides a much greater increase in green mass compared to the use of only mineral fertilizers.

Even at the Poltava Regional Experimental Agricultural Station on deep low-humus chernozems, the combination of nitragin with nitrogen fertilizers, albeit in small doses (N_{20}), significantly increased the yield of alfalfa green mass.

The data given in Table 3.3 obtained in the conditions of the Right Bank Forest-Steppe are quite significant and this measure is effective in all farms.

However, seeds treated with mercury should not be treated with rhizotorphin, as bacteria die from it, and seeds prematurely treated with fungicides 2-4 weeks before sowing can be treated with rhizotorphin on the day of sowing. If alfalfa is sown under the cover of barley, corn, millet and other crops, rhizotorphin can be used to treat the seeds of the cover crop, and this will have a beneficial effect on alfalfa.

It should be noted that in the experiments, treatment with rhizotorphin provided a significant increase in the yield of green mass of alfalfa – by 14.9-24.1%. Increasing the dose of mineral fertilizers from $N_{60}P_{60}K_{60}$ to $N_{90}P_{60}K_{60}$ on the background of pre-sowing treatment with rhizotorphin contributed to an increase in plant productivity by 5.5%, whereas in the untreated version such an increase (0.3 t/ha) was less than the smallest significant difference in this factor (LSD_{05} – 1.2 t/ha).

3.3. Yield of alfalfa green mass using rhizotorphin under conditions SS NULES of Ukraine "Agronomic Research Station", t/ha (average for 2005-2008)

Dose of fertilizers (factor A)	Seed treatment with bacterial fertilizer (factor B)	
	without rhizotorphin	with rhizotorphin
$P_{60}K_{60}$	37.0	43.5
$N_{30}P_{60}K_{60}$	40.7	50.0
$N_{60}P_{60}K_{60}$	38.9	48.1
$N_{90}P_{60}K_{60}$	38.6	50.9
LSD_{05}, t/ha for factors:A – 1.22; B – 1.59		

Analysis of variance confirmed the maximum effect of seed treatment with rhizotorphine at 69.0% in terms of the impact on the yield of alfalfa green mass, compared with the effect of mineral fertilizers – 13.2% (Fig. 3.2).

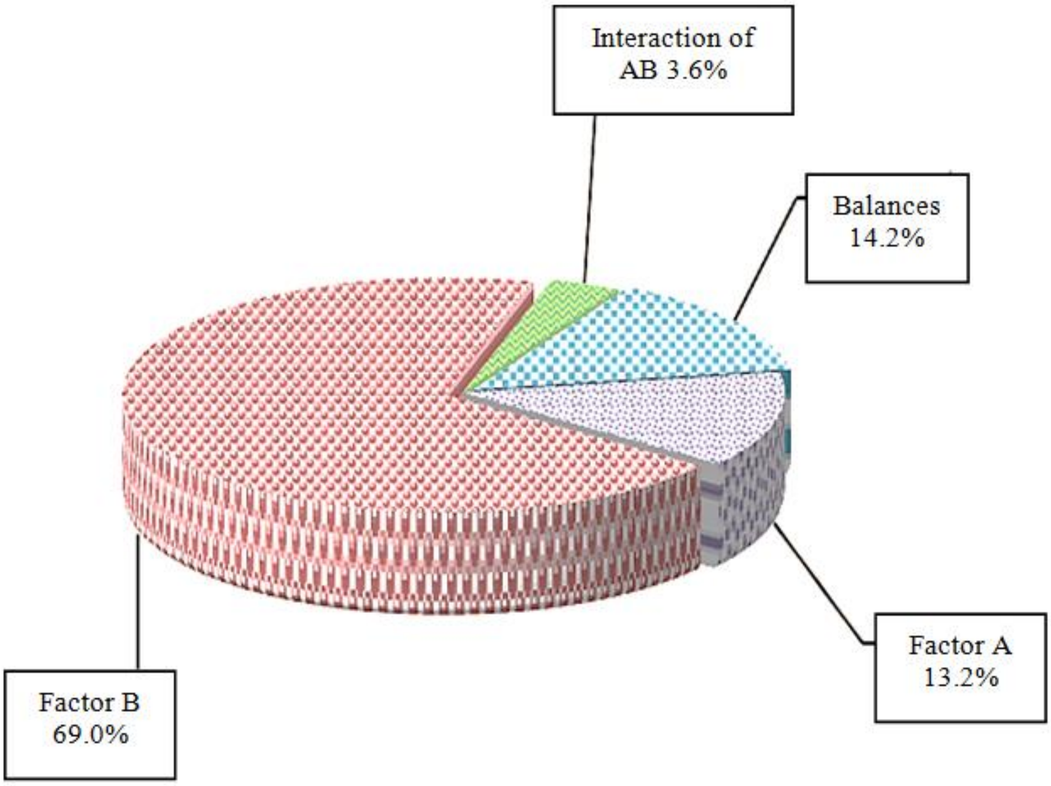


Fig. 3.2. Proportion of factors (%): dose of mineral fertilizers (factor A) and seed treatment with bacterial fertilizer (factor B)

The interaction of factors accounts for only 3.6%, and the influence of other unaccounted for factors (primarily changes in weather conditions during the research years) is characterized by an effect of 14.2%.

3.5. Agroecological substantiation of alfalfa system of fertilization

The fertilizer system is developed on the basis of available crop rotations in the farm, taking into account soil and climatic conditions, the size of the planned yields, predecessors, biological characteristics of crops and their role in the economy of the farm. The alfalfa fertilization system was based on fertilizer norms determined by the normative method taking into account the recommended norms established by the results of the geographical network of field experiments. In determining the norms of fertilizers took into account the data of agrochemical survey of soils, conducted by the Department of Forage Production, Land Reclamation and Meteorology in cooperation with the Department of Soil Science and Soil Protection named after Professor M.K. Shukula NULES of Ukraine in 2013.

The following features were taken into account during the implementation of the developed fertilizer systems:

1. Fertilizer rates and doses to be applied in certain periods may be partially adjusted upwards or downwards to take account of agrochemical soil survey data. In the developed systems, this adjustment was made in part because there was no final placement of crops in crop rotation fields.

2. In the developed systems pre-sowing application of fertilizers for most crops is planned. If it is impossible to apply fertilizers in this way due to the lack of fertilizer units on the drills, these doses should be transferred to the main fertilizer.

3. At introduction of the developed systems of fertilizer of agricultural crops it is offered to provide need of nitrogen at the expense of ammonium nitrate. Ammonium nitrate can be used for early spring fertilization of winter crops, and Urea Ammonia Mix or urea can be used for foliar fertilization. If there is a technological possibility (sprayers with nozzles), it is advisable to carry out radical fertilization of Urea Ammonia Mix in crops of winter wheat and corn.

4. These doses of phosphorus and potassium in the main fertilizer from agronomic, economic and organizational points of view is more effective in the form of fertilizer mixtures (mixtures of ammophos and potassium chloride). If phosphorus and potassium are used separately in

the form of unilateral or complex fertilizers, additional application costs, loss of time and deterioration of the uniformity of fertilizers on the field surface are possible, which reduces their potential availability and, accordingly, nutrient utilization factors.

5. To increase the productivity of crops should be applied foliar fertilization with microfertilizers. This measure can be carried out simultaneously with the introduction of plant protection products.

6. If it is impossible to use fertilizers for spring crops, moderate amounts of them can be applied to the main tillage (50-60% of the dose in the main fertilizer) for pre-sowing cultivation.

7. For pre-sowing application of fertilizers in the dose of $N_{10}P_{10}K_{10}$ it is optimal to use nitroammophoska brand 16:16:16.

8. In case of development and development of the developed systems of fertilizer of agricultural crops it is necessary to consider features of food of some of them.

9. With large volumes of production can accumulate a significant amount of manure, which should be made in the main fertilizer for corn – 30 t/ha, winter wheat – 20-25 t/ha.

The performed analyzes show insignificant level of fluctuations in the indicators of active acidity, content of ammonium nitrogen, nitrate nitrogen, mobile phosphorus compounds and potassium metabolic compounds. The studies emphasize the importance of agrochemical observations for the formation of the optimal ratio of nutrients in order to obtain high and quality yields of alfalfa and other crops at the local level of each farm.

Due to the annual increase in the price of raw materials and the reduction of net profit, the rational use of fertilizers is becoming very important. To obtain high yields, alfalfa must be placed after fertilized predecessors, as well as fertilize directly under this crop. For the formation of 1 kg of absolutely dry matter of the aboveground mass of alfalfa uses: nitrogen – 2.4 kg, phosphorus – 0.6-0.7 kg, potassium and calcium, respectively, 1.5-1.7 and 2.6-2.8 kg.

There are three ways to determine the nutrient supply of the soil: according to soil analysis, analysis and interpretation of visual changes that occur during the growing season and through laboratory analysis of selected plant samples. Soil analysis is the most convenient and cost-effective way to determine the level of nutrient supply. This is only a diagnostic method that predicts the level of plant nutrition before sowing.

Visual observations are made during the growing season, but nutrition problems can be too acute, which will lead to significant crop losses (Table 3.4).

3.4. Visual signs of nutrient deficiency

Element	Visual signs
N	Undersized, elongated slender stems; plant color from light green to yellow
P	Blue-green or dark green color of the leaves, especially pronounced on acidic soils; young leaves are often twisted, and their reverse side and stem become red or crimson
K	White spots on the edge of the leaf blade. Spots appear on the lower leaves, but become more noticeable on the upper ones. Developed leaves turn yellow and fall off

Laboratory analysis of selected plants makes it possible to determine the state of nutrition of grasses before the appearance of any visual signs. For elements such as sulfur and most trace elements, this is the most acceptable method of determining the need. For a somewhat broader understanding of the food system, it is necessary to combine soil and laboratory analysis of plants.

As shown by the obtained data (Table 3.5), fertilizers had different effects on seed germination. In the variants where mineral fertilizers were applied, germination was more intensive and the mass of 10 seedlings was larger compared to the control.

In the variant where superphosphate granules were used, the weight of 10 seedlings was 250 mg, with the introduction of ammonium nitrate granules – 242 mg. In the control version, this figure was 230 mg.

3.5. Influence of phosphorus and nitrogen fertilizers on weight of seedlings and weight of one plant of alfalfa under conditions SS NULES of Ukraine "Agronomic Research Station", g (average for 2009-2011)

A variant of the experiment	Weight of 10 seedlings, mg	The weight of one plant during the development period of 60 days, g		
		aboveground mass	root mass	plant mass
Control	230	0.66	1.43	2.09
P_{15}	250	1.14	1.78	2.92
N_{15}	242	1.09	1.64	2.73
V, %	**4.2**	**27.4**	**10.9**	**16.9**

Variation analysis revealed minimal variability (V = 4.2%) in the mass of 10 seedlings of one alfalfa plant. On the contrary, the mass of one plant during the development period of 60 days was characterized by significant fluctuations of the coefficient of variation, and its largest value (V = 27.4%) was observed relative to the aboveground mass.

Phosphorus fertilizers helped to increase the mass of seedlings compared with ammonium nitrate. This is due to the physiological role of phosphorus in the plant. Phosphorus here acts as an energy element that promotes the formation of the root system, the fuller use of moisture by the seeds during germination.

High supply of alfalfa plants with phosphorus and nitrogen in the initial period of development significantly improves the further growth of alfalfa. This is confirmed by data obtained in a vegetation experiment close to the field. In the variant where phosphorus fertilizers were used, the weight of one plant was the largest and was 2.92 g. This is 0.83 g more than in the control variant and 0.19 g more than with the application of nitrogen during pre-sowing treatment.

To determine the benefits of phosphorus and nitrogen fertilizers during alfalfa sowing, studies were conducted on the effect of fertilizers on the content of various forms of nitrogen and phosphorus in the leaves and roots of alfalfa in different periods of growth and development (Table 3.6).

3.6. Influence of phosphorus and nitrogen fertilizers on the content of forms of nitrogen and phosphorus in alfalfa plants in different phases of growth and development under conditions SS NULES of Ukraine "Agronomic Research Station" (average for 2009-2011)

A variant of the experiment	Nitrogen,%	Phosphorus,%
	general	general
In the phase of the first true leaf (leaves)		
Control	2.38	0.50
P_{15} kg/ha	2.51	0.54
N_{15} kg/ha	2.46	0.52
Roots		
Control	0.613	0.72
P_{15} kg/ha	0.78	0.69
N_{15} kg/ha	0.73	0.68
During the growth period of 60 days (leaves)		
Control	2.73	0.65
P_{15} kg/ha	2.88	0.71
N_{15} kg/ha	2.83	0.69
Roots		
Control	1.56	0.39
P_{15} kg/ha	1.64	0.57
N_{15} kg/ha	1.66	0.58
V, %	**44.8**	**17.1**

The high supply of alfalfa plants with phosphorus in the initial period of development significantly improves their further growth, which is confirmed by the data of the vegetation experiment.

In addition, studies were performed on the effect of phosphorus and nitrogen fertilizers on the content of various forms of nitrogen and phosphorus in alfalfa leaves during the first leaf and in alfalfa leaves during the development period of 60 days.

According to the analysis of the obtained experimental data, it was found that the application of both phosphorus and nitrogen fertilizers had different effects on the content of different forms of nitrogen and phosphorus in the leaves and roots of alfalfa. This content was different both in the phase of the true leaf and in the period of alfalfa growth of 60 days.

In fertilized versions, where phosphorus fertilizers were applied, the total nitrogen content reached 2.51%. The application of nitrogen fertilizers resulted in a lower content of total nitrogen, with an average of 2.46% and a control of 2.38%.

The introduced phosphorus contributed to the increase of the protein nitrogen content and the reduction of its non-protein form in comparison with the application of nitrogen fertilizers. The same pattern was observed for the content of various forms of nitrogen in the roots of alfalfa. The increase in total phosphorus in alfalfa roots in the phase of the first true leaf, as well as organophosphorus compounds indicates that the roots are intensive phosphorylation processes associated with metabolism.

In the phase of alfalfa development for 60 days, the mentioned differences were not so convincing, and the content of inorganic phosphorus and nitrogen in the root was approximately the same for all variants of the experiment.

According to the above data, the application of phosphorus and nitrogen fertilizers affected the forms of nitrogen in the leaves and roots in different ways. Phosphorus introduced during the sowing of alfalfa, contributed to the highest content of total nitrogen – 2.51%, and caused the highest amount of protein nitrogen – 1.93%. The content of total protein nitrogen was also higher with the application of nitrogen fertilizers compared to the control.

Coefficients of variation that reflected the effect of fertilizers on the content of different forms of nitrogen and phosphorus in alfalfa plants in different phases of growth and development had a very high level of variability. It should be noted that the minimum (17.1%) and maximum (113.2%) coefficients of variation were obtained with respect to the content of total and mineral phosphorus.

Increased nitrogen content in alfalfa plants with the application of phosphorus fertilizers during the sowing of alfalfa is observed in vegetation and field experiments. Analysis of alfalfa plants for total nitrogen and total phosphorus in the 30- and 60-day development periods and for the second year of the growing season shows that the introduction of phosphorus during sowing improves the nitrogen nutrition of alfalfa (Table 3.7). Improving nitrogen nutrition is a characteristic effect on chernozem soils. This is confirmed by data on the content of nitrogen and phosphorus in alfalfa plants in the field experiment, the increased content of total nitrogen indicates an increased content of crude protein. Hence, as the results showed, phosphorus fertilizers contributed to an increase in the mass of seedlings compared with the introduction of ammonium nitrate.

In addition, the application of phosphorus fertilizers during the sowing of alfalfa helped to increase the protein nitrogen content in various phases of growth and development. Phosphorus fertilizers applied during the sowing of alfalfa, almost did not affect the content of various forms of nitrogen and phosphorus during the development period of 60 days.

3.7. The content of total nitrogen and phosphorus in alfalfa leaves in different periods of growth and development under conditions SS NULES of Ukraine "Agronomic Research Station" (average for 2009-2011)

A variant of the experiment	Nitrogen	Phosphorus
Growth and development of alfalfa 30 days		
Control	1.72	0.51
P_{15} kg/ha	2.08	0.53
N_{15} kg/ha	1.93	0.52
Growth and development of alfalfa 60 days		
Control	2.73	0.65
P_{15} kg/ha	2.88	0.71
N_{15} kg/ha	2.83	0.69
The second year of alfalfa vegetation, flowering phase		
Control	2.40	0.52
P_{15} kg/ha	2.69	0.55
N_{15} kg/ha	2.47	0.53
V, %	**17.3**	**13.9**

Variation analysis showed slightly greater variability in the content of total nitrogen in alfalfa leaves in different periods of growth and development – 17.3%, compared with phosphorus (V = 13.9%).

3.6. Determination of leaf surface area and grass yield depending on the share of alfalfa and fertilizer

Due to the fact that the leaves are the main organ of photosynthetic activity of plants in which organic matter is formed, the area of the assimilation surface of any crop largely determines its yield. Studies have shown that the leaf surface area of perennial grasses varied and depended on their composition, level of mineral nutrition and mowing.

According to Table 3.8, it was found that with the improvement of the level of mineral nutrition in all studied variants, the leaf surface area increased. Thus, grasslands grown in variants without fertilizers (control), depending on the mowing formed a leaf surface within 17.6-41.4 thousand m²/ha.

Application of phosphorus-potassium fertilizers under grassland in the norm of $P_{90}K_{120}$ contributed to the growth of this indicator to 19.4-50.2 thousand m²/ha. The most significant increase in leaf area was provided by the introduction of mineral nitrogen in the normal N_{90} on a phosphorus-potassium background $P_{90}K_{120}$. In such conditions, the grasslands, depending on their composition and mowing, formed a leaf surface within 23.1-56.4 thousand m²/ha.

3.8. Leaf surface of grass hay depending on its composition, level of mineral nutrition and mowing under conditions SS NULES of Ukraine "Agronomic Research Station" (average for 2009-2011)

A variant of the experiment		Mowing	
culture	fertilization	the first	the second
Medicago sativa	Without fertilizers (control)	26.8	17.6
	$P_{90}K_{120}$	31.9	19.4
	$N_{90}P_{90}K_{120}$	35.0	23.1
V, %		**13.3**	**14.0**
Bromus inermis	Without fertilizers (control)	28.5	24.9
	$P_{90}K_{120}$	33.6	29.6
	$N_{90}P_{90}K_{120}$	39.7	34.8
V, %		**16.5**	**16.7**
Medicago sativa + Bromus inermis	Without fertilizers (control)	41.4	28.3
	$P_{90}K_{120}$	50.2	34.4
	$N_{90}P_{90}K_{120}$	56.4	38.8
V, %		**15.3**	**15.9**

Experimental data showed that the leaf surface area also changed on the mowing. It was found that all studied grasslands formed a much larger assimilation surface area in the first (26.8, 56.4 thousand m²/ha) than in the second (17.6, 38.8 thousand m²/ha) mowing.

Also, according to the results of the study, the largest leaf surface area in all variants of fertilizer during the growing season was in grass mixtures, which consisted of alfalfa and *Bromus inermis* (28.3, 56.4 thousand m^2/ha). The yield of this herb mixture was also the highest.

Variation analysis proved the average level of variability of the leaf surface of the studied crops depending on the doses of mineral fertilizers with fluctuations of the coefficient of variation from 13.3% (the first mowing of alfalfa) to 16.7% (the second mowing of the *Bromus inermis*).

As already mentioned, the yield of perennial grasses depends on a significant number of factors. This indicator is most affected by light, heat, air, water and nutrient regimes of the soil. During the research it was studied how the yield of grass changes depending on its composition and level of mineral nutrition.

According to Table 3.9, the yield of the studied grasslands depended on their composition and level of mineral fertilizer. Thus, the lowest yield of dry matter (from 3.15 to 4.22 t/ha) was observed in the variants without the use of mineral fertilizers. Application of phosphorus-potassium fertilizers under perennial grasses in the norm of $P_{90}K_{120}$ helped to increase their yield to 4.26-6.84 t/ha of dry matter.

The most significant increase in this indicator was influenced by the use of complete mineral fertilizer in the norm $N_{90}P_{90}K_{120}$. Depending on the composition of the grass, its yield was in the range of 6.38-7.56 t/ha of dry matter.

At the same time, it should be noted that the yield of the studied grasslands in the second mowing decreased by 35.0 to 40.2%.

3.9. Yield of grass hay depending on its composition and rates of mineral fertilizers under conditions SS NULES of Ukraine "Agronomic Research Station" (average for 2007-2009)

A variant of the experiment		Mowing		For two mowings
culture	fertilization	the first	the second	
Medicago sativa	Without fertilizers (control)	2.68	1.76	3.15
	$P_{90}K_{120}$	3.19	1.94	4.26
	$N_{90}P_{90}K_{120}$	3.50	2.31	6.38
V, %		**13.3**	**14.0**	**35.7**
Bromus inermis	Without fertilizers (control)	2.85	2.49	3.88
	$P_{90}K_{120}$	3.36	2.96	5.53
	$N_{90}P_{90}K_{120}$	3.97	3.48	6.91
V, %		**16,5**	**16.6**	**27.9**
Medicago sativa + Bromus inermis	Without fertilizers (control)	4.14	2.83	4.22
	$P_{90}K_{120}$	5.02	3.44	6.84
	$N_{90}P_{90}K_{120}$	5.64	3.88	7.56
V, %		**15.3**	**15.6**	**28.3**

Hence, it can be argued that on chernozem soils of the Right Bank Forest-Steppe of Ukraine to obtain high-quality feed with high protein levels it is necessary to grow a grass mixture consisting of alfalfa and *Bromus inermis* with mineral fertilizers in the norm $N_{90}P_{90}K_{120}$. Indicators of coefficients of variation regarding the variability of grass yield of sown hay depending on its composition and rates of mineral fertilizers fluctuated insignificantly. Thus, when harvesting the first cut of alfalfa, which was grown with a differentiated feeding background, the coefficient of variation was 13.3%, and in the variants with *Bromus inermis* for the second cut, this figure increased to 16.6%. The total values of the coefficient of variation for the two mowings were at the level of 27.9-35.7%, which is 1.7-2.7 times higher compared to the variation separately for the first and second mowings.

One of the main tasks in creating a strong feed base is the use of high-energy and high-protein feeds. Currently, the average protein content in the diets of Ukraine does not exceed 85-90 g, and in some areas – 50-60 g per feed unit instead of 110-115 g according to the zootechnical norm. A significant role in eliminating the deficit of plant protein is played by grasses, which are characterized by its high content and far exceed the zootechnical norm.

Scientists claim that the creation of sown grasslands with a significant share of legumes in them – one of the promising areas of intensification of crop production. Legume-cereal grasses in productivity and protein collection are 8-10 times or more higher than natural coenoses.

With proper technology, legume-cereal grass mixtures provide yields at the level of 50-60, or 7-9 t/ha of feed units, 1-1.5 t/ha of digestible protein, and the feed unit of these grass mixtures contains 130-160 g of protein (as mentioned above, the zootechnical norm is 110-115 g).

Based on research, it is established that in the presence of a significant amount of legumes in the mixtures due to nitrogen fixation creates favorable conditions for nitrogen nutrition for growth and development of grasses and, as a result, significantly increases protein, improves mineral composition of grass feed, animal consumption and increases yield of livestock products. In addition, it allows you to get cheap, environmentally friendly food, balanced in protein and other valuable substances, as well as increase nitrogen fixation and bring the protein content in the feed to the required level – 12-14%.

Therefore, the study of the formation of alfalfa-grass stands, depending on the proportion of legumes in them are important issues for the theory, practice and intensification of crop production. In view of this, special studies have been conducted, which today seem relevant and necessary.

Based on the analysis of the obtained data in Table 3.10, it was found that the highest productivity of the grass mixture was found when saturated with alfalfa in the amount of 70%.

3.10. Yield of green mass of alfalfa-cereal grass mixtures depending on the share of alfalfa and fertilizer rate under conditions SS NULES of Ukraine "Agronomic Research Station", t/ha (average for 2010-2013)

The share of alfalfa in the grass mixture	Fertilizer rate	Year				Average for 2010-2013
		2010	2011	2012	2013	
Medicago sativa (100%)	Without fertilizers (control)	29.8	30.1	28.6	27.3	29.0
	P_{90} K_{60}	30.6	29.1	28.4	27.8	29.0
	N_{90} P_{90} K_{60}	29.9	27.4	28.1	26.3	27.9
Medicago sativa (30%) + *Bromus inermis* + *Poa pratensis* (70%)	Without fertilizers (control)	28.5	29.8	27.4	27.1	28.2
	P_{60} K_{90}	30.1	30.8	30.9	29.4	30.3
	N_{90} P_{60} K_{90}	32.9	31.4	29.9	29.6	31.0
Medicago sativa (40%) + *Bromus inermis* + *Poa pratensis* (60%)	Without fertilizers (control)	30.9	31.4	30.6	29.2	30.5
	P_{60} K_{90}	32.4	33.1	32.6	31.9	32.5
	N_{90} P_{60} K_{90}	33.1	33.6	31.7	30.4	32.2
Medicago sativa (50%) + *Bromus inermis* + *Poa pratensis* (50%)	Without fertilizers (control)	33.2	34.2	31.9	30.8	32.5
	P_{60} K_{90}	34.7	35.1	34.3	33.2	34.3
	N_{90} P_{60} K_{90}	33.8	32.9	32.1	31.8	32.7
Medicago sativa (60%) + *Bromus inermis* + *Poa pratensis* (40%)	Without fertilizers (control)	36.1	37.9	37.2	36.2	36.9
	P_{60} K_{90}	37.4	38.2	37.8	36.9	37.6
	N_{90} P_{60} K_{90}	33.7	34.2	33.3	32.8	33.5
Medicago sativa (70%) + *Bromus inermis* + *Poa pratensis* (30%)	Without fertilizers (control)	38.4	38.9	38.5	37.9	38.4
	P_{60} K_{90}	39.1	40.1	39.7	38.5	39.3
	N_{90} P_{60} K_{90}	32.9	34.8	32.6	31.7	33.0

At the same time, in the variants without fertilizer application and when applying only $P_{60}K_{90}$ phosphorus-potassium fertilizers, the yield over the years of research was the highest and averaged 38.4-39.3 t/ha. The high yield of the grass mixture was ensured due to significant nitrogen fixation, which affected the increase of the leaf surface, density and height of the grass.

It should be noted that when applying fertilizers at the rate of $N_{90}P_{60}K_{90}$, the yield was much lower and on average over the years of research was only 33.0 t/ha. The reason for this decrease in yield was the deterioration of conditions with significant nitrogen fixation by alfalfa and fertilizers in the norm $N_{90}P_{60}K_{90}$, which are unfavorable for the growth and development of alfalfa, which leads to intensive loss. Studies have shown that when the grass mixture was saturated with alfalfa in the amount of 60%, the yield was high, but lower compared to the grass mixture, where the share of alfalfa reached 70%.

The lowest yield of the grass mixture was provided when saturating it with alfalfa in the amount of 30%. This is due to the fact that at such saturation nitrogen fixation by grass is low and in such conditions to increase its yield you need to make expensive and energy-intensive fertilizers in the amount of $N_{90}P_{60}K_{90}$.

3.7. Yield formation of alfalfa leaf mass depending on seeding rates

The peculiarity of the preparation of seeds for sowing perennial legumes, including alfalfa, is the presence in the seeds of the shell, which is impermeable to water and air. Such seeds are called solid. Its quantity varies depending on the species, variety, weather conditions, etc. If the seed contains more than 20% hard seed, it must be scarified mechanically or electro-hydraulically with micronutrient treatment. After that, inoculation with special strains of nodule bacteria and air-heat heating of seeds.

This preparation of seeds for sowing, first, increases, due to electrohydraulic scarification and treatment of seeds with trace elements, germination energy by 20-30% and germination by 5-10%; secondly, promotes early and friendly seedlings; third, it helps to increase yields by 10-12% and reduce unit costs. Due to inoculation, the total nitrogen content increases by 5%, and the increase in hay yield is 9-10%. Scarification is performed on special machines 10-12 days before sowing or immediately before sowing.

The seeds are treated before sowing. In farms or in areas where alfalfa is grown for the first time, it is necessary to treat the seeds with alfalfa nitragin (rhizotorphin). This work is performed on the day of sowing in a shaded area. Due to inoculation, the yield increases by 20-30%. Before sowing the seeds are aired and enriched with trace elements (molybdenum, boron, manganese).

Alfalfa is sown in early spring at the same time as sowing spring early crops or with cover crops in undercover cultivation. Coverless spring and summer sowing of alfalfa is possible. More favorable terms of summer sowing are in the Forest-Steppe zone for the period from June 20 to July 20. The main requirement is sufficient soil moisture. For sowing alfalfa use grain-grass seeder Klen-1,2 and others, sown in early spring in the usual row method. Alfalfa is sown with seeds of regional varieties not lower than the second class, free from weeds, especially quarantine.

Different ecological conditions of growth and development of alfalfa in the first year of the growing season, depending on the method of sowing, require the determination of optimal sowing rates, which guarantee the creation of highly productive grass in the following years of the growing season. The biological feature of alfalfa is the ability of one plant to form a bush of up to 300 stems, depending on the feeding area. Studies have shown that the density of plants in the first year of vegetation in the forest-steppe should be approximately 200 pcs/m^2. This provides a density of grass 450-500 pcs/m^2 of stems.

The formation of optimal grass density and yield of alfalfa leaf mass are also influenced by seeding rates, sowing methods, quality of soil preparation, seed wrapping depth, moisture content and varietal affiliation. Therefore, the recommendations for sowing rates of alfalfa for fodder purposes are ambiguous and need to be clarified, taking into account environmental conditions, especially given the shortage and high cost of seeds.

Based on the obtained data, which characterize the average agro-ecological conditions of alfalfa growth and development, it should be noted that with increasing sowing rates, field germination increases. However, at higher densities of alfalfa in the first year of the growing season is more intense process of liquefaction of grasses in subsequent years. It is established that the density of alfalfa seedlings depends on the type of compatible crop and the rate of its sowing. Significantly less field germination of alfalfa in cover and compatible crops with barley, compared with spring rye and late spring crops and, especially, coverless sowing.

The optimal sowing rate of alfalfa to ensure maximum nutrient production in the first year of the growing season is 6-8 million/ha of seeds. In the second year of alfalfa vegetation, coverless sowing provides much higher yields at all seeding rates. The general pattern is to increase yield growth at low seeding rates.

As it was determined, the optimal sowing rate of alfalfa for coverless sowing should be considered 6-8 million/ha, which determines the density of plants in the first year of vegetation 250-300 pcs/m², in the second – 200-330 and in the third year of vegetation – 160-170 pcs/m² (Table 3.11).

3.11. Influence of seeding rates on alfalfa yield under conditions SS NULES of Ukraine "Agronomic Research Station", t/ha (average for 2007-2009)

Sowing rate, million units/ha	Year of vegetation				**V, %**	
	the second		the third			
	leaf mass	dry matter	leaf mass	dry matter	**leaf mass**	**dry matter**
6	40.0	8.64	41.3	9.21	**2.3**	**4.5**
8	42.6	9.72	45.9	9.98	**5.3**	**1.9**
10	42.0	9.08	48.7	10.79	**10.4**	**12.2**
V, %	**3.3**	**5.9**	**8.2**	**7.9**	–	

The study of sowing rates of alfalfa 6, 8 and 10 million/ha of seeds in uncovered and compatible crops with late spring crops showed that the maximum dry matter yield for two years of use of grass provided sowing with a sowing rate of 8 million/ha of seeds. So, during early spring sowing, the maximum yield of alfalfa, with two years of use of grass, is formed in coverless sowing with a sowing rate of 6-8 million/ha, and under cover cultivation with early spring 10-12 million/ha of seeds. However, cover crops with increased seeding rates form a lower yield of leaf and stem mass, with a lower yield of dry matter and crude protein.

Combined sowing of alfalfa with a rate of 8 million/ha of seeds with early grain at a rate of sowing 1.0-2.0 million/ha of seeds, provides almost the same productivity as coverless sowing. At late sowing dates, with uncovered and joint cultivation of alfalfa with corn for green fodder, the maximum yield is formed at a sowing rate of 8 million/ha of seeds.

Variation analysis shows the stability of alfalfa yields of the coverless method of sowing for the second and third years of the growing season both in terms of leaf and stem mass and relatively dry matter, with fluctuations in the coefficient of variation from 3.3 to 8.2%. Changes in seeding rates significantly affected the variability of the indicators obtained in the experiment. Thus, at sowing rates of 6-8 million units/ha, the coefficient of variation for both indicators ranged from 1.9 to 5.3%, and when the sowing rate was increased to 10 million units/ha, there was also an increase in yield variability of leaf and stem mass and dry matter up to 10.4-12.2%.

Dispersion analysis proved the uneven effect of seeding rates on the yield of leaf and stem mass and dry matter of alfalfa by coverless method of sowing depending on the years of use of the crop (Fig. 3.3).

The share of sowing rate in the formation of the yield of leaf and stem mass of the studied crop was 55.1%, which is 2.4 times higher than the influence of the growing season, the share of which was 22.6%.

In addition, the interaction of factors had a high level (17.0%), which is explained by the proportional increase in plant productivity under more favorable weather conditions in the variants with the maximum norm. Residual values (influence of other unaccounted factors) on the formation of leaf mass yield were at a low level – 5.3%.

The share of influence on the yield of alfalfa dry matter, depending on the studied factors, reflected the general trends that were found regarding the yield of leaf and stem mass. However, the share of factor A influence (seeding rate) which decreased from 55.1 to 42.6%, relative to factor B (growing season), on the contrary, increased from 22.6 to 26.7%. There was also an increase in the interaction of the studied factors on the formation of dry matter by 6.9 percentage points, and the residual values were almost at the same level – 6.8 versus 5.3%.

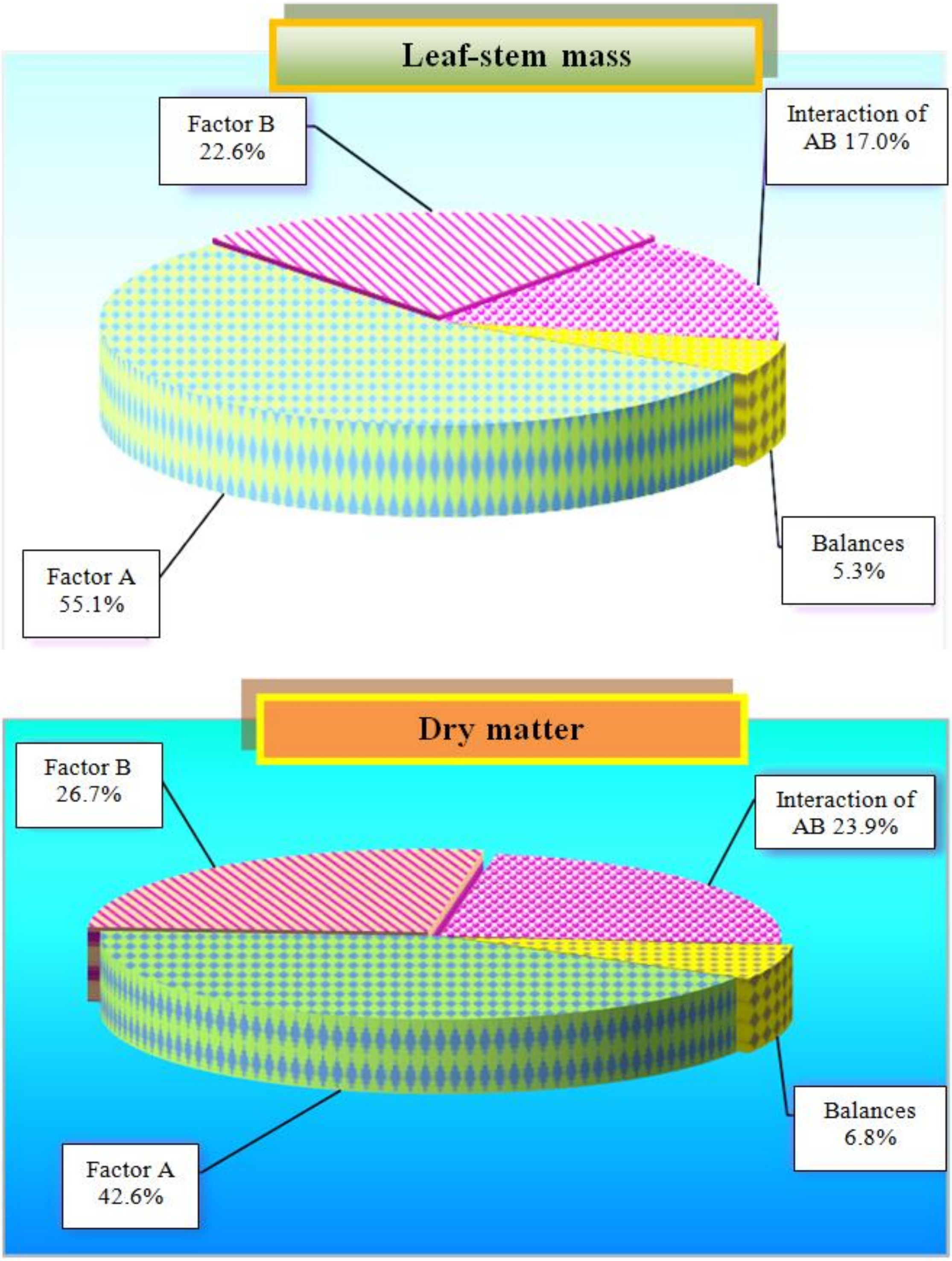


Fig. 3.3. The share of influence of factors (seeding rates – factor A; growing season – factor B) on alfalfa yield, %

If we take into account the above, then for any method of sowing it is necessary to create a grass stand, the density of which in the first year of use would be 200 plants/m^2 in the Forest-Steppe. However, it should be remembered that small-seeded crops, including alfalfa, have low field germination, a significant proportion of plants die in winter and under cover.

Therefore, in order to determine the seeding rate, it is necessary to take into account the indicators of field germination and liquefaction in the cover period. That is, in order to obtain 200 plants/m2, it is necessary to sow: in the Forest-Steppe under barley 15-16, under corn 14 kg/ha of alfalfa seeds.

The sowing rate for high-quality seed and soil preparation is in the range of 10-12 kg/ha. In the zone of the Right Bank Forest-Steppe of Ukraine, the optimal sowing rate of alfalfa is 8-10 million seeds per 1 ha, or 16-20 kg/ha with 100% suitability.

In the case of spring sowing, the first-year agrophytocenoses of the alfalfa field are unstable ecosystems with low competitiveness against weeds, which requires constant control and regulation of their relationship by agricultural techniques that involve weed control.

3.8. Comparative efficiency and scheme of fertilizer application (UAM-32) and means of protection in the technology of growing alfalfa

In modern economic conditions, visions and approaches to providing technologies with resources, including mineral fertilizers, are changing. Currently, there is a need for such types of fertilizers, the use of which not only increases the productivity of crops, but also reduces the unit cost of production.

Of the available and offered on the market today is noteworthy urea-ammonia mixture (UAM-32), which is an aqueous solution of ammonium nitrate and urea in the ratio: urea – 35.4%; nitrates – 44.3; water – 19.4; ammonia water – 0.5%. As the composition and ratio of components show, UAM-32 contains three forms of nitrogen – ammonia (25%), amide (50%) and nitrate (25%), so the fertilizer is prolonged, and plants are supplied with nitrogen throughout the growing season.

All forms in the fertilizer are not volatile and do not cause nitrogen loss, so it can be applied superficially without wrapping in the soil. Nitrate and ammonia forms are directly available to plants. Initially, nitrate nitrogen is absorbed, which is very mobile in the soil. Ammonia nitrogen is retained in the soil and does not leach into deeper layers. When UAM-32 is applied to the soil, this form accumulates in the arable layer and becomes available to plants during the growing season. Part of the ammonia form is converted into nitrate. The amide form in the soil is transformed into ammonia, and later into nitrate. This nitrogen uptake system converts UAM-32 into fertilizers of both rapid and long-lasting action. Due to the lack of free ammonia in UAM-32, it does not evaporate into the atmosphere during application, but the presence of ammonium form makes it desirable for minimal wrapping, especially in conditions of high temperatures and in conditions of no precipitation after application.

Produced brands UAM-28, UAM-30, UAM-32, in which the mass fraction of nitrogen is, respectively, 28; 30; 32%. Of the properties – UAM-32 crystallizes at 0°C, while UAM-30 – at minus 9°C, and UAM-28 – minus 17°C. Therefore, at low temperatures it is advisable to use the brand UAM-28.

The cost of nitrogen in UAM-32 is the lowest, because its losses when using UAM-32 do not exceed 10% of the total content. At the same time with the introduction of granular nitrogen fertilizers, they can reach 30-40%.

In addition, high application accuracy and uniform distribution on the soil surface compared to solid nitrogen fertilizers are achieved during application. The use of UAM-32 can be combined with trace elements, pesticides, plant growth regulators, which minimizes the cost of their use.

The use of UAM-32 reduces the cost of transportation, unloading, storage and application in the range of 25-30% compared to solid nitrogen fertilizers.

In addition to all the above advantages, UAM-32 does not pollute the environment, improves the supply of nitrogen to plants during drought, and operating costs for its application are much lower than other fertilizers.

Studies conducted in Vinnytsia region found the highest efficiency of 95% application of urea-ammonia mixture for the second year of use in the spring before the restoration of vegetation at the rate of 80-120 l/ha. The rates of use differed significantly: before sowing – in the range of 100-150 l/ha, for the second or third years of use before the restoration of vegetation – 80-120 kg/ha, while during the growing season their rate was 10-20 kg/ha (Fig. 3.4).

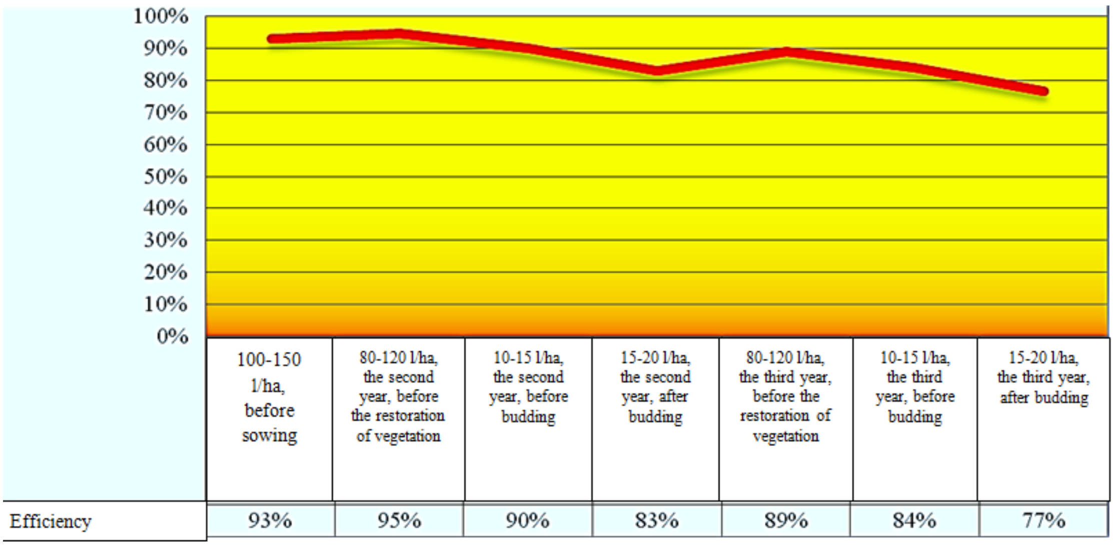


Fig. 3.5. Comparative efficiency of alfalfa cultivation technologies

It is expedient to use UAM-32 in parts, distributing on phases of growth and development by feeding vegetative plants. At the same time there is both root and foliar feeding. The need for foliar feeding is due to the following factors: stressful situations (low or high temperatures of air and soil, frost, moisture deficit); intensive, rapid growth of vegetative mass, in which the reserves of easily accessible mineral nutrients from the soil are depleted or their assimilation "does not keep up with the growth rate of plants"; reduction of intensity of assimilation of nutrients by root system owing to low activity of a current of microbiological processes or other factors that leads to decrease in rates of growth and development. Often critical periods regarding the lack of macro- and microelements in cereals occur in the phase of "exit into the tube – earing".

The degree (percentage) and rate of assimilation of nutrients from fertilizer UAM-32 through the leaf surface is much higher than from fertilizers applied to the soil. Given the above, the most acceptable is the use of a dilute solution of UAM-32. The amide form of nitrogen penetrates rapidly through the leaf surface of cereals and other crops. Foliar nutrition should be combined with the introduction of plant growth regulators, micronutrients, plant protection products.

UAM-32 can be used in the following terms in the following ways: – in the fall – under the main tillage; in the spring – for pre-sowing tillage; during the growing season of crops for root and foliar feeding; use as a compensatory dose of mineral nitrogen to increase the humification rate of straw, eliminate its effect on the growth and development of plants by balancing the ratio of carbon and nitrogen.

Studies conducted to compare the effectiveness of technologies with the use of fertilizers (conventional) and with the use of liquid fertilizer UAM-32 suggests the advantages of the latter, because the yield of green mass here increases from 3.6 to 5.0 t/ha (Table 3.12).

It is important to note that for the third year of use with the use of liquid fertilizer UAM-32 the yield of green mass is higher by 5 t/ha, as there is an aftereffect of the second year of use. This pattern can be traced to all years of the growing season.

3.12. Comparative efficiency of alfalfa cultivation technologies in the conditions of Vinnytsia region, t/ha (average for 2005-2015)

№	Indicator	Technology		To the standard, ±
		generally accepted with the use of tuck	using liquid fertilizer UAM-32	
1	Green mass yield: for the second year	36.2	39.8	3.6
	for the third year	35.2	40.2	5.0
2	Green mass increase: for the second year	2.1	4.3	2.2
	for the third year	1.7	4.3	2.6
3	Hay harvest: for the second year	2.7	3.5	0.8
	for the third year	2.5	3.2	0.7

Analysis of the growth of green mass showed that during the study period for the second year its indicator was at the level of 2.1 t/ha, for the third – 1.7 t/ha, with the generally accepted technology using fertilizers. The use of liquid fertilizer UAM-32 in the study period provided a better result compared to conventional technology with an increase in green mass by 4.3 t/ha for both the second and third years.

With regard to hay yield, the same trend is observed: with the use of liquid fertilizer UAM-32 in the study period received a larger increase in yield by 0.8 and 0.7 t/ha for the second and third year, respectively.

Studies indicate the effect of urea-ammonia mixture on the yield of green mass (Table 3.13). According to the obtained results, the efficiency of UAM-32 was manifested in increasing the yield of the latter by 4.4, 5.8, 6.1 and 7.0 t/ha compared to the control.

The norms and doses of UAM-32 application depend on the type of crop (alfalfa sowing), time and method of application, precursor and other factors.

3.13. Influence of urea-ammonia mixture on the yield of alfalfa green mass in the conditions of Vinnytsia region, t/ha (average for 2005-2015)

№	Variant	Yield, c/ha	To control, ±
1	Control	36.5	0.0
2	$P_{60}K_{60}$ + N_{60} (ammonium nitrate)	38.6	2.1
3	$N_{90}P_{90}$ + K_{120} (ammonium nitrate)	42.0	5.5
4	$P_{60}K_{60}$ + N_{60}UAM-32	40.9	4.4
5	$N_{90}P_{90}K_{120}$ + UAM-32	42.3	5.8
6	$N_{90}P_{90}K_{120}$ + N_{10}UAM-32 + N_{10}UAM-32	42.6	6.1
7	P_{60} K_{60} + N_{60}UAM-32 + N_{60}UAM-32 + N_{60}UAM-32	43.5	7.0
V, %		5.3	–

Studies have shown that the first spring application should be carried out in the absence of snow cover, before the resumption of vegetation, in March, at a dose of 80-120 liters per 1 ha, when the air temperature does not exceed 10°C; dilution in this case UAM-32 does not require. It is possible to increase the rate of fertilizer application, depending on the physiological condition of plants (Table 3.14).

The coefficient of variation, which shows the effect of the use of different options, is equal to 5.3%, which is smal.

Feeding is performed in combination, with the addition of plant protection products, growth regulators during their regrowth at the end of April. The single rate of UAM-32 should not exceed 10-20 l/ha with the addition of herbicide (active substance metribuzim, 700 g/kg). In the case of fertilizing alfalfa to avoid burns, UAM-32 should be diluted with water in a ratio of 1:2, and when co-applied with the herbicide – 1 : 3 or 1 : 4.

3.14. Scheme of application of fertilizers and plant protection products for alfalfa for 2015 (1 ha) in the Vinnytsia region (average for 2005-2015)

№	Operation	Deadlines	Preparation	Content of active substances	Cost per 1 ha, kg (l)	Efficiency	Cost per 1 ha, $
1	Application of mineral fertilizers	March	UAM-32		100	97.8	20
2	Herbicide	the end of April	Antisapa + UAM-32	Metribuzim, 700 g/kg	0.4+6	98.0	10.2+1.2
3	Herbicide	May	Selenite + UAM-32	Cletodim, 120 g/l	1+6	97.6	13+1.2
4	Insecticide	June	Fas + Avangard (micro-fertilizers)	Alphaci-permethrin, 100 g/l	0.2+1.5	98.2	1.8+4.5
Total costs							**51.9**

The next feeding should be in May, with the addition of 1 liter of herbicide (active ingredient kletodim, 120 g/l) and 6 liters of UAM-32.

During the development of pests and intensive growth of green mass in June, the obligatory measure is the application of a tank mixture of insecticide – 0.2 kg/ha (active ingredient Alfaci-permethrin 100 g/l) with the addition of 1.5 l/ha of microfertilizer Avangard.

Under this scheme of application of fertilizers and plant protection products, the efficiency of their use reaches 97.6-98.2%, which is a very important and effective indicator. The cost is 51.9 US dollars.

The most acceptable for foliar feeding solutions UAM-32 are morning (in the absence of dew) and evening. In cool and cloudy weather, this work can be organized during the day. It is not recommended to feed the plants with solutions of UAM-32 at temperatures above 20°C, low relative humidity, on a sunny day, because in these cases, possible burns of the leaf surface of plants. Young leaves of plants suffer the most from burns. In all phases of plant development, UAM-32 solutions, even at a dose of 10 l of nitrogen per 1 ha, can cause some plant burns, but they do not reduce crop yields. In the case of using UAM-32 for foliar feeding, the pH of the solution should be within 8-9 units. The effectiveness of this, as well as other types and forms of fertilizers depends on weather conditions. It is maximum in the case when the solution remains on the leaf surface for a long time. Therefore, the most effective cultivation of crops in cloudy cool weather.

Immediately after heavy, heavy rains, in the presence of abundant dew, the use of UAM-32 in the mixture is not recommended, because during precipitation the structure of the upper leaf blade becomes more permeable (and therefore more sensitive), so spraying should be carried out after drying the leaves on plants.

The optimal time for the application of UAM-32 in a mixture with herbicides in the evening, because it is known that nitrogen uptake is slower at night. When applying UAM-32 it is necessary to use sprays with a droplet size twice as large as for herbicides.

Any sprayer can be converted to make UAM-32. For this purpose it is necessary: to replace details from non-ferrous metals on polyvinylchloride, corrosion-proof, or fiberglass; to replace flush nozzles of sprayers with deflector ones for foliar feeding.

The size of the drops sprayed by sprayers in the case of application of plant protection products (herbicides, fungicides, insecticides) should not exceed 0.3 mm. This is necessary so that the solution covers the harmful object as much as possible, stays on the leaves, thus providing a protective effect.

However, in the case of fertilization, only UAM-32 requires a drop of such a size that the substance rolls out of the plant only by wetting the leaves. Otherwise, the plant may get burned. It is the deflector nozzles that form the desired coarse-droplet solution. Slotted nozzles can be used only when applied with herbicides with mandatory dilution of UAM-32 with water; for work in windy weather it is expedient to use extension hoses; line or tape application is carried out by means of pouring pipes.

CHAPTER 4

TECHNOLOGICAL ASPECTS OF FORMATION OF HIGH PRODUCTIVITY OF CLOVER MEADOW AND ITS ROLE IN SOLVING ECOLOGICAL PROBLEMS OF PLANT PRODUCTION

Specific weather conditions for the last ten years, namely the increase in the duration of the periods of the year, the rise in temperature and extremely unfavorable wintering conditions in 2002-2003 confirmed the necessity of the study.

Concrete results in selection also testify to its efficiency. In recent years, meadow clover varieties have become widespread: Agros-12 (Nosiv Research Station of the Chernihiv Institute of APV UAAS), and Marusya (AIP Institute of Agriculture of NAAS).

In the course of the research the issues of growing meadow clover of known varieties for fodder purposes in fodder crop rotations are considered. The best varieties, clover sowing rates and forage productivity assessment were established.

Clover is a universal forage crop. It is willingly eaten by all animals, as well as birds. Clover is used to prepare high-quality hay, haylage, silage, high-protein grass meal, pellets and briquettes, and it is used for green fodder. Clover contains a lot of protein, minerals and vitamins. In terms of nutrition, it is second only to alfalfa. The high protein nutritional value of clover feed is that per 1 feed unit it contains 1.5 times more digestible protein than in accordance with zootechnical standards. Therefore, the use of clover, as well as alfalfa, allows you to balance carbohydrate feeds for protein content.

The green mass contains essential and fatty oils, tannins, glycosides trifolin and isotrifolin, organic acids (salicylic, ketoglutaric), sitosterol, isoflavones, resins, calcium salts, phosphorus, trace elements, vitamins (ascorbic acid) , tocopherol, A, B_1, B_2, C, D, E).

During haymaking, especially natural drying, part of the leaves breaks off, is lost, the fodder value is reduced. When harvesting hay, the leaves are completely preserved, nutrient losses are minimal. Leavesness of meadow clover is 40-44%, creeping clover – more than 50%.

4.1. Varieties of intensive type of meadow clover in the formation of highly productive grasslands

Variety Agros-12. Originator: Nosiv Research Station of the Chernihiv Institute of AIP UAAS. Entered in the Register of Plant Varieties of Ukraine since 1993. Suitable for growing in the forest-steppe and Polissya zones. The bush is erect, with a strong bushiness; stem 80-90 cm tall, medium thickness, highly deciduous. Weight of 1000 seeds – 2 g. The variety grows quickly in the spring after mowing.

It is characterized by high yield of green mass in all mowings. High-quality hay is obtained from Agros-12 alfalfa, and its crops are left productive for three years. Early ripening, resistant to diseases, seed yield – 3 kg/ha, green mass yield – 1100 kg/ha, hay yield – 244 kg/ha. Seeds can be sown both in spring and summer (July 15 – August 21). Pre-sowing tillage should be aimed at destroying as many weeds as possible, accumulating and retaining moisture, creating conditions for friendly germination. The optimal depth of seed wrapping is 1.5 cm. The sowing rate is 15 kg/ha for row sowing. Before and after sowing it is necessary to roll the soil (Fig. 4.1).

Variety Marusya. Originator: National Research Center "Institute of Agriculture of the National Academy of Sciences of Ukraine", Kyiv Research Station. The variety was entered into the Register of Plant Varieties of Ukraine in 1998. The first domestic early-maturing diploid variety of long-term and reusable use: up to 2.5-3 years in contrast to 1-2-year-old use. The plants differ in the upright shape of the bush, the rosette is medium in size.

The color of the stems is brownish-purple. They are average in size and pubescence, protrusion of 100-120 cm, on the index, which is superior to all other diploid varieties.

The leaves are green, medium in size, pubescent, lanceolate. The flowers are pinkish-red, gathered in an egg-shaped inflorescence. The fruit is mostly monocotyledonous, brown bean. Margin of average size, has a yellow-purple color, elongated.

Fig. 4.1. Meadow clover (*Trifolium pratense* L.), variety Agros-12

It can be successfully used for hayfields and pastures.

Medium resistant to root rot and powdery mildew. On average, during the years of state cultivation, the dry matter yield was 13.3 t/ha, seeds 0.26 t/ha.

The maximum yield of fodder mass for three mowing reaches 70-80 t/ha, sowing – 0.4 t/ha. The protein content in green mass is at the level of 16-17%, digestion – 90% (Fig. 4.2).

4.2. Features of the formation of meadow clover coenoses depending on the elements of technology

Yield is a quantity that is determined by a number of factors, namely: the level of soil fertility, environmental factors, technologies.

It is known that due to the presence of weeds in crops, their yields can be significantly reduced. However, no poisonous or quarantine weeds were found in the cultivation of meadow clover for forage purposes, so the self-seeding vegetation can be considered as an additional supplement.

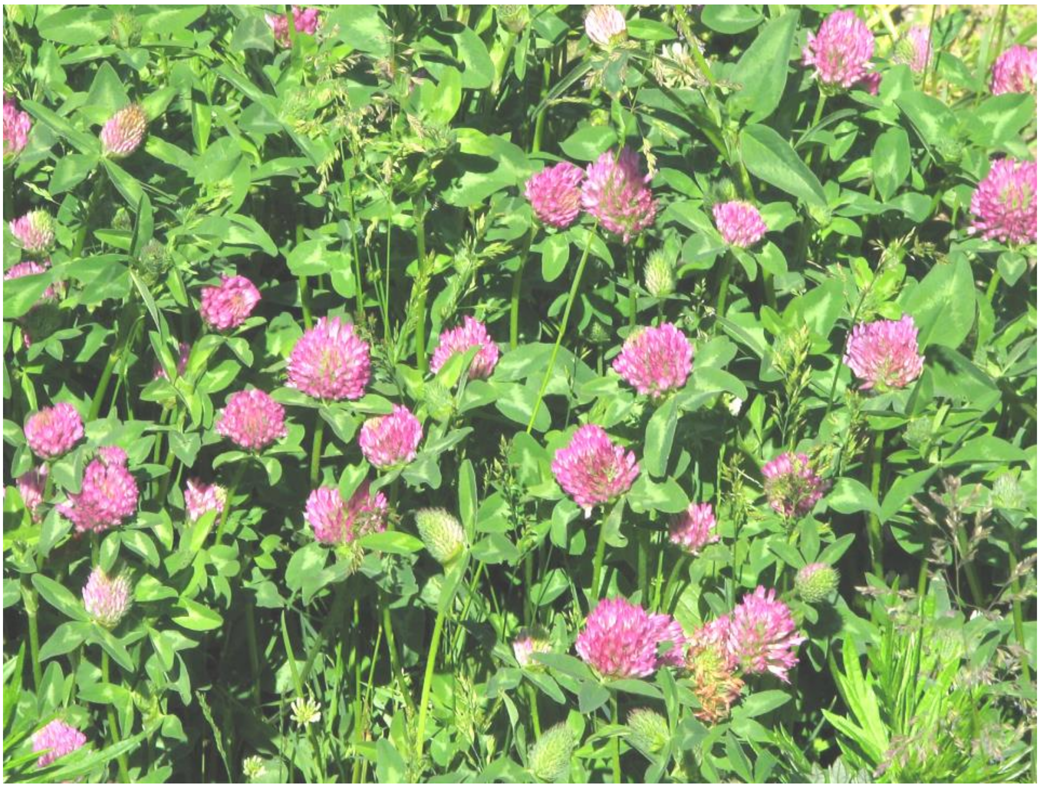


Fig. 4.2. Clover meadow (*Trifolium pratense* L.), variety Marusya

This statement can be argued by the fact that the composition of agrophytocenosis, in addition to meadow clover (*Trifolium pratense* L.), also included yellow foxtail (*Setaria glauca* L., *Setaria viridis* L.), cockspur (*Echinochloa crus-galli* L.), common dandelion (*Taraxacum officinale*), shepherd's purse (*Capsella bursa pastoris L.*), ribwort plantain (*Plantago lanceolata* L.) and chamomile (*Matricaria recutita L.*).

Before and after sowing, for fuller contact of seeds with the soil and faster germination, soil rolling was performed. To destroy weeds on clover crops, you can use the following herbicides, which are currently on the list of pesticides allowed for use on crops of this crop: Agritox 0.8-1.4 l/ha, it is used in the phase of the first true trifoliate leaf of clover; Bazagran 2 l/ha – on clover crops of the first and second years of vegetation during spring regrowth; Herbitox 0.8 – 1.2 l/ha – in the phase of the first or second true trifoliate leaf. These herbicides are effective against annual dicotyledonous weeds. Herbicides with the active substance imazethapyr (pivot, pulsar, sapphire, etc.) with a rate of 1 l/ha in the phase of the first or second trifoliate leaf of clover can be used to destroy annual and biennial weeds on coverless clover crops.

An essential method of caring for clover crops in the year of sowing is fertilizing with mineral fertilizers.

Studies have shown (Table 4.1) that for all methods of sowing meadow clover in the first year of the growing season, before entering the winter, the maximum number of plants as a percentage of sown is observed at an increased seeding rate. With the usual method of sowing (15 cm) at a sowing rate of 6 million units/ha, this figure is 72%, with a row spacing of 30 cm – 75, with a row spacing of 45 cm – 75%, while with an increase in seeding rate to 8, 10 million units/ha these indicators were respectively: 76-78%, 77-79, and 80-82%.

4.1. Influence of methods and norms of sowing on viability of meadow clover (average for 2010-2012)

Method of sowing	Sowing rate, million pcs./ha	Number of plants per 1 running meter				
		before winter (1 year of life)		after winter (2 years of age)		deaths during the winter, %
		pcs.	from sown, %	pcs.	from sown, %	
Normal (15 cm)	6	65	72	53	59	19
	8	93	78	80	67	14
	10	114	76	82	55	28
Row spacing (30 cm)	6	135	75	116	64	14
	8	185	77	102	43	45
	10	237	79	166	55	30
Row spacing (45 cm)	6	203	75	134	50	34
	8	288	80	210	58	27
	10	369	82	247	55	33

The seeding rate is determined by the density of plants before harvest, which provides the highest yield of vegetative mass. Given that the density of 1.8 million units/ha variety can realize potential productivity, taking into account field germination – 75%, winter-spring and summer liquefaction of crops – 30%, it is enough to sow 3.5-4 million seeds/ha, or 7-8 kg/ha.

Increased seeding rate is used in condition of low agricultural techniques, in particular in the case of incorrect choice of cover crop, clogged field, insufficient soil moisture and after not the best predecessor. The actual sowing rate is 6-10 million units/ha, which is 10-20 kg/ha of seeds. On well-prepared fields for sowing, the optimal sowing rate is 14-16 kg/ha. At this sowing rate there are 280-350 plants/m^2 or 330-500 productive stems.

We also found that with reduced sowing rates and, accordingly, reduced density, with different methods of sowing, clover overwinters better. The rate of dead plants during the winter at sowing rates of 6 million seeds by the usual method of sowing (15 cm) was 19%, with the inter-row method of sowing (30 cm) – 14% and with the inter-row method of sowing (45 cm) – 34%. This pattern is explained by the fact that in liquefied crops meadow clover before winter forms a more developed bush with a large number of shoots (18-20), accumulates a significant amount of sugar at the end of the growing season, which contributes to better winter hardiness.

It should be noted that depending on the fertilization and method of sowing, the number of weeds in the agrophytocenosis varied. In addition, the intensity of weed infestation of meadow clover was influenced by weather conditions, which were formed during the years of research (Table 4.2).

During the research it was established that in the conditions of 2010-2012 the share of meadow clover, which was grown by the usual method of sowing (15 cm), for the variety Marusya in the first mowing was 55.3-60.1%; 56.5-61.1% with using inoculation (background); 34.8-40.2% for the application of $P_{60}K_{90}$, and 26.5-30.2% for the application of mineral fertilizers $N_{60}P_{60}K_{90}$ (Table 4.2). Slightly lower results were shown in the first mowing of Agros-12: 56.7-62.1% in the control variant; 53.1-57.3% in the application of inoculation (background); 34.6-40.1% for the application of $P_{60}K_{90}$, and 23.2-29.1% for the application of mineral fertilizers $N_{60}P_{60}K_{90}$.

4.2. The share of meadow clover depending on the sowing rate and weeds in the crop of agrophytocenosis of the first year of vegetation in the conditions of SS NULES of Ukraine "Agronomic Research Station", %

Fertilizers	Method of sowing	Seeding rate, million units/ha	The average for 2010-2012			
			the first mowing		the second mowing	
			clover	weeds	clover	weeds
Marusya						
Without fertilizers (control)	The usual method of sowing (15 cm)	6	55.3	44.7	91.2	8.8
		8	58.3	41.7	94.7	5.3
		10	60.1	39.9	95.4	4.6
Inoculation (background)		6	56.5	43.5	88.3	11.7
		8	57.3	42.7	91.2	8.8
		10	61.1	38.9	93.1	6.9
Background + $P_{60}K_{90}$		6	34.8	65.2	79.8	20.2
		8	36.9	63.1	82.6	17.4
		10	40.2	59.8	84.5	15.5
Background + $N_{60}P_{60}K_{90}$		6	26.5	73.5	75.8	24.2
		8	28.3	71.7	78.2	21.8
		10	30.2	69.8	82.1	17.9
V, %			**29,0**	**23.2**	**7.5**	**48.5**
Agros-12						
Without fertilizers (control)	The usual method of sowing (15 cm)	6	56.7	43.3	93.2	6.8
		8	59.5	42.2	96.1	3.9
		10	62.1	37.9	97.5	2.5
Inoculation (background)		6	53.1	46.9	92.1	7.9
		8	55.9	42.8	94.5	5.5
		10	57.3	42.7	95.2	4.8
Background + $P_{60}K_{90}$		6	34.6	65.4	76.1	23.9
		8	37.8	60.8	81.9	18.1
		10	40.1	59.9	83.2	16.8
Background + $N_{60}P_{60}K_{90}$		6	23.2	76.8	76.2	23.8
		8	27.9	72.3	79.4	20.6
		10	29.1	70.9	82.3	17.7
V, %			**30.1**	**24.3**	**9.0**	**63.6**

Significantly better are the indicators of the second mowing of meadow clover, especially without the use of fertilizers, where the variety Marusya shows indicators in the range of 91.2-95.4%, the variety Argos-12 – 93.2-97.5%.

Thus, meadow clover, under favorable growing conditions, is quite a competitive crop, which after mowing quickly forms a dense grass.

4.3. The height of meadow clover plants depending on the elements of technology

As a result of the influence of abiotic and biotic factors on plants in the process of vegetation, their height undergoes constant changes, which in turn causes a change in yield.

Plant height is one of the important indicators in assessing the forage productivity of most crops. At the same time, it largely depends on agro-meteorological conditions during cultivation, as well as on agrotechnics applied to culture.

The phase of oblique ripeness for meadow clover plants occurred when they reached the beginning of flowering. It should be noted that not always when the phase of oblique maturity was reached, the grass clover was mowed. It is known that the height of the cut is in the range of 8.0-10.0 cm, while the height of clover plants, especially in the second mowing, did not always exceed these indicators.

Thus, it was not economically expedient to carry out such mowing of the leaf-stem mass of clover.

In the course of research, the influence of fertilizers and methods of cultivation on the height of meadow clover plants was studied (Table 4.3).

When growing varieties of meadow clover, in the conditions of 2010-2012, the height of plants, in the variants without the use of mineral fertilizers, in the first mowing 63,4-63,8 cm, in the second 24.9-28.2 cm. In the second mowing, the height was 24.9 cm in the variety Marusya and 28.2 cm in the variety Agros-12.

Inoculation of clover seeds with a bacterial preparation before sowing allowed to receive plants with a height of 64.2-64.5 cm in the first mowing and 32.6-33.6 cm in the second with the usual method of sowing (15 cm).

4.3. Height of plants of varieties of clover of the first year of vegetation depending on methods of cultivation and fertilizer in the conditions of SS NULES of Ukraine "Agronomic Research Station", cm

Fertilizers	Method of cultivation	Average 2010-2012	
		the first mowing	the second mowing
Marusya			
Without fertilizers (control)	The usual method of sowing (15 cm)	63.4 ±0.94	24.9 ±1.37
Inoculation (background)		64.5 ±0.77	32.6 ±1.28
Background + $P_{60}K_{90}$		67.1 ±0.78	34.9 ±0.93
Background +$N_{60}P_{60}K_{90}$		77.9 ±0.87	29.5 ±1.24
V, %		**8.4**	**12.3**
Agros-12			
Without fertilizers (control)	The usual method of sowing (15 cm)	63.8 ±0.84	28.2 ±0.94
Inoculation (background)		64.2 ±1.05	33.6 ± 1.08
Background + $P_{60}K_{90}$		65.8 ±1.08	34.1 ±0.85
Background + $N_{60}P_{60}K_{90}$		77.8 ±1.07	27.5 ±0.81
V, %		**8.5**	**9.8**

The application of phosphorus-potassium fertilizers ($P_{60}K_{90}$) in combination with inoculation with a bacterial preparation contributed to an increase in the height of plants of meadow clover varieties up to 65.8-67.1 cm in the first mowing, and up to 32.6-33.6 cm in the second. At the same time, the plants of meadow clover when using the background + $N_{60}P_{60}K_{90}$ were much higher, but only in the first mowing, with an index of 77.8-77.9 cm.

During the cultivation of meadow clover varieties without the use of mineral fertilizers, the lowest plant height indicators were obtained. In the second year of the growing season, the plants that were grown on the variants with the use of $P_{60}K_{90}$ in pre-sowing cultivation were distinguished by a higher height. This is explained by the fact that phosphorus-potassium fertilizer creates favorable conditions for the activity of nodule bacteria and actively proceeds the process of nitrogen fixation.

It should be noted that the influence of fertilization and cultivation methods on the linear growth of the variety Agros-12 for the second year of vegetation had a similar tendency as in the variety Marusya.

Variation analysis proved a low level of height variability of clover cultivars of the first year of vegetation depending on the methods of cultivation and fertilization. The coefficient of variation of the oscillations of the studied indicator on the first mowing was 8.4-8.5%, while in the second mowing – increased to 9.8-12.3%.

Thus, the maximum height of the clover plant of both the Marusya variety and the Agros-12 variety is achieved by growing with the introduction of phosphorus-potassium fertilizers (P_{60}).

4.4. Optimization of fertilizer system and its role in the formation of phytomass productivity of clover varieties in the first and second years of vegetation

The experiment was conducted on April 26. During the vegetation period, two mowings of the leaf-stem mass of clover were obtained. The leaf-stem mass of meadow clover for green fodder was collected when it reached the phase of the beginning of flowering.

The first mowing was carried out 93 days after sowing (July 28), while the second was formed 50 days and was harvested on

September 15. The sum of active temperatures for the first cutting period was 1524°C, and 864°C for the second. At the same time, the amount of precipitation for the first period was 288 mm, for the second 151 mm.

During the study, it was established that the yield of clover grass stands of the first year of vegetation significantly depended on the method of cultivation and mineral levels (Table 4.4).

4.4. Yield of leaf and stem mass and dry matter yield of clover in the first year of vegetation depending on the influence of the method of cultivation and fertilization in the conditions of SS NULES of Ukraine "Agronomic Research Station", t/ha (average 2010-2012)

Fertilizers (factor B)	Growing method (factor C)	Indicator	
		leaf-stem mass	dry matter
Marusya (factor A)			
Without fertilizers (control)	The usual method of sowing (15 cm)	31.57	6.09
Inoculation (background)		32.39	6.25
Background + $P_{60}K_{90}$		34.78	6.71
Background + $N_{60}P_{60}K_{90}$		38.71	7.47
V, %		**8.1**	
Agros-12 (factor A)			
Without fertilizers (control)	The usual method of sowing (15 cm)	31.97	6.17
Inoculation (background)		31.89	6.15
Background + $P_{60}K_{90}$		35.55	6.86
Background + $N_{60}P_{60}K_{90}$		39.39	7.60
V, %		**8.9**	
LSD_{05}, t/ha for factors	A	1.12	0.34
	B	0.98	0.25
	C	1.12	0.34

According to the analysis of experimental data, it was established that in the conditions of 2010-2012 in the control variant the yield of leaf-stem mass of clover was 31.57-39.87 t/ha. At the same time, the dry matter yield was in the range of 6.09-6.17 t/ha, respectively.

During the pre-sowing inoculation of clover seeds, the meadow harvest of the leaf-stem mass of grasses in the crops reached 31.89-32.39 t/ha with a yield of 6.15-6.25 t/ha of dry matter.

At full mineral fertilization in the norm $N_{60}P_{60}K_{90}$, with the pre-sowing inoculation of seeds, the yield of leaf-stem mass of 38.71-39.39 t/ha was obtained. The yield of dry matter was 7.47-7.60 t/ha, respectively.

Variation analysis proved not very high variability of fluctuations in the yield of leaf and stem mass and the yield of dry matter of clover in the first year of vegetation depending on the effect of fertilizer. The coefficient of variation increased insignificantly to 8.9% in relation to the assessment of leaf mass on Agros-12 compared to Marusya variety (V = 8.1%).

Thus, clover meadow in the first year of vegetation with the use of $N_{60}P_{60}K_{90}$ and conducting pre-sowing inoculation of seeds forms a higher yield of deciduous seedlings.

As it was established during the research, the formation of the yield of the leaf-stem mass of clover meadow was significantly influenced by the studied factors, namely: varietal characteristics of the crop and fertilizers.

For the second year of vegetation, clover meadow on variants without fertilization provided the yield of leaf-stem mass at the level of 21.41-22.44 t/ha (Table 4.5).

4.5. Yield of leaf and stem mass of meadow clover varieties in the second year of vegetation depends on the influence of fertilizer, method of cultivation and mowing in the conditions of SS NULES of Ukraine "Agronomic Research Station", t/ha (average 2010-2012)

Fertilizers (factor B)	Growing method (factor C)	Mowing (factor D)		Together
		the first	the second	
Marusya (factor A)				
Without fertilizers (control)	The usual method of sowing (15 cm)	14.08	7,33	21.41
Inoculation (background)		14.98	8.17	23.15
Background + $P_{60}K_{90}$		20.06	12,06	32.12
Background + $N_{60}P_{60}K_{90}$		18.11	11.24	29.35
V, %		**14.3**	**20.6**	**16.5**
Agros-12 (factor A)				
Without fertilizers (control)	The usual method of sowing (15 cm)	13.98	8.46	22.44
Inoculation (background)		14.69	8.98	23.67
Background + $P_{60}K_{90}$		21.04	12,93	33.97
Background + $N_{60}P_{60}K_{90}$		17.93	10.56	28.49
V, %		**16.6**	**17.0**	**16.7**
LSD_{05}, t/ha for factors			A	0.11
			B	0.16
			C	0.11
			D	0.11

Carrying out of such technological action, as inoculation of seeds, allowed to receive in the first mowing of 14.7-14.98 t/ha, in the second – 8.17-8.96 t/ha.

When $P_{60}K_{90}$ was applied to the pre-sowing cultivation on the background of seed inoculation, the yield of leaf-stem mass of the Marusya variety was obtained – 32.12 t/ha, Agros-12 variety – 33.97 t/ha.

The application of complete mineral fertilizer $N_{60}P_{60}K_{90}$ on the background of inoculation allowed to obtain 28.49-29.35 t/ha of leaf mass.

It should be noted that the norms of mineral fertilizers and the method of cultivation also affected the yield of crude protein and feed units in clover.

In the second year of meadow clover vegetation, the highest yield of dry matter was observed in the variant where seed inoculation was carried out for the application of mineral fertilizers in the $P_{60}K_{90}$ norm. Thus, in the first mowing the yield of dry matter was 6.19 t/ha for the variety Marusya and 6.56 t/ha for the variety Agros-12.

The lowest rates of dry matter yield were found in the variants without mineral fertilizers and without inoculation – 4.13 t/ha for the variety Marusya.

It should be emphasized that the variability of yield indicators of leaf and stem mass of meadow clover varieties, depending on the influence of fertilization and mowing, was almost at the same level with coefficients of variation in the range of 16.5-16.7%.

Analysis of variance proved that among the studied factors on the productivity of clover plants were affected by fertilizers (factor B) – 43.9% and mowing (factor D) – 18.2 (Fig. 4.3).

The varietal composition and method of cultivation had a weak effect – 7.2 and 4.7%, respectively. The interaction of factors was also insignificant – in the range of 0.4-2.9%, and the residual effect of other unaccounted for factors exceeded 5%.

In addition, for the second year of the growing season, higher forage productivity was formed by grass clover grasses, which were grown in the background with seed inoculation.

For the Marusya variety, the yield of metabolic protein was 0.83 t/ha, fodder units 5.87 t/ha, and fodder protein units 6.97 t/ha. The yield of pre-protein for the cultivar Agros-12 was 0.87 t/ha, the yield of feed units and feed-protein units, respectively, 6.13 and 7.33 t/ha (Table 4.6).

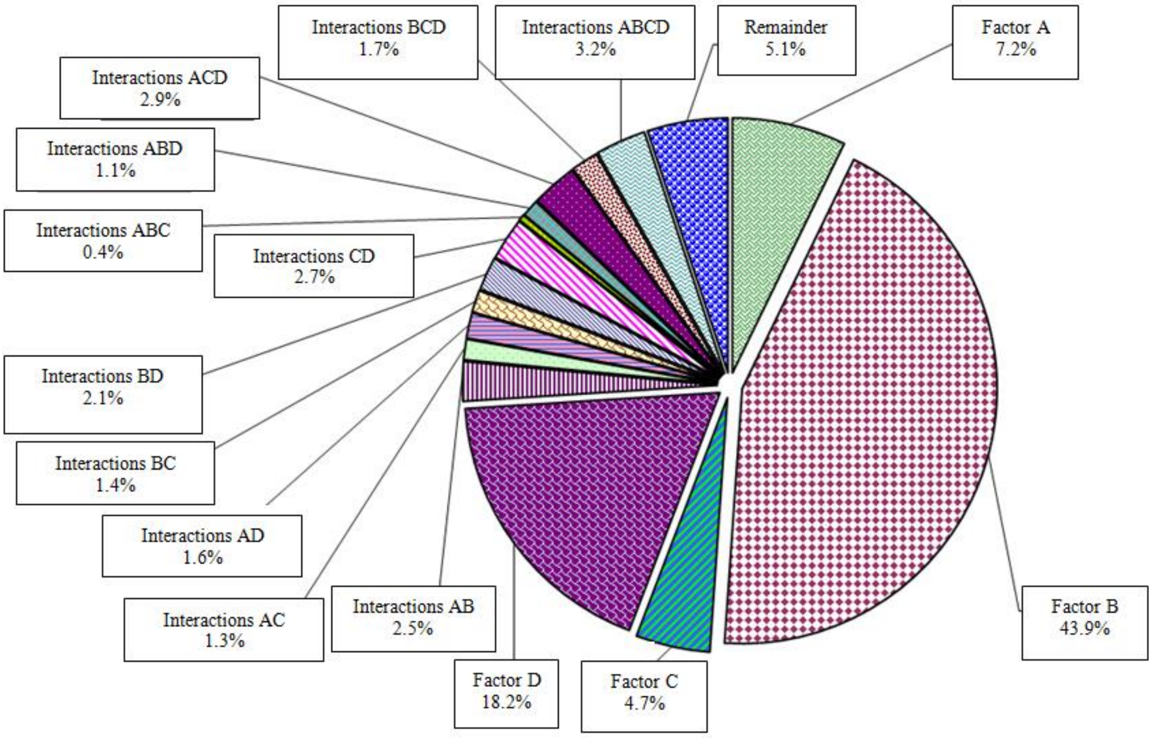


Fig. 4.3. The share of influence of factors (grade – factor A; fertilizer – factor B; method of cultivation – factor C; mowing – factor D) on the yield of leaf and stem mass of meadow clover

The lowest forage productivity of varieties of meadow clover was marked on the control variant, that is, without the use of fertilizers and without inoculation. Thus, during the cultivation of clover of the variety Marusya, the yield of digestible protein was 0.49 t/ha, fodder units – 4.11 t/ha, the yield of fodder protein – 4.5.

Under such growing conditions, the yield of pereprotein protein in the Agros-12 variety was 0.51 t/ha, while the yield of feed units was 4.32 t/ha and feed protein was 4.7.

4.6. Fodder productivity of meadow clover grasslands, t/ha (average 2010-2012)

Fertilizers	Method of cultivation	Digestible protein	Fodder units	Feed and protein units
Marusya				
Without fertilizers (control)	The usual method of sowing (15 cm)	0.49	4.11	4.58
Inoculation (background)		0.53	4.23	4.82
Background + $P_{60}K_{90}$		0.83	5.87	6.97
Background + $N_{60}P_{60}K_{90}$		0.76	5.20	6.50
V, %		**22.3**	**14.9**	**18.1**
Agros-12				
Without fertilizers (control)	The usual method of sowing (15 cm)	0.51	4.32	4.79
Inoculation (background)		0.56	4.50	5.10
Background + $P_{60}K_{90}$		0.87	6.13	7.33
Background + $N_{60}P_{60}K_{90}$		0.81	5.47	6.83
V, %		**22.5**	**14.4**	**18.1**

The coefficient of variation of forage productivity indicators of meadow clover grasslands depending on the studied factors had an average level of variability. Its lowest values (V = 14.4%) were relative to feed units, the highest – relative to digestible protein (V = 22.5%).

4.5. Determination of leaf surface area depending on the elements of technology

The role of photosynthesis in the biosphere processes of the planet Earth is so large and diverse, and its nature is so unique that the problem of photosynthesis is so important. In the process of photosynthesis, plants produce about 400 billion tons of organic matter per year, emitting 400 billion tons of oxygen. It is now known that 90-95% of the organic matter of the whole crop is formed in the leaves in the process of photosynthesis.

Any type of cover crop in the period from germination to the end of the tillering phase, has a positive effect on sown grasses, protecting them from overheating on days with high temperatures, or vice versa, from frost, which often occurs not only in April but also in May. At the same time, after the beginning of the phase of exit into the tube to the phase of milk ripeness inclusive, the seeds sown under the cover of grass feel a sharp lack of light.

According to A.I. Artyukhov and I.D. Sazonov, the dynamics of chlorophyll accumulation can influence the processes of photosynthesis and crop formation. All measures aimed at creating favorable conditions for growth and development, in the end, determine the maximum productivity of photosynthesis, at the expense of which 95% of which is formed.

It is known that at low light at 5,000 lux the photosynthesis of leaves is quite high. At the same time, the higher the soil fertility, the higher the intensity of photosynthesis of young leaves. The special need for light is observed before the budding phase. At 5000 lux, photosynthesis predominates in the old clover leaves, while in the young leaves the intensity of photosynthesis is 2.0-2.7 mg CO_2 per 100 cm^2.

As noted, clover leaves are the most nutritious part of the plant, as they contain a significant percentage of protein and a small part of fiber. Therefore, the indicators of the leaf surface area are an important criterion when assessing the quality and yield of the leaf-stem mass of clover.

The calculation of the leaf surface area of clover plants during the growing season showed that its size depends on the varietal characteristics, norms of mineral fertilizers and methods of cultivation.

At the moment of the first mowing clover plant of the second year of vegetation, the higher indicators of the leaf area are formed in comparison with the second. This can be explained by a longer growing season and better moisture supply conditions.

The cultivation of meadow clover varieties without the use of mineral fertilizers and the use of rhizotorphine did not contribute to the intensive formation of the leaf surface.

At the time of the first mowing, low rates of 33.32-50.71 thousand m^2/ha were found in the area of the leaf surface of the clover. At the time of the second mowing, the area of the leaf surface of clover meadow, on the options without fertilizer, was 19.64-20.96 thousand m^2/ha, or in the amount for vegetation 52.96-56.26 thousand m^2/ha (Table 4.7).

Growing of clover on variants with seed inoculation, but without the use of mineral fertilizers, contributed to the formation of the assimilation surface at the level of 34.52 thousand m^2/ha during the cultivation of the Marusya variety.

4.7. Area of leaf surface of meadow clover of the second year of cultivation, thousand m^2/ha (average for 2010-2012)

Fertilizers	Method of cultivation	At the time of the first mowing	At the time of the second mowing	For the growing season
Marusya				
Without fertilizers (control)	The usual method of sowing (15 cm)	33.32	19.64	52.96
Inoculation (background)		34.52	20.45	54.97
Background + $P_{60}K_{90}$		48.05	28.08	76.13
Background + $N_{60}P_{60}K_{90}$		43.44	25.53	68.98
V, %		**15.4**	**15.0**	**15.3**
Agros-12				
Without fertilizers (control)	The usual method of sowing (15 cm)	35.30	20.96	56.26
Inoculation (background)		36.46	21.85	58.31
Background + $P_{60}K_{90}$		50.71	30.08	80.79
Background + $N_{60}P_{60}K_{90}$		45.90	27.15	73.05
V, %		**15.3**	**15.1**	**15.2**

The indicators of the area of clover leaves of variety Agros-12 for vegetation period were 58.31 thousand m^2/ha. Thus, the indicators of leaf area in clover of the Marusya variety at the time of the first mowing were at the level of 34.52 thousand m2/ha, at the time of the second mowing – at 20.45 thousand m^2/ha.

With the use of $P_{60}K_{90}$, the assimilation surface in the clover of the variety Marusya was 34.52, for the second – 20.45 thousand m^2/ha. While the indicators of Agros-12 at the time of the first mowing were at the level of 50.71 thousand m^2/ha, and in the second mowing the area of the leaf surface was 30.08 thousand m^2/ha. During growing clover varieties with the use of complete mineral fertilizer ($N_{60}P_{60}K_{90}$) and seed inoculation, the leaf area on these variants exceeded the variants without fertilizer and the use of rhizotorphin, but was inferior to the variant with the use of phosphorus-potassium fertilizer. During growing clover of the Marusya variety for the second year of vegetation, on the variant with application $N_{60}P_{60}K_{90}$, the leaf area in the first mowing was 43.44 thousand m/ha, in the second 25.53 thousand m/ha, or 68 ha 98 thousand m^2/ha. The application of $N_{60}P_{60}K_{90}$ in pre-sowing cultivation and inoculation of seeds contributed to higher indicators of variety Agros-12 – 45.90 thousand m^2/ha in the first mowing and 27.15 in the second mowing, or together for the growing season 73.05 thousand m^2/ha.

By establishing the coefficients of variation of the area of the leaf surface of the second year of vegetation, it is proved that the indicator varies slightly both in varietal composition and in relation to the first and second mowing, being in the range from 15.0 to 15.4%, with the average level of variability of these experimental data.

4.6. Net productivity of photosynthesis depending on the elements of technology

It is established that the net productivity of photosynthesis (NPP) of meadow clover stands increases by the leaf surface index of 3.5. At the same time, the achievement of higher indicators is gradually decreasing, regardless of the variety, levels of mineral nutrition and plant density.

To obtain high and stable yields, it is very important to have not only a strong but also a highly productive photosynthetic apparatus, the indicator of which is the net productivity of photosynthesis, which characterizes the increase in dry matter per unit area per unit time. It was investigated that the net average productivity of photosynthesis in productive crops reaches 5-6 g/m^2, the maximum – 10-14 g/m^2 per day. The net productivity of photosynthesis in clover is relatively low – on average during the growing season about 3-4 g/m^2 per day.

Analyzing how indicators affect on net productivity of photosynthesis of different varieties of clover meadow cultivation methods and levels of mineral nutrition, the highest indicators of NPP (3.39 g/m^2 per day) clover meadow variety Marusya second year of vegetation in the first mowing was recorded on the variant without seed treatment and application of mineral fertilizers.

In the same mowing of Marusya variety of the second year of vegetation on the variant with inoculation of seeds and the brought fertilizers in norm $N_{60}P_{60}K_{90}$ at cultivation of a clover was noted the lowest indicator of NPP – 3.14 g/m^2 per day (Fig. 4.4).

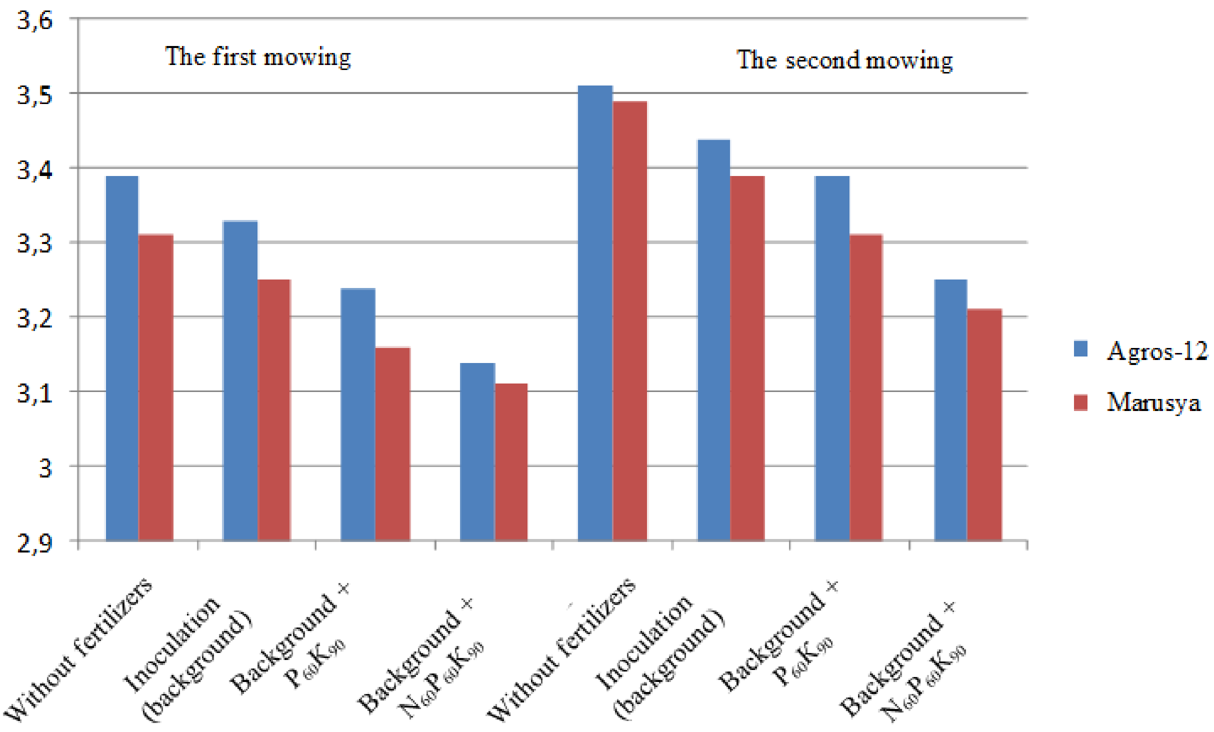


Fig. 4.4. Net productivity of photosynthesis of clover plants of the second year of vegetation, depending on the method of cultivation, g/m per day (average for 2010-2012)

In the second mowing, the indicators of net productivity of photosynthesis of Marusya variety were as follows: the maximum values for the variant without fertilizers and inoculation 3.51 g m^2 per day and the minimum – 3.25 g/m^2 per day for the variant with cultivation and application of fertilizers at the rate of $N_{60}P_{60}K_{90}$ and seed treatment by rhizotorphin.

Similar indicators, but with insignificant deviations, were found on the grass clover of the meadow of the second year of vegetation of the variety Agros-12. The lowest value of the net productivity of photosynthesis for the Agros-12 on average in the first and second mowing was recorded on the variant with the norm of fertilizers $N_{60}P_{60}K_{90}$ and seed inoculation.

In addition, it was established that for the second year of use of clover meadows of both varieties, the maximum indicators of net productivity of plant photosynthesis were found to be the most common.

The use of $N_{60}P_{60}K_{90}$ significantly changed the size of the leaf apparatus in comparison with the control. Thus, when the norm was brought to 90 kg/ha, the leaf area increased to 56-60 thousand m^2/ha, which in turn caused a decrease in NPK in these variants. This is due to the fact that on a higher background of nutrition with the development of a strong leaf surface, the leaves overshadow each other, the lighting conditions deteriorate, resulting in a decrease in the intensity of photosynthesis per unit leaf surface.

Determination of root mass and nitrogen content showed (Table 4.8) that under different methods of sowing the root mass of clover in the first year of use was in the range of 4.41-4.69 tons of dry matter with a nitrogen content of 81.6-86.8 kg. In the second year of use, the mass of roots increased and reached 5.34-6.63 tons with a nitrogen content of 96.1-119.3 kg/ha in the soil layer of 0-20 cm.

4.8. Accumulation of root mass and nitrogen by meadow clover

Method of sowing	Sowing rate, million units/ha	The first year of use		The second year of use	
		root mass, t/ha	nitrogen, kg/ha	root mass, t/ha	nitrogen, kg/ha
Normal (15 cm)	6	4.51	83.4	6.17	111.1
	8	4.57	84.5	6.63	119.3
	10	4.52	83.6	5.96	107.3
Row spacing (30 cm)	6	4.46	82.5	6.16	110.9
	8	4.69	86.8	5.41	97.4
	10	4.61	85.3	5.60	100.8
Row spacing (45 cm)	6	4.41	81.6	6.01	108.2
	8	4.59	84.9	5.34	96.1
	10	4.54	84.0	5.50	99.0
V, %		**1.7**		**6.9**	

In addition to high forage productivity and protein collection, the value of meadow clover determines its ability to meet its own needs in nitrogen nutrition due to symbiosis with nodule bacteria, and high nitrogen content in root residues allows to increase its amount in the soil, which turns clover into.

The prospect of development of the Forest-Steppe zone is the conduct of highly efficient animal husbandry, first of all, dairy and meat cattle. To increase production, improve the quality and reduce the cost of feed, it is necessary to introduce and master special feed crop rotations with maximum saturation of legumes.

CHAPTER 5

PECULIARITIES OF FORMATION OF YIELD OF COMMON SAINFOIN DEPENDING ON THE ACTION OF AGROTECHNICAL FACTORS

Currently, three types of sainfoin are grown in Ukraine: Onobrychis viciafolia, Onobrychis arenaria, Onobrychis transcaucasica. In terms of quality of green mass, hay, haylage, fodder value sainfoin is close to alfalfa and clover. Sainfoin is a valuable high-protein fodder crop and honeydew (up to 200 kg of honey is obtained from 1 hectare of crops).

Sainfoin has a taproot, which, unlike alfalfa and clover, branches to a depth of 30-70 cm. That is why it uses nutrients from deeper layers of soil.

Features of the structure of the root system of sainfoin and the increased need for calcium determine its distribution. It is sown mainly on the mowing, washed away and unproductive soils of the Steppe and Forest-Steppe, the upper layer of which contains a sufficient amount of calcium.

On the roots of sainfoin develop nodule bacteria and it accumulates annually in the soil 100-200 kg/ha of nitrogen. On the taproot, similar to the above-ground mass, a new root system grows every year, and last year's mineralizes, enriching the soil with nutrients and organic matter.

Seeds during germination absorb moisture 1.5 times more than their own weight. It begins to germinate at a soil temperature of 3-5°C. The optimum temperature is 10-12°C at a depth of 3-4 cm and under such conditions the seedlings appear on the 7th-10th day after sowing.

In terms of drought resistance, sainfoin is superior to meadow clover and some varieties of alfalfa. It is a fairly winter-hardy crop. High yields of sainfoin are grown while providing the soil with moisture, especially the lower layers.

It should be noted that sainfoin responds well to the application of nitrogen fertilizers – they are applied in the spring at 60 kg/ha of active substance on permafrost soil or earn to a depth of 10-12 cm.

The following varieties of sainfoin are most common in Ukrainian farms: Kirovohradskyi 27, Konstantan, Amethyst Donetskyi – recommended for cultivation in the Steppe, variety Pischanyi 1251 – in all areas of Ukraine. Sainfoin is characterized by rapid regrowth, forming two mowing. Varieties Kirovogradskyi 22, Smaragd grow better in the steppe and forest-steppe, variety Medino – in the forest-steppe and Polissya.

The potential productivity of all varieties of sainfoin ranges from 250 to 500 kg/ha of green mass and from 40 to 80 kg/ha of hay.

Variety Kirovohradskyi 22 *(*1987*)*. Created for Forest-Steppe and Steppe zones, entered in the Register of Plant Varieties of Ukraine. Originator: Kirovohrad State Agricultural Research Station, Institute of Feed UAAS. The bush is erect. The color of the stem is green, height – 112 cm, has lateral branches on the stems – from 7-8 to 10 (Fig. 5.1).

Fig. 5.1. Sainfoin (*Onobrychis viciafolia*), Kirovohradskyi 22

Bushiness is strong and medium – 4-6, up to 8 stems. Leavesness – in the range of 42-48%. Leaves of medium size; with slight pubescence; dark green in the lower tier and light green in the upper tier. Inflorescences are collected in racemes, cylindrical and spindle-shaped; length medium and long; density – medium. Seeds – medium in size, bean-shaped, greenish-brown, hard accounted for up to 2-3%.

Weight of 1000 seeds – 19.3 g. From a grade Kirovogradskyi 83 differs in a short brush. The variety is medium ripe. It is characterized by high drought and winter hardiness. Resistant to shedding and lodging. The incidence of disease is insignificant. During the years of testing, the average yield of green mass in the Forest-Steppe zone was 99.9 c/ha of dry matter, in the Steppe zone – 87.2; seeds – 11.2 kg/ha.

Given the above, during 2007-2012 in the conditions of SS of NULES of Ukraine "Agronomic Research Station" were conducted studies to study the agronomic basis for the formation of high yields of sainfoin depending on fertilizer and mowing height. Field and laboratory methods were used.

5.1. Technological aspects in the formation of leaf above-ground mass of sainfoin

The study of the dynamics of phenological processes is important in terms of establishing the influence of natural and agronomic factors on plants, their productivity, the formation of quantitative and qualitative indicators of agrophytocenoses.

The results of phenological observations on the development of sainfoin sowing depending on fertilizers and mowing height for the years of research are given in Tables 5.1 and 5.2.

Studies have shown that the applied fertilizer and the height of mowing affected the development of grass sainfoin. The applied fertilizers promoted fast growth of grass in the spring. Comparing the development of grasses at different mowing heights, it should be noted that the grass grew more intensively with mowing at a height of 11 cm, the phases of development occurred earlier.

5.1. Phenological observations on the development of sainfoin depending on fertilizers and mowing height in the conditions of SS NULES of Ukraine "Agronomic Research Station" (average for 2007-2012)

Fertilizer rate	Development phase				
	regrowth	stalking	budding	beginning of flowering	mass flowering
Mowing height 6 cm					
Without fertilizers (control)	7.04	2.05	13.05	24.05	29.05
$P_{60}K_{60}$	7.04	2.05	13.05	24.05	29.05
$N_{30}P_{60}K_{60}$	6.04	1.05	13.05	23.05	29.05
$N_{45}P_{60}K_{60}$	6.04	1.05	13.05	23.05	19.05
V, %	**8.8**	**37.2**	**0**	**2.5**	**18.8**
Mowing height 11 cm					
Without fertilizers (control)	5.04	30.04	10.05	19.05	25.05
$P_{60}K_{60}$	5.04	30.04	10.05	18.05	25.05
$N_{30}P_{60}K_{60}$	5.04	29.04	9.05	18.05	24.05
$N_{45}P_{60}K_{60}$	5.04	29.04	9.05	18.05	25.05
V, %	**0**	**2.0**	**6.0**	**2.7**	**2.3**

This is due to the fact that at higher mowing the grass contained more spare nutrients. As a result, the grassland grew earlier, the corresponding phases of development came faster and better conditions were created for the formation of higher yields. This indicates that under equal conditions of growth and mineral nutrition, the most influential factor is the height of mowing. The most favorable conditions for growth and development are at a mowing height of 11 cm.

Variation analysis showed a significant level of fluctuations in phenological observations of the development of sainfoin depending on fertilizers and cutting height. The coefficient of variation changed from 0 to 37.2%.

The yield of each crop is determined by a set of indicators, the main of which are the height, leaf surface area and density of grass.

5.2. Phenological observations on the development of sainfoin depending on fertilizers and mowing height in the conditions of SS NULES of Ukraine "Agronomic Research Station" (average for 2007-2012)

Fertilizer rate	Development phase				
	regrowth	stalking	budding	beginning of flowering	mass flowering
Mowing height 6 cm					
Without fertilizers (control)	4.04	29.04	10.05	19.05	26.05
$P_{60}K_{60}$	4.04	29.04	9.05	19.05	25.05
$N_{30}P_{60}K_{60}$	4.04	28.04	9.05	18.05	25.05
$N_{45}P_{60}K_{60}$	4.04	28.04	9.05	18.05	25.05
V, %	**0**	**2.1**	**5.4**	**3.1**	**2.0**
Mowing height 11 cm					
Without fertilizers (control)	2.04	27.04	7.05	16.05	2.04
$P_{60}K_{60}$	2.04	26.04	7.05	15.05	2.04
$N_{30}P_{60}K_{60}$	2.04	26.04	7.05	15.05	2.04
$N_{45}P_{60}K_{60}$	2.04	26.04	7.05	15.05	2.04
V, %	**0**	**1.9**	**0**	**3.3**	**0**

Therefore, the experiments studied how the height of the grass varies depending on the fertilizer and the height of mowing. The height of plants and the intensity of their linear growth can be used to estimate the mass of the aboveground part, the conditions of growth and development and to predict the harvest.

It is established that the height of the grass is a complex indicator, the development of which is influenced by many factors. Plant height is linearly related to grass yield.

Studies have shown that the height of the grass varies on the mowings. Thus, the height of the grass in the first mowing was greater than the height of that in the second. This is due to more favorable conditions for growth and development and the use of spare nutrients left in plants after winter, as well as the presence of significant reserves of soil moisture accumulated in the autumn-winter period.

In addition, the moisture supply during the formation of the second mowing was worse than during the first, precipitation was uneven, high temperatures caused inefficient moisture loss due to evaporation from the soil and transpiration (Table 5.3).

5.3. Height of sainfoin depending on fertilizers and mowing height in the conditions of SS NULES of Ukraine "Agronomic Research Station" (average for 2007-2012)

Fertilizer rate	Mowing height			
	6 cm		11 cm	
	the first mowing	the second mowing	the first mowing	the second mowing
Without fertilizers (control)	77.5	44.0	79.5	47.0
$P_{60}K_{60}$	83.0	47.0	87.0	50.0
$N_{30}P_{60}K_{60}$	84.5	47.5	88.0	50.0
$N_{45}P_{60}K_{60}$	84.5	48.0	87.5	51.5
V, %	**4.0**	**3.9**	**4.7**	**3.8**

Yield and nutritional value of grass largely depends on its structure. Leaves and inflorescences are plant organs that primarily determine the chemical composition of plants and the nutritional value of grasses. In addition, the number of leaves and their total area depends on the area of the assimilating surface and the amount of energy that will be converted into the energy of chemical bonds of organic compounds.

The leaves contain 2-3 times more protein and less fiber, many vitamins and other physiologically active compounds that are good for the general condition than the stems.

Coefficients of variation in the range from 3.8 to 4.7% indicate low variability and stability of height of grass sainfoin sowing depending on fertilizers and mowing height.

The ratio of stems and leaves is directly dependent on environmental conditions. Agrotechnical methods can adjust this ratio in a useful way from an economic point of view. With the improvement of growth and development conditions, the ratio of leaves and stems changes towards the former, which in turn increases the nutritional value of feed and intensifies the assimilation activity of the plant (Table 5.4).

5.4. The ratio of stems and leaves of sainfoin depending on fertilizers and cutting height in the conditions of SS NULES of Ukraine "Agronomic Research Station" (average for 2007-2012)

Fertilizer rate	Mowing /development phase			
	the first mowing		the second mowing	
	stems	leaves	stems	leaves
Mowing height 6 cm				
Without fertilizers (control)	51.9	48.1	48.8	51.2
$P_{60}K_{60}$	52.0	48.0	48.2	51.8
$N_{30}P_{60}K_{60}$	51.8	48.2	48.6	51.4
$N_{45}P_{60}K_{60}$	52.1	47.9	48.8	51.2
Mowing height 11 cm				
Without fertilizers (control)	50.3	49.7	47.7	52.3
$P_{60}K_{60}$	49.6	50.4	47.7	52.3
$N_{30}P_{60}K_{60}$	49.5	50.5	47.6	52.4
$N_{45}P_{60}K_{60}$	49.2	50.8	47.3	52.7

According to research, the ratio was most affected by the height of mowing. With mowing at a height of 11 cm, the proportion of leaves was greater, while the stems were smaller. The increase in leaf mass is explained by the fact that with mowing at a height of 11 cm reproduced more stems, and therefore, increased leavesness.

Observations and measurements showed that in the conditions of a higher cut the process of shoot formation intensified. This contributed to the formation of denser grass. More intensive shoot formation occurred due to the axillary buds of the stems and the formation of buds on the root neck.

It should be noted that the formation of a significant number of leaves at higher mowing affected the chemical composition. It is known that the leaves – the main organ of the plant, which forms a larger amount of protein.

It was found that this indicator was highest at a mowing height of 11 cm. At a mowing height of 6 cm in the structure of the crop was dominated by stems, which in turn affected the chemical composition of the grass. At this height, the content of protein, ash decreased and contained more fiber.

Therefore, in the technology of cultivation, an important element that has a positive effect on the ratio of stems and leaves is the height of mowing. High mowing (11 cm) provided more intensive leaf formation, which had a positive effect not only on increasing yields, but also on improving the nutritional value of feed.

The formation of the yield of each crop, the accumulation of nutrients occurs in the vegetative organs of plants. Intensive development of the vegetative mass of each crop is an important and necessary prerequisite for the formation of high yields. Crop yield depends on many indicators of vegetative mass, among which the main ones are height, density, standing, leaf surface area.

Plant density is an indicator on which the completeness of the use of spare nutrients, moisture, above-ground space, solar radiation, and finally, yield depends.

According to the obtained data, the applied fertilizers had a negligible effect on the density of sainfoin. Both in the variants without fertilizer application and in the application of the latter, the standing density was almost the same. The height of mowing was more affected by the standing height. The grass was thicker at a mowing height of 11 cm.

The most important factor that determines the use of solar energy is the structural organization of sowing, its ability to form a sufficiently active photosynthetic apparatus. The development of vegetative mass due to the surface area of the leaf surface is a quantitative assessment of the degree of favorable conditions for growth and yield formation. In the formation of yield and feed quality is important leaf surface, as the leaves are the main organs of photosynthetic activity of plants.

Studies have shown that the size of the leaf surface was different and the greatest influence on its formation was the height of mowing (Table 5.5).

At a mowing height of 11 cm, the leaf surface was much higher compared to the grass stand, which was mowed at a height of 6 cm.

It was found that high mowing (11 cm) provided more intensive growth of vegetative mass, and maturity of grass came a little earlier. It should be noted that the grass stand when mowing at a height of 11 cm formed not only a larger surface, but also the fact that the leaves were larger and had a higher specific weight, formed a denser and closed crop.

5.5. Leaf surface area of sainfoin depending on fertilizers and mowing height in terms of SS NULES of Ukraine "Agronomic Research Station", thousand m²/ha (average for 2007-2012)

Fertilizer rate	Mowing			
	the first mowing		the second mowing	
	mowing height		mowing height	
	6 cm	11 cm	6 cm	11 cm
Without fertilizers (control)	49.1	50.3	29.7	32.6
$P_{60}K_{60}$	50.4	50.9	31.0	32.4
$N_{30}P_{60}K_{60}$	51.2	52.3	31.1	32.0
$N_{45}P_{60}K_{60}$	50.7	51.8	29.2	32.2
V, %	**1.8**	**1.7**	**3.1**	**0.8**

All this gives grounds to claim that at a cutting height of 11 cm the plants have more spare substances, the process of formation of axillary buds, from which the shoots and leaf surface are formed, is more intensive.

It should be emphasized that the indicators of the leaf surface area of sainfoin, depending on the fertilizer and the height of mowing are characterized by minimum values in the range of 1.4-3.1%.

The yield of green mass, the yield of feed units, protein harvest largely depend on the phase of mowing sainfoin. As already mentioned, in the practice, determining the time of harvesting sainfoin, it is necessary to strive to not only get a high yield, but also to collect from a unit area as much nutrients as possible, especially protein. The amount of mass obtained is closely related to the development phase of sainfoin. Harvesting in both the early and late stages of development leads to a shortage of crops, protein and other nutrients.

It is especially undesirable to use the herb in later phases. The decrease in the content of protein and other nutrients in the later stages of the development of sainfoin is associated not only with the aging of plants, but also with a significant reduction in the proportion of the most valuable and nutritious part of it – the leaves. Given the value of the leaves, studies have observed how the leaf surface changes depending on the phase of plant development (Table 5.6).

5.6. The area of sainfoin leaves depending on fertilizers and the height of mowing in different phases of development in terms of SS NULES of Ukraine "Agronomic Research Station", thousand m²/ha (average for 2007-2012) (first mowing)

Fertilizer rate	Development phase (calendar dates)			
	stalking (5.05)	budding (15.05)	beginning of flowering (26.05)	mass flowering (1.06)
Mowing height 6 cm				
Without fertilizers (control)	29.0	42.3	49.1	44.9
$P_{60}K_{60}$	29.7	43.0	50.4	45.8
$N_{30}P_{60}K_{60}$	29.4	43.4	51.2	46.1
$N_{45}P_{60}K_{60}$	30.2	43.6	50.7	46.2
V, %	**1.7**	**1.3**	**1.8**	**1.3**
Mowing height 11 cm				
Without fertilizers (control)	30.6	44.3	50.3	46.7
$P_{60}K_{60}$	31.2	44.6	50.9	47.2
$N_{30}P_{60}K_{60}$	30.9	45.3	52.3	46.9
$N_{45}P_{60}K_{60}$	31.4	44.9	51.8	47.6
V, %	**1.1**	**1.0**	**1.7**	**0.8**

It is proved that the largest area of leaves is formed at a mowing height of 11 cm during the beginning of flowering – 50.3-52.3 thousand m²/ha. At the time of mass flowering, the leaf surface decreased to 46.7-47.63 thousand m²/ha. This is due to the fact that in the phase of mass flowering of sainfoin, there is first a gradual, then more intense yellowing and, finally, the fall of the lower leaves on the stem. The loss of leaves leads to a sharp decrease in feed quality and, in particular, protein content.

Harvesting sainfoin should begin at the beginning of flowering and perform in a very short time. Mowing at the end of flowering, when the stems reach the maximum height, but lose a significant part of the leaves, causes a decrease in harvest, feed units, the most valuable substance in terms of feed – protein and other important nutrients.

Variation analysis confirmed the stability of the leaf surface area of sainfoin sowing depending on fertilizers and mowing height in different phases of development at the first mowing. The lowest coefficients of variation of 0.8-1.0% were obtained at a cutting height of 11 cm in the phase of mass flowering and budding, and at the beginning of flowering there was a slight tendency to increase to 1.7-1.8% regardless of the height of mowing.

The effect of fertilizers and mowing height on sainfoin yield was studied during the research. The research results are shown in Table 5.7.

5.7. Yield of sainfoin depending on fertilizers (factor A) and mowing height (factor B) in the conditions of SS NULES of Ukraine "Agronomic Research Station", t/ha

Fertilizer rate	Average for 2007-2012			
	green mass		dry mass	
	mowing height		mowing height	
	6 cm	11 cm	6 cm	11 cm
Without fertilizers (control)	36.87	39.41	7.47	7.99
$P_{60}K_{60}$	37.57	40.50	7.61	8.23
$N_{30}P_{60}K_{60}$	37.47	40.53	7.59	8.25
$N_{45}P_{60}K_{60}$	37.28	40.29	7.54	8.14
LSD_{05}, t/ha	A – 1.05; B – 1.23		A – 0.27; B – 0.34	

According to the obtained results, the herbage of sainfoin was almost unresponsive to the application of fertilizers, and the yield under their influence did not increase. This indicates that sainfoin is a culture that is different from others. Due to its biological and morphological features, it effectively uses the elements of natural soil fertility and provides itself with optimal conditions for the fuller realization of the existing biological potential.

The economic importance of sainfoin culture is determined by yield. One of the most significant factors in increasing the yield of almost all crops is fertilizers.

A powerful factor that affected the yield was the height of mowing. It was found that at a mowing height of 11 cm the yield was higher compared to variants where the grass was mowed at a height of 6 cm.

The formation of higher yields at a mowing height of 11 cm becomes possible under conditions of strengthening and rapid flow of synthetic processes of intensification of the assimilation process, increasing the density of standing, more favorable factors for growth, development of grasses. In this case, the negative interaction between plants is leveled (Fig. 5.2).

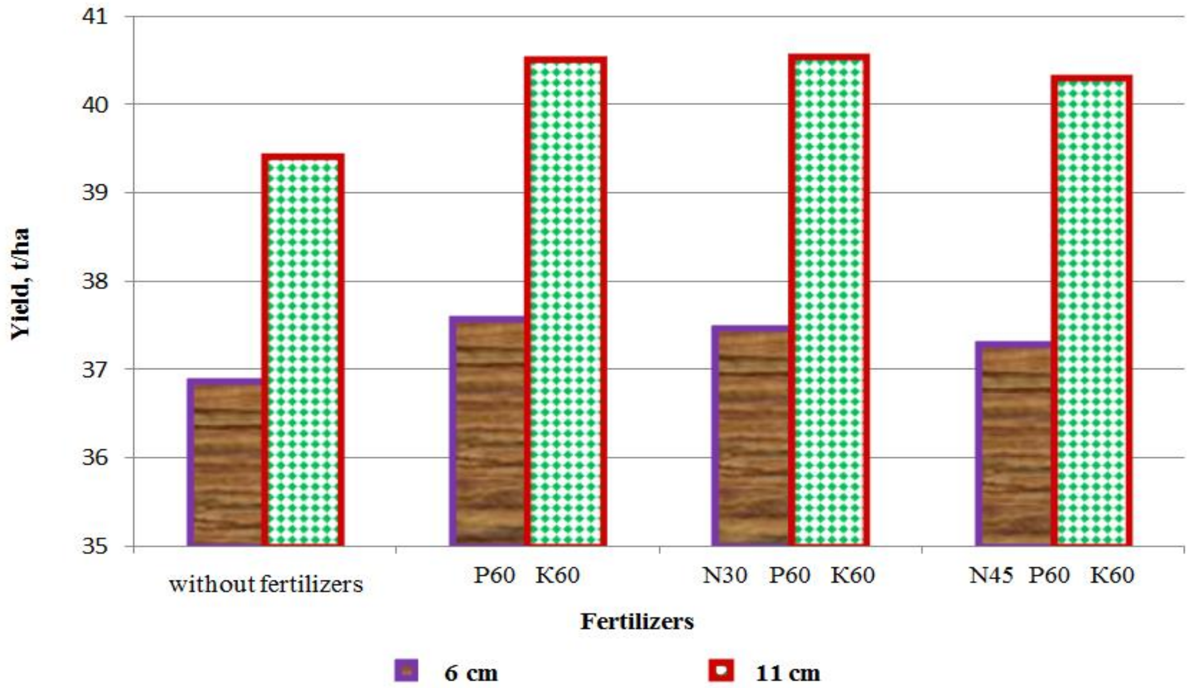


Fig. 5.2. Average factor yield of green mass of sainfoin depending on fertilizers and mowing height

The significance of the effect of mowing height is confirmed by the analysis of the results of analysis of variance of experimental data on the productivity of sainfoin (Fig. 5.3).

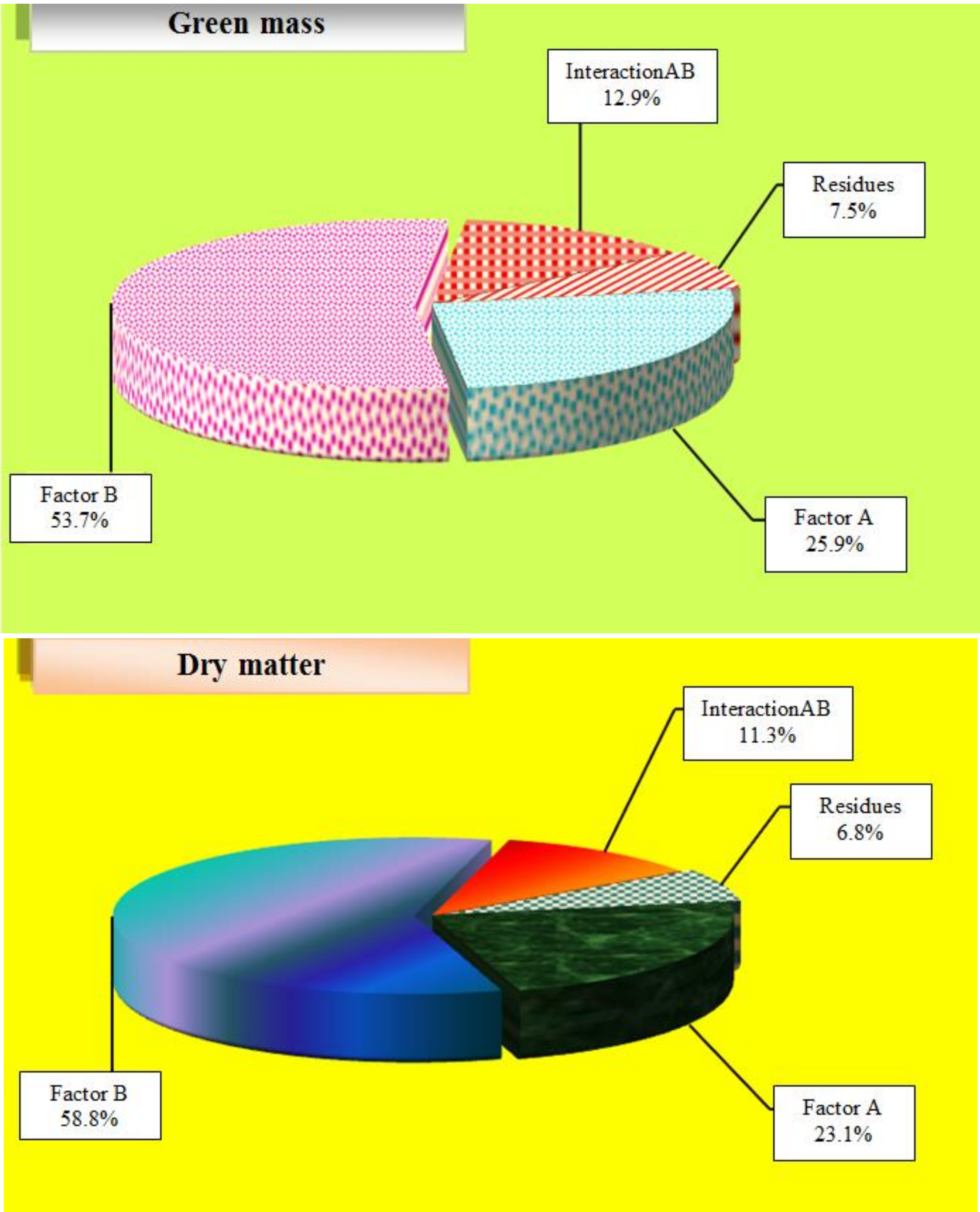


Fig. 5.3. The share of influence of factors (rate of mineral fertilizers – factor A; mowing height – factor B) on the yield of sainfoin

When forming the yield of green mass of the studied crop, the share of the influence of factor B (mowing height) was 53.7%, compared with the influence of fertilizers (factor A) – 25.9%. Also significant was the interaction of the studied factors – 12.9%.

The influence of the factors put on the study on the yield of dry mass reflected the trends that have emerged with respect to green mass. The height of mowing determined the formation of the crop by 58.8%, mineral fertilizers – by 23.1%. The interaction of factors decreased compared to the yield of green mass to 11.3%, but was at a high level.

Residual values, which reflected the influence of other unaccounted factors, primarily changes in weather conditions during the years of research, ranged from 7.5% relative to green mass and to 6.8% relative to dry matter.

The share of the impact on the dry matter yield of uncovered alfalfa, depending on the studied factors reflected the general trends that were found regarding the yield of leaf mass, but the share of factor A (seeding rate) decreased from 55.1 to 42.6%, factor B (vegetation years), on the contrary, increased from 22.6 to 26.7%.

There was also an increase in the interaction of the studied factors on the formation of dry matter by 6.9 percentage points, and the residual values were almost at the same level – 6.8 versus 5.3%.

5.2. Chemical composition of sainfoin and economic efficiency of its cultivation

The nutritional value of plant foods is determined by many indicators, among which the most important are protein, ash, fiber, fat, phosphorus, calcium. Data on the chemical composition of the green mass are given in Table 5.8.

According to these data, the applied fertilizers and the height of mowing had almost no effect on most of the chemical composition. Of all the indicators, the crude protein content changed the most. Sainfoin, under which fertilizers were applied, contained more protein than that grown without fertilizers. It was also found that under different conditions of mineral nutrition in the cut mass of sainfoin crude protein contained more in the case of mowing at the height of 11 cm.

5.8. Chemical composition of green mass of sainfoin depending on fertilizers and mowing height in terms of SS NULES of Ukraine "Agronomic Research Station", % of dry mass (average for 2007-2012)

Fertilizer rate	Mowing height						
	6 cm						
	crude protein	crude fiber	fat	ash	calcium	phosphorus	potassium
Without fertilizers (control)	15.9	25.8	1.7	9.4	1.73	0.59	2.1
$P_{60}K_{60}$	16.1	25.2	1.8	10.1	1.81	0.64	2.4
$N_{30}P_{60}K_{60}$	16.4	25.4	1.7	9.7	1.79	0.62	2.2
$N_{45}P_{60}K_{60}$	16.6	25.1	1.6	9.5	1.75	0.63	2.3
11 cm							
Without fertilizers (control)	16.5	24.6	1.6	9.3	1.71	0.61	2.0
$P_{60}K_{60}$	16.7	24.4	1.7	10.9	1.76	0.63	2.2
$N_{30}P_{60}K_{60}$	17.9	24.2	1.8	10.6	1.74	0.64	2.4
$N_{45}P_{60}K_{60}$	18.1	24.3	1.7	10.7	1.75	0.60	2.1

The potassium content varied slightly depending on the fertilizer and the cutting height. This is due to the fact that the supply of potassium to the soil is sufficient. In addition, the root system of sainfoin penetrates deep into the soil and the culture selects this element to the need even without fertilizer. According to zootechnical norms, in sainfoin it was contained in sufficient and harmless quantity.

Grass productivity is a very important, but not the only indicator when choosing the best option and the use of sainfoin. The main criterion for the effectiveness of agricultural measures is the increase in yield, output per unit cost, net income, level of profitability. The value of economic indicators, in addition to quantitative, is largely influenced by quality (feed balance, digestibility), because they depend on the productivity of farm animals.

Each method used to increase the yield of sainfoin is acceptable only when it provides an economic effect. That is, when the costs associated with its implementation receive such an amount of additional products, the cost of which exceeds the cost of its production.

Only in this case, the reception can be considered profitable, i.e. appropriate from an economic point of view. Additional costs that do not give an economic effect and do not pay off, increase the cost of production and slow down the pace of expanded reproduction.

Therefore, economic evaluation is an urgent part of determining the practical feasibility of the studied factor.

Given that the cost of livestock feed is at least 50% of total production costs, the development and implementation of highly effective agricultural techniques aimed at increasing the yield of sainfoin, is of paramount importance in creating a strong fodder base, improving livestock efficiency and reducing production costs.

The economic efficiency of grain growing is determined by the following indicators: crop yield, the value of gross output per 1 ha of agricultural land, production costs per 1 ha of agricultural land, the level of profitability.

It was found that the productivity of sainfoin sowed depended primarily on the height of mowing, as the applied fertilizers generally did not increase crop yields. At a mowing height of 11 cm, the cost of one quintal of green mass was UAH 0.98, respectively, against the background without fertilizers (control), while at a mowing height of 6 cm it was UAH 0.95 per 1 quintal of green mass. At a mowing height of 11 cm, labor costs per unit of output were lower, which amounted to 0.36-0.39 man-hours per 1 quintal of feed units, respectively.

EPILOGUE

The monograph presents the results of research, analyzes and solves a new scientific problem to substantiate the biological and organic bases of perennial legumes, developed new technological measures for the Forest-Steppe and Steppe of Ukraine based on the existing patterns of climatic and meteorological factors. Regularities of conditions of growth, development and formation of productivity of alfalfa, clover and sainfoin are established, theoretical and practical bases of modern technologies of cultivation of perennial legumes are developed. In turn, this allowed us to draw the following conclusions:

Agroclimatic resources of the Forest-Steppe of Ukraine in terms of natural soil fertility, moisture conditions, temperature and light regimes are favorable for the maximum realization of the biological potential of forage productivity of alfalfa, clover, sainfoin. It is established that when determining the volume of commodity production of perennial legumes in the farms of the Forest-Steppe zone, the location of the latter in the structure of sown areas should give preference to the most favorable regions of their cultivation, which include temperature factors Kyiv (Selyaninov's hydrothermal coefficient (SHC) – 1.05), Vinnytsia (SHC – 1.25), Khmelnytsk (SHC – 1.28), and Poltava (SHC – 0.90) regions. When adjusting the technological methods to take into account the negative impact of weather conditions, which indicates the tendency of a certain change in climatic characteristics in the direction of warming and greater humidity. Hence, give preference to and grow alfalfa in all areas of the Forest-Steppe of Ukraine.

The yield of alfalfa seeds depends on the individual productivity of its plants, the morphological structure of the seed bush, the number of productive stems, beans, weight of 1000 seeds. Under the conditions of combined use of alfalfa for fodder, as a result of the formation of the harvest of varieties with higher leaf content, the quality of green mass and hay can be significantly improved. In the year of research, the content of leaves in aboveground biomass in the budding phase ranged from 43.9 to 46.6%. In the study population, the proportion of leaves was 44.3%. One of the most important components of the harvest is the number of racemes on one stem, but this figure had a slight variation in the samples and was in the range of 9.2-9.7 pieces per one stem.

Treatment with rhizotorphin provided a significant increase in yield of alfalfa green mass by 14.9-24.1%. Increasing the dose of mineral fertilizers from $N_{60}P_{60}K_{60}$ to $N_{90}P_{60}K_{60}$ on the background of pre-sowing treatment with rhizotorphin contributes to the growth of plant productivity by 5.5%. Analysis of variance confirmed the maximum effect of seed treatment with rhizotorphine at the level of 69.0% in terms of impact on the yield of alfalfa green mass, compared with the effect of mineral fertilizers – 13.2%. Application of fertilizers, both phosphorus and nitrogen, differently affected the content of different forms of nitrogen and phosphorus in the leaves and roots of alfalfa. This content was different both in the phase of the true leaf and in the period of alfalfa growth of 60 days. In fertilized versions, where phosphorus fertilizers were applied, the total nitrogen content reached 2.51%. The application of nitrogen fertilizers resulted in a lower content of total nitrogen, with an average of 2.46% and a control of 2.38%. Coefficients of variation that reflected the effect of fertilizers on the content of different forms of nitrogen and phosphorus in alfalfa plants in different phases of growth and development had a very high level of variability. The application of phosphorus fertilizers during the sowing of alfalfa helped to increase the protein nitrogen content in various phases of growth and development.

It was found that with the improvement of the level of mineral nutrition in all studied grasslands the leaf surface area increased.

Grasslands grown in variants without fertilizers (control), depending on the mowing formed a leaf surface within 17.6-41.4 thousand m^2/ha, and the application of fertilizers at the rate of $P_{90}K_{120}$ contributed to the growth of this indicator by 9.3-17.5%. Variation analysis proved the average level of variability of the leaf surface of the studied crops depending on the doses of mineral fertilizers with fluctuations of the coefficient of variation from 13.3% (the first mowing of alfalfa) to 16.7% (the second mowing of *Bromus inermis*).

The share of alfalfa saturation of the grass mixture had the greatest influence on the formation of alfalfa-cereal grass yield. The highest productivity of the grass mixture was provided when it was saturated with alfalfa in the amount of 70% in the variants without fertilizers and when applying only phosphorus-potassium fertilizers $P_{60}K_{90}$ (38.4-39.3 t/ha of green mass). Herbal mixtures with alfalfa saturation in the amount of 60-70% provide high yields without fertilizers, they are low-cost and play an important role in the biologization and intensification of crop production.

The optimal sowing rate of alfalfa for coverless sowing should be considered 6-8 million seeds/ha, which determines the density of plants in the first year of vegetation 250-300 pcs./m^2, in the second – 200-330 and in the third year of vegetation – 160-170 pcs./m^2. The study of alfalfa sowing rates of 6, 8 and 10 million seeds/ha in uncovered and compatible crops with late spring crops showed that the maximum dry matter yield for two years of grass use was provided sowing with a sowing rate of 8 million seeds/ha. Analysis of variance proved the uneven effect of seeding rates on the yield of leaf and stem mass and dry matter of alfalfa coverless method of sowing depending on the years of use of the crop. The share of sowing rate in the formation of the yield of leaf and stem mass of the studied crop was 55.1%, which is 2.4 times higher than the influence of the growing season, the share of which was 22.6%. In addition, the interaction of factors has a high level – 17.0%, which is explained by the proportional increase in plant productivity in more favorable weather conditions in the options with the maximum rate.

In experiments, there is an inverse relationship in the dynamics of dry matter and protein content during the phases of alfalfa vegetation, an increase in the dry matter content in plants and a decrease in the crude protein content in the dry matter. Due to this, there is a difference in the growth of dry matter and protein during the growing season of alfalfa. Of course, the quality of the implementation of measures is of some importance. And to carry out loosening with chisels it is necessary across, instead of on a diagonal of sowing. Diagonal cultivation increases the number of damaged plants.

As a result of deep loosening, especially autumn, the yield of alfalfa can be significantly increased without fertilizer and irrigation, only through mechanical cultivation. The latter improves the air regime of the soil, which has a positive effect on the growth of alfalfa. Destroying cracks is advisable when caring for alfalfa crops of the second or third years of use, especially in autumn. Spring loosening is not always possible to a depth of more than 10-12 cm, due to the slow maturation of the soil. Deep loosening reduces the bulk density of the soil to 1.12-1.11 g/cm^3, increases the foliage of plants, their height, stem density, the number of buds on the root collar.

The highest efficiency was established – 95%, the use of urea-ammonia mixture UAM-32 for the second year of use in the spring before the restoration of vegetation at a rate of 80-120 l/ha. Comparison of the efficiency of technologies with the use of fertilizers (conventional) and with the use of liquid fertilizer UAM-32 suggests the advantages of the latter, because the yield of green mass here increases from 3.6 to

5.0 t/ha. According to the obtained results, the efficiency of UAM-32 was shown in increasing the yield of the studied crops by 4.4, 5.8, 6.1 and 7.0 t/ha (alfalfa, clover, sainfoin) compared to the control.

The scheme of application of fertilizers and means of protection is developed, according to which it is established that their first spring application should be carried out before the restoration of vegetation, in March, at a dose of 80-120 l per 1 ha. At the end of April, the single rate of UAM-32 should not exceed 10-20 l/ha with the addition of herbicide, in May – with the addition of 1 liter of herbicide and 6 liters of UAM-32. During the development of pests and intensive growth of green mass in June, it is mandatory to apply a tank mixture of insecticide 0.2 kg/ha with the addition of 1.5 l/ha of microfertilizer. Under this scheme of application of fertilizers and plant protection products, the efficiency of use reaches 97.6-98.2%, which is quite a significant and effective indicator. The cost is 51.9 US dollars.

During growing clover meadow height of plants, in variants without the use of mineral fertilizers, in the first mowing was 63.4-63.8 cm, in the second 24.9-28.2 cm and in the second mowing, the height was 24.9 cm in the Marusya variety and 28.2 cm in the Agros-12 variety. The application of phosphorus-potassium fertilizers ($P_{60}K_{90}$) in combination with inoculation with a bacterial preparation contributed to an increase in the height of plants. At the same time, the plants of meadow clover whith using background + $N_{60}P_{60}K_{90}$ were much higher, but only in the first mowing, with an index of 77.8-77.9 cm. This is explained by the fact that phosphorus-potassium fertilizers create life-improving fertilizers and actively undergoes the process of nitrogen fixation.

During the study, it was established that the yield of grass clover in the first year of vegetation significantly depended on the method of cultivation and levels of mineral content. During the pre-sowing inoculation of clover seeds, the harvest of the leaf-stem mass of grasslands in crops reached 31.89-32.39 t/h with a yield of 615-6.25 t/ha of dry matter. At full mineral fertilization in the norm $N_{60}P_{60}K_{90}$, with the pre-sowing inoculation of seeds, the yield of leaf-stem mass of clover was obtained at level 38.71-39.39 t/ha. The dry matter yield was 7.47-7.60 t/ha, respectively.

For the second year of vegetation, clover meadow on variants without fertilization provided the yield of leaf and stem mass at the level of 21.41-22.44 t/ha. Carrying out of such technological action, as inoculation of seeds, allowed to receive in the first mowing 14.7-14.98 t/ha, in the second 8.17-8.96 t/ha. When $P_{60}K_{90}$ was applied to the pre-sowing cultivation against the background of seed inoculation, the yield of leaf-stem mass of clover of the Marusya variety was 32.12 t/ha and Agros-12 variety – 33.97 t/ha. The application of complete mineral fertilizer in the norm $N_{60}P_{60}K_{90}$ on the background of inoculation allowed to obtain 28.49-29.35 t/ha of leaf mass. For the second year of meadow clover vegetation, the highest dry matter yield was observed in the variant where seed inoculation was carried out for application of mineral fertilizers in the $P_{60}K_{90}$ norm. Thus, in the first mowing the yield of dry matter was 6.19 t/ha for the variety Marusya and 6.56 t/ha for the variety Agros-12.

The chemical composition of sainfoin grasses differed depending on the factors studied. In level soil conditions and at different levels of fertilizer, the most influential factor is the height of mowing. Higher indicators of chemical composition were observed at a cutting height of 11 cm. At the same time, the content of crude protein and ash increased and the indicator of crude fiber decreased.

Deep autumn destroying of cracks on alfalfa of the second-third years of use belongs to energy efficient measures in the technological chain of growing a given crop. Preference should be given to deeper loosening of the soil in the alfalfa field by 18-20 cm, despite the higher total energy consumption, compared to tillage by 14-16 cm. At the same depth of both cultivation options, the yield of alfalfa dry mass at autumn cultivation on the depths of 18-20 cm on 2.9 c/ha of dry mass higher than with the depth of 14-16 cm.

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