SCIENTIFIC ASPECTS OF TECHNOLOGIES OF GROWING, STORAGE AND PROCESSING OF LEGUMINS

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Abstract. The monograph presents scientific and experimental research that reveals the theoretical and practical issues of production of legumes that can solve the problem of protein deficiency and replenish the world's food and feed resources. The research is based on the tasks of applied research on the topic: «Development of methods for improving the technology of growing legumes using biofertilizers, bacterial preparations, foliar fertilizers and physiologically active substances», state registration number 0120U102034. The authors' research is aimed at solving current problems of technological renewal and development of the agro-industrial complex of Ukraine. Scientific substantiation of innovative aspects of cultivation, storage and processing of legumes allows to modernize the system of training of future specialists in the field of agrotechnologies and to increase the production and practical orientation of such professional training. The scientific work theoretically substantiates and practically develops a competitive bioorganic varietal technology for growing legumes, which provides for the development of regulations for the use of a set of alternative types of biofertilizers for their cultivation in terms of short-term and long-term action. enterprises, the ecological state of the region. The developed effective regulations for the use of different types of biofertilizers for their vegetation and biosoil preparations by classical types in the system of agrotechnologies for growing legumes are presented. A comprehensive strategy for the transition to bioorganically adapted varietal technologies for growing legumes, taking into account the resource supply of the enterprise and hydrothermal supply of the territory. The research of the

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authors is aimed at solving current problems of technological renewal and development of the agro-industrial complex on the basis of substantiation of energy-efficient and resource-saving modes of operation of the vibrating disc crusher during grinding of feed grain by experimental evaluation of the process. The scientific work is performed in line with a new direction of research focused on the integration of paradigms of scientific knowledge in the field of crop production and agriculture, mechanization, technology, as well as the synthesis of different concepts of domestic and world practice.

1. Introduction

The task of modern agricultural production in Ukraine is to ensure the growth of grain production, which will contribute to the formation of stocks of plant resources, improve the provision of the livestock industry with high quality feed, and the population – food. The most important component of this task is to overcome the deficiency of feed and food protein. Modern technologies for growing fodder legumes do not provide a real yield of fodder protein, which would be close to the genetic potential of plants. The main source of vegetable protein is legumes, which in terms of crude protein content are 2.2–2.5 times predominant in cereals [1; 77].

In modern conditions, to solve the protein problem, legumes are attracting attention as a source of balanced amino acid composition, the cheapest and most environmentally friendly protein. Compared to cereals, legumes contain 1.5–2.0 and some 3 times more protein in seeds and provide the highest yield of digestible protein and essential amino acids per hectare of crop. Due to this, annual legumes – peas, beans, lupines, vetch and others – can be used as protein supplements for livestock needs [71–76].

Creation of modern technology of growing legumes and development of their separate technological methods for varieties introduced into production in order to increase grain production is an important area of modern crop production in solving the problem of vegetable protein and improving soil fertility [2; 7–10].

Modern field crop rotations of Ukraine, involved in commercial cultivation of crops, cover an area of about 19991900 hectares. Of these, about 70% of this area of arable land is occupied by intensive farming technologies used in agricultural enterprises that cultivate leased land [11; 35–37].

In Ukraine, such technologies are characterized by the cultivation of a limited number of crops in crop rotation, among which winter wheat predominates, occupying 31% in the structure of sown areas, sunflower – 30%, corn – 23% in the structure [26]; intensive use of mineral fertilizers, the volume of which for the cultivation of these crops reaches 200-300 kg/ha in the active substance of the main nutrients of nitrogen, phosphorus and potassium, which in the physical mass of mineral fertilizers reaches 1000 kg/ha [40–41; 70]; repeated use of synthetic pesticides, the amount of application of which during one growing season can be up to 10 times when growing one crop [3–5]; frequent return to the same field of cultivated crop, which can be in one or two years, and for corn – growing in a row for two or three years; suboptimal crop rotation, when sunflower is the main precursor for winter corn and wheat, and corn is the main precursor for sunflower [27–28; 55–56].

Given the lack of organic fertilizers in the modern crop rotation of Ukrainian agriculture, when in 2019 the fertilized area of manure was only 503,600 ha, which is only 2.7% of arable land with an estimated application of organic fertilizers for the entire arable land of Ukraine 0.5 t/ha at scientifically based norm of 18.3 t/ha, which could partially stabilize the resilience of such agroecosystems, there is an important problem of finding alternative ways to replenish the stock of organic matter in the soil, which will not only improve the agro-ecological condition of soils, but also increase the resilience of such homogeneous agroecosystems. exposure to pests – pests, diseases and weeds, the number of which has increased sharply [20; 22; 65].

In modern conditions of intensive agriculture in Ukraine, an alternative way to replenish the supply of nutrients and organic matter in the soil is plowing by-products of the most common crops grown in crop rotation: straw, stalks and stubble of winter wheat, winter rape, corn and sunflower [12–13; 47]. In Ukraine, such an agri-environmental measure has not been used for a long time, because during the Soviet era, cereal straw, corn stalks and sunflowers were used for livestock as feed and bedding [6; 14; 19; 38; 68–69]. Since the 2000s, the sharp decline in the livestock sector of Ukrainian agriculture has led to the abandonment of crop by-products in the field with its subsequent burning. It was only in the 2010s that agricultural enterprises began to grind crop residues and plow them as organic fertilizers. And in such conditions, part of the by-products of winter wheat, corn, sunflower, winter oilseed rape is removed from the fields for biofuel production [29–30].

Along with these properties of by-products of cereals, legumes have a number of advantages that can significantly increase their positive agri-environmental effect at lower economic costs [15–16; 69]. The growth of agroecological importance of legumes in crop rotation is determined not only by their accumulation of organic matter with by-products at a more favorable ratio between nitrogen and carbon, but also by symbiotic nitrogen fixation, taproot, which loosens the soil, variety of crops and crop rotation. short vegetation period of legumes – additional accumulation of moisture in the soil, cleaning the agroecosystem from pests, diseases and weeds. At the same time, the unreasonably small sown area of legumes in Ukraine does not allow to fully realize their agri-environmental potential [66–68].

At the same time, the main agroecological emphasis today is on traditional in recent years legumes – peas and soybeans, but farms are beginning to grow sown areas of other legumes, including chickpeas, lentils, beans, beans [17; 21; 49–50]. Very little is known about their agroecological significance in crop rotation.

2. Analysis of recent research and publications

An urgent problem for Ukraine is the development of alternative farming systems in the direction of developing new organic technologies for growing basic agricultural products. crops, in accordance with the directions of the European strategy for the development of biological systems of crop and livestock. Unlike other methods of agriculture, organic production is based on the use of resource-saving technologies, minimization of mechanical tillage and eliminates the use of synthetic substances [18; 23–5].

Issues of optimization of the structure of sown areas of legumes and their role in regulating soil fertility and increasing the productivity of farm animals are given in studies Cherenkov A. Models of crop rotations with elements of biologization at saturation by their legumes are developed, and also offers concerning complex development of branch of grain production Petrichenko V. (2017), Chynchik O. are brought. (2019), Kalenska S. (2015), Cherenkov A. (2016), Bakhmat O. (2018), Pantsyreva H. (2020) [1–3; 7–8; 10–11; 24–40; 42; 47; 56; 57; 61].

Studies of the effectiveness of biofertilizers and biostimulants have been actively conducted in Ukraine since the 1990s. These issues have been fruitfully discussed in the last five years in the studies of Beloved A. (2016), Vinyukova O. (2015), Volkogon V. (2015), Breginets O. (2015), Polishchuk I. (2015), Naidenova O. (2015), Kovalenko O. (2015), Dubovika D. (2016), Sokol S. (2016), Koltunova V. (2018) and others. Petrychenko V. devoted his works to the introduction of bioorganic cultivation methods (2018), Mazur V. (2017), Patika V. (2015), Babich O. (2017), Kolisnyk S. (2015); Shevnikov M. (2019), Kot S. (2016), Kaminsky V. (2017), Bakhmat O. (2018), Sherstoboeva O. (2016), Elsheikh E. (2016), Tagore G. (2016), Mishra A. (2016) and others [1–3; 7–8; 10–11; 24–40; 42; 47; 56; 57; 61]. However, the question of the peculiarities of water consumption of legumes remains insufficiently studied and requires appropriate scientific justification.

Unresolved issues of these studies, taking into account the positive effect found mainly during the application of biological fertilizer systems are the complexity of biofertilizers in seed treatment, soil application, application in several stages during the growing season using biofertilizers of different nature from symbionts, humates to complex biocomponents. foliar feeding format.

An important aspect of research remained the study of the interaction of biopotential of legumes in the soil-plant system from the standpoint of the potential for accumulation of biological nitrogen, the impact on nutrient and microbiological regime of soils and its biota, the impact of legumes as precursors. Thus, it is important to determine the technological modernization of agriculture, the involvement of artificial means of regulating plant productivity, significant climate change, through innovative guidelines in land use, structure of sown areas, application of fertilizers and organic residues, selection of varieties and hybrids, legislative consolidation of scientifically sound positions [43–44].

Legumes are the most important source of vegetable protein, which is the basis of human nutrition and animal nutrition. In the conditions of the right-bank Forest-Steppe, legumes are of the greatest importance for agricultural production. Important scientific developments in the technology of growing peas, soybeans, chickpeas, white and narrow-leaved lupine were made by well-known domestic and foreign scientists Babych A., Petrichenko V., Cherenkov A., Kalenskaya S., Mikhailov V., Bakhmat M., Pantsyreva H., Shevnikov M., Bakhmat O., Likhochvor V., Ovcharuk O., Novák K., B., Furseth and others [1–3; 7–8; 10–11; 24–40; 43–46; 56; 57; 61].

3. Literature review

Among crops, legumes have the highest protein content [48; 52]. Grain and green mass of legumes contain 1.5-3 times more protein than cereals, which makes it possible to obtain the highest yield of digestible protein and essential amino acids per hectare of crop. It is also important that their proteins are complete in amino acid composition and are much better absorbed by the body than proteins of cereals. Due to the valuable chemical composition of grain, legumes are of great industrial and raw material value [51; 59–60]. Legumes can be used to prevent deficiencies in both protein and amino acids, especially lysine [58]. Also, legumes, along with the provision of valuable food and feed should be crucial in phytomelioration, phytosanitary cleaning of the soil, as well as in reducing costs in crop production. An important source of growth in the production of competitive crop products in the system of sustainable agriculture is the increase in the share of legumes in the structure of sown areas, due to their ability to symbiotic fixation. The introduction of legally sound crop rotations of legumes can be an important factor in the intensification of agriculture, which ensures the rational use of biological and mineral nitrogen, reducing energy consumption and improving the environmental condition [53–54].

Legumes play an important role in improving soil fertility. They are characterized by an extremely valuable ability to bind free air nitrogen with the help of nodule bacteria and to enrich the soil with nitrogen compounds. After harvesting legumes per 1 ha, 20-70 c/ha of root and crop residues remain in the soil, which contain 45-130 kg of nitrogen, 10-20 kg of phosphorus and 20-70 kg of potassium. Nitrogen of root and crop residues of legumes is practically not washed away, as it is mineralized gradually. Growing legumes in crop rotation provides an increase in the yield of other crops and significantly improves its quality. At the same time, they improve biological processes in the soil due to the favorable chemical composition of root and post-harvest residues. This creates optimal biological processes in the soil, which increase the enzymatic activity and the ability of subsequent crops to use insoluble nutrients. The active activity of nodule bacteria in combination with biological processes improves the nitrogen balance of the soil, which significantly increases its fertility. Increasing the area under legumes is part of the greening of agriculture.

An important role in solving the problem of protein is assigned to legumes, a prominent place among which is soybeans. It is used to feed all species of animals and birds. Soybeans contain 36-48% protein, 17-26% fat and more than 20% carbohydrates. 100 kg of grain contains 131 units. and 29.2 kg of digestible protein. Soy protein is completely balanced in amino acid composition, it is easily digested and its biological value is close to the protein of animal origin – meat, milk and eggs. In addition, soybeans contain enzymes, vitamins, minerals, which allows it to be used for food production, industrial goods and medicine. The study of models of adaptive varietal technologies of soybean cultivation is of particular importance both for the general trends of crop production and for obtaining the maximum possible level of grain yield in a specific soil-climatic zone of Ukraine.

In the food market, the consumer value of soybean seeds is determined by the high content in the seeds of protein (30-55%), fat (13-26%), carbohydrates (20-32%). Ash contains a lot of potassium, phosphorus, and vitamins (A, B1, C, B2, E, K, D1, D3, PP). In terms of amino acid composition, soy protein is closest to animal protein consumed by humans. Soybeans contain almost all the necessary nutrients for humans and animals. The high content of protein and its extremely favorable balance in amino acid composition, make legumes good substitutes for products of animal origin in human nutrition. Sauces, milk, cheese, cutlets, egg powder substitutes, confectionery, sausages, canned food, etc. are made from legumes.

Today the population of our planet is 6.82 billion people. According to scientists, in 2050 their number will increase to 9.2 billion. By then, the area of productive land per capita will be reduced by almost a third. Mankind will find itself on the brink of a global food crisis. One of the ways to solve this problem is to intensify the cultivation of legumes. Since 2000, there has been a structural restructuring of legume crops in the direction of reducing the share of peas, fodder beans, lupine, but an increase in soybean crops.

To eliminate the deficit of feed protein, an important lever is the cultivation of legumes, the grain of which contains up to 50% protein and up to 25% oil. Legume protein is completely balanced in amino acid composition and is easily digested by humans and animals. In terms of biological value, it is equal to the proteins of meat, milk, eggs and is much cheaper than the proteins of other products. The introduction of legumes into the diets of farm animals significantly improves the use of roughage and succulent feed. Growing legumes allows to provide certain sectors of the economy not only with vegetable protein, but also to reduce the cost of crop production by including atmospheric nitrogen in the production process, improve the phytosanitary condition of crops and significantly increase crop rotation productivity. Most legumes are the leading and widespread, profitable protein-oil crops of world land use and occupy a prominent place after such crops as wheat, rice and corn.

Modern agricultural science has accumulated some information material on the impact of technological measures on the protein composition of legumes. However, the question of the influence of technological methods on the content of crude protein in seeds on most types of soils is insufficiently studied. This is especially true for areas of Ukraine, where in recent years there has been an increase in the area under these plants.

The main final indicator of the effectiveness of development and improvement of elements of any technology of growing crops, including legumes is to obtain their maximum yield with high quality. This issue requires appropriate scientific justification.

The scientific work theoretically substantiates and practically develops a competitive bioorganic varietal technology for growing legumes, which provides for the development of regulations for the use of a set of alternative types of biofertilizers for their cultivation in terms of short-term and long-term action. enterprises, the ecological state of the region. Effective regulations for the use of different types of biofertilizers for their vegetation and biosoil preparations by classical types in the system of agrotechnologies for growing legumes are presented. A comprehensive strategy for the transition to bioorganically adapted varietal technologies for growing legumes, taking into account the resource supply of the enterprise and hydrothermal supply of the territory.

The unique properties of legumes open an extremely wide range in the solution of vegetable protein and can be used in many areas of the processing industry: a variety of products for daily, dietary and functional nutrition, feed production, drug production, cosmetics.

Today, in the period of globalization of the world economy, the production of legumes requires a flexible approach to international competition, ensuring the solution of food and environmental security. Legumes play an important role in the grain and fodder balance of agricultural formations in Ukraine. Strategically, Ukraine should take a course to reduce the export of raw materials and create conditions for the organization of in-depth processing, which will contribute to: meeting the needs of intensive livestock with high-protein feed; creation of additional jobs; increase in tax revenues; ensuring food and environmental security of Ukraine.

Intensification of grain production, including fodder, should become one of the strategic directions of accelerated development of all agro-industrial production of Ukraine by 2030. To do this, focus on creating high-yielding varieties with clarification of the stable production zone, introduction of science-intensive, innovative technologies for their cultivation, which will be based on the effective use of life factors (light, heat, moisture, nutrients), which will promote maximum synthesis of organic matter and protein. In addition, in the context of climate change, it will be necessary to form a unified agricultural policy for the production of legumes.

Among the resources of society, food is the most important. Ukraine is the world's leading food producer, even in terms of technological backwardness. However, the further development of the agricultural sector requires the state to develop and implement a well-thought-out strategy for the modernization of agricultural production. The agro-industrial complex, which produces agricultural raw materials and food, is the guarantor of the country's food security.

One of the urgent needs of the agricultural sector is to ensure the growth of crop production, including legumes, and increase the competitiveness of domestic agricultural enterprises, which is impossible without government regulation and economic support for agriculture.

The strategic development of agrotechnologies with a focus on global trends in approaches to growing and fertilizing crops necessitates the development of adapted varietal technologies, which will ultimately ensure the formation of a modern technological strategy for the development of Ukraine's agro-industrial complex and ensure its long-term food security. To date, many types of legumes have not lost their importance as important food crops and occupy a prominent place in the formation of food and protein resources in many countries.

The problem of ensuring and improving the quality of protein plant products is relevant for all countries and enterprises. The success and efficiency of the national economy largely depend on its solution. This is an urgent and important task, the solution of which will be a significant contribution to solving the problem of vegetable protein, the formation of its own protein and grain resources, increasing soil fertility and strengthening the economy of Ukraine.

4. Conditions, objective and methods of research

Field experiments were conducted during 2018–2020 on the basis of the Research Farm «Agronomichesky» of Vinnytsia National Agrarian University in the village of Agronomichne of Vinnytsia district of Vinnytsia region. Research by Vinnytsia NAU is based on the tasks of applied research on the topic: «Development of methods for improving the technology of growing legumes using biofertilizers, bacterial preparations, foliar fertilizers and physiologically active substances».

Studies to study the impact of technological methods of cultivation on grain productivity of legumes were conducted during 2016–2019, with a comparative description of their yield and the main indicators of seed quality. Gray forest soils, medium loamy are characterized by the following indicators: humus content – average (2.4%), supply of P2O5 (271.2 mg/kg) and K2O (220.0 mg/kg) is very high. Soil acidity is close to neutral. Field experiments were performed with randomized blocks.

Growing technology is generally accepted for the Forest-Steppe zone of Ukraine, except for the envisaged technological methods of cultivation. uring the research, the scheme of the experiment was developed according to the methodology of the research case, as well as observations, accounting, calculations were performed. Field, statistical and laboratory research methods were used in the experimental work. The indicators obtained in the experiments from legumes were processed by the method of analysis of variance.

5. Grain yield of legumes depending on technological methods of cultivation

Agriculture is a branch of the national economy, the results of which largely depend on natural factors, and in particular weather and climatic conditions. They in different proportions are the natural basis of agricultural production. All components of the «soil-plant-air» system, and in particular hydrometeorological factors, take an active part in the accumulation of biomass and the formation of crop yields.

In addressing these issues, it is necessary to have an objective assessment of the impact of various factors on the level of grain production, including weather and climate. This will allow to reasonably determine the contribution of various indicators of agrometeorological conditions in the assessment of crop yield levels. Increasing the production of legumes and improving its quality remains the main problem of agricultural production in Ukraine, which can be solved only on the basis of rational use of land resources, introducing a scientifically sound system of agriculture in each farm, increasing soil fertility and using intensive technologies for growing legumes.

The efficiency of production of any crop products can be analyzed by comparing the yield of the main crop products. The main task of breeders when creating a variety is to obtain a new genotype with high yields. However, the actual yield of the variety is usually twice lower than the potential. Therefore, the main task of the technologist is the selection of the necessary elements of the technology of growing crops, due to which the new variety maximized its productive potential.

The productivity of agrophytocenosis is determined by quantitative and qualitative indicators of yield and is the final stage of assessing the effectiveness of the elements of cultivation technology. The factors that were put to the study, in turn, influenced the growth and development of legumes, the dynamics of dry matter accumulation, the formation of structural elements of plants and ultimately – to increase grain productivity.

The potential level of yield of legumes can be achieved only under ideal soil-climatic and agronomic conditions. However, each farm harvests a real economic harvest, which depends on weather conditions, soil fertility and the technology used. Therefore, it was very important to identify in our research the impact of technological methods of cultivation on the activation of growth and development, improvement of structural elements and the formation of higher yields of legumes.

A characteristic feature of the grain production process in Ukraine is a sharp increase in yield variance in recent years. This trend can be explained by the influence of meteorological factors that undergo similar changes. It is climate change in recent years that has led to legumes being severely depressed by drought. Therefore, farmers need varieties for different weather conditions. One of the ways to increase the production of legumes is to create and introduce into production more productive varieties adapted for growing in a specific climate zone. The diversity and variability of natural and climatic, soil, economic and technological factors cause inter-year fluctuations in the production of legumes, which reach 10% of the total gross domestic product.

A common measure for both intensive and adaptive technologies for growing crops, including legumes, is to improve the technological aspects of cultivation, which help to improve all growth processes and increase yields and improve product quality. In the conditions of the right-bank Forest-Steppe of Ukraine in recent years legumes are gradually displacing traditional oilseeds and cereals and are beginning to occupy an important place in the structure of sown areas of crops.

However, the level of their yield remains low and unstable over the years of cultivation, which encourages the study and improvement of elements of cultivation technology. Among the measures aimed at realizing the genetic potential of high-yielding varieties of legumes of intensive type, first of all are the following: efficient use of bioclimatic potential of the growing region, optimal, taking into account hydrothermal resources, varietal location of production, competitive technologies.

According to agricultural scientists, the determining factor in the formation of a high yield of legume seeds is the system of improving the model of cultivation technology through the use of high-yielding varieties and biological products.

It is established that in general the right-bank Forest-Steppe of Ukraine in terms of soil-climatic and hydrothermal conditions is favorable for growing legumes and the formation of their high grain productivity. The results of research indicate a significant impact of the studied technological methods of cultivation on the yield of legumes (Table 1).

Table 1

Grain yield and yield of crude protein of legume varieties depending on technological methods of cultivation in the conditions of the Right-Bank Forest-Steppe of Ukraine, t/ha (average for 2016–2019)

№	Culture	Variety	Pre-sowing seed treatment	Retardant concentration, %	Yield, t/ha	Yield of crude protein, t/ha
1	Sowing peas	Tsarevych	without p.s.t.	without processing (к)	2,08	0,98
				0,5	2,15	1,00
			Rhyzogumin	0,75	2,55	1,04
				1	2,48	1,02
		Prystan	without p.s.t.	without processing	2,12	1,00
				0,5	2,22	1,02
			Rhyzogumin	0,75	2,62	1,09
				1	2,52	1,06
2	White lupine	Veresnevyi	without p.s.t.	without processing (к)	2,74	1,12
				0,5	2,97	1,20
			Rhyzogumin	0,75	3,37	1,27
				1	3,07	1,22
		Chabanskyi	without p.s.t.	without processing	2,86	1,22
				0,5	3,06	1,25
			Rhyzogumin	0,75	3,47	1,33
				1	3,25	1,29
3	Lupine narrow-leaved	Olimp	without p.s.t.	without processing (к)	2,06	0,87
				0,5	2,21	0,90
			Rhyzogumin	0,75	2,54	0,98
				1	2,45	0,92
		Peremojets	without p.s.t.	without processing	2,12	1,00
				0,5	2,33	1,04
			Rhyzogumin	0,75	2,67	1,10
				1	2,55	1,07

(End of Table 1)

№	Culture	Variety	Pre-sowing seed treatment	Retardant concentration, %	Yield, t/ha	Yield of crude protein, t/ha
4	Soybean	Pegas	without p.s.t.	without processing (к)	2,08	1,24
				0,5	2,27	1,26
			Rhyzogumin	0,75	2,48	1,31
				1	2,37	1,28
		Skarb	without p.s.t.	without processing	2,16	1,28
				0,5	2,45	1,30
			Rhyzogumin	0,75	2,68	1,35
				1	2,55	1,32

HIP$_{0,05}$ t/ha (Sowing peas): A-0,07; B-0,10; C-0,08; AB-0,14; AC-0,12; BC-0,17; ABC-0,24
2016 HIP$_{0,05}$ t/ha: A-0,04; B-0,05; C-0,04; AB-0,07; AC-0,06; BC-0,08; ABC-0,12
2017 HIP$_{0,05}$ t/ha: A-0,05; B-0,06; C-0,06; AB-0,04; AC-0,08; BC-0,11; ABC-0,16
2018 HIP$_{0,05}$ t/ha: A-0,04; B-0,06; C-0,05; AB-0,04; AC-0,07; BC-0,10; ABC-0,14.
2019 HIP$_{0,05}$ t/ha: A-0,05; B-0,04; C-0,03; AB-0,05; AC-0,04; BC-0,07; ABC-0,09
HIP$_{0,5}$ t/ha (White lupine): A-0,05; B-0,08; C-0,06; AB-0,12; AC-0,10; BC-0,15; ABC-0,04
2016 HIP$_{0,05}$ t/ha: A-0,03; B-0,04; C-0,03; AB-0,06; AC-0,05; BC-0,07; ABC-0,10
2017 HIP$_{0,05}$ t/ha: A-0,04; B-0,07; C-0,07; AB-0,10; AC-0,07; BC-0,12; ABC-0,15
2018 HIP$_{0,05}$ t/ha: A-0,05; B-0,05; C-0,04; AB-0,07; AC-0,06; BC-0,11; ABC-0,13.
2019 HIP$_{0,05}$ t/ha: A-0,04; B-0,0; C-0,03; AB-0,05; AC-0,04; BC-0,07; ABC-0,09
HIP$_{0,05}$ t/ha (Lupine narrow-leaved): A-0,05; B-0,08; C-0,06; AB-0,12; AC-0,10; BC-0,14; ABC-0,09
2016 HIP$_{0,05}$ t/ha: A-0,03; B-0,04; C-0,03; AB-0,05; AC-0,04; BC-0,08; ABC-0,10
2017 HIP$_{0,05}$ t/ha: A-0,04; B-0,05; C-0,05; AB-0,06; AC-0,06; BC-0,09; ABC-0,12
2018 HIP$_{0,05}$ t/ha: A-0,04; B-0,06; C-0,05; AB-0,07; AC-0,07; BC-0,08; ABC-0,13
2019 HIP$_{0,05}$ t/ha: A-0,06; B-0,05; C-0,05; AB-0,06; AC-0,08; BC-0,08; ABC-0,10.
HIP$_{0,05}$ t/ha (Soybean): A-0,02; B-0,03; C-0,03; AB-0,02; AC-0,04; BC-0,14; ABC-0,05
2016 HIP$_{0,05}$ t/ha: A-0,02; B-0,03; C-0,03; AB-0,02; AC-0,02; BC-0,02; ABC-0,05
2017 HIP$_{0,05}$ t/ha: A-0,02; B-0,01; C-0,02; AB-0,03; AC-0,03; BC-0,03; ABC-0,06
2018 HIP$_{0,05}$ t/ha: A-0,03; B-0,02; C-0,03; AB-0,03; AC-0,02; BC-0,02; ABC-0,03
2019 HIP$_{0,05}$ t/ha: A-0,07; B-0,04; C-0,02; AB-0,08; AC-0,03; BC-0,04; ABC-0,13.

Over the years of experimental research, the maximum indicators of grain and fodder productivity in the varieties of the proposed legumes have been determined. Therefore, in sowing peas the most productive variety was Prystan (yield – 2.62 t/ha, crude protein yield – 1.09 t/ha), white lupine – Chabansky (yield – 3.47 t/ha, crude protein yield – 1.33 t/ha), lupine –

(yield – 2.67 t/ha, crude protein yield – 1.10 t/ha), and soybeans – Azimuth (yield – 2.68 t/ha, yield) crude protein – 1.35 t/ha). The largest increases in grain and fodder productivity were obtained by seed treatment with the bacterial preparation Rhizohumin and spraying of crops with chlormequat chloride retardant in the budding phase.

In addition to the studied factors, the value of crude protein content in legumes was influenced by agrometeorological factors, in particular the air temperature and moisture level. Therefore, the most favorable conditions for the accumulation of the maximum content of crude protein were formed in 2018, which was characterized by low average daily temperatures and a large amount of precipitation.

6. Technological methods of storage and processing of legumin crops depending on quality indicators

The most difficult task of post-harvest processing of grain is its storage before processing. It can be solved only through in-depth study of the processes occurring in the grain, purposeful use of its physiological properties during processing and storage. At present, the technological methods of storage and processing of legumes, depending on quality indicators, remain insufficiently studied and defined.

Legumes are part of the most promising crops in Ukraine, the chemical composition of which, in comparison with traditionally cultivated and grown cereals, includes a large number of energy and biologically valuable substances, the ratio and composition of which forms unique features and high consumer properties of products of their processing. Despite the large number of publications devoted to the study of chemical properties, positive effects on humans and animals, as well as agrotechnology of cultivation and use of legumes in the food and pharmaceutical industries and green mass in feeding farm animals, today are insufficiently studied physico-mechanical, aerodynamic and hygroscopic properties, dimensional and thermophysical characteristics, grain respiration intensity, their dependence on grain moisture and temperature has not been established. Therefore, the development of recommendations with scientifically sound regimes for cleaning, drying and storage of legumes, which will help reduce the energy consumption of post-harvest processing and guaranteed storage of grain of this crop.

All the above confirms the relevance of the work, determines the purpose and objectives of research.

The study of the properties of grain masses and the influence of environmental conditions on them showed that the intensity of all physiological processes depends on the same factors, the most important of which are: moisture of the grain mass and the environment; temperature of grain mass and surrounding objects; air access to the grain mass.

Three modes of storage of grain masses are based on regulation of parameters of these factors: in a dry condition, ie with humidity close to critical; in the cooled state, ie under such conditions, when their temperature is reduced to such limits that significantly inhibit the vital functions of the components of the grain mass; without air access.

There is also a prospect of chemical preservation of grain masses by treating them with some organic acids, which kill all living components of the grain mass and thus protect it from biological spoilage.

The choice of storage regime is determined by a number of conditions, including the climatic conditions of the area where the farm is located, types of granaries and their capacity, technical capabilities of the farm to bring batches of grain to a stable condition, purpose of grain batches, quality of grain batches, economic feasibility of applying a particular regime.

The best results are obtained with the integrated use of modes, such as storage of dry grain mass at low temperatures with the use of cold dry air for cooling during natural temperature changes.

It was found that the grain quality of most legumes, even at a humidity of 11-12%, for several years of storage at temperatures above 20 °C deteriorates, it darkens and acquires a bitter taste. In storage, the height of the mound of legumes of medium dryness (14-16%) is allowed up to 3 m, and wet (16-18%) – not more than 2 m. In the warm period of the year the height of the mound is reduced. Raw grain cannot be stored.

The most favorable conditions for legumes are at a temperature of 10 °C, grain humidity up to 14% and relative humidity up to 70%. At a grain moisture content of 16%, free moisture is formed, which causes the development of mold. Storage for three years and 10 months at a temperature of 4-7 °C and humidity of 13-15% did not lead to a decrease in food and feed qualities, contributed to the slowing down of biochemical processes.

At a humidity of 16% and a temperature of 24-25 °C, after 3 months of storage, the taste qualities change noticeably and molds develop, primarily in the cracks of the seeds. Legumes are easily cracked on impact (wet and raw less, dry – more). Therefore, when carrying out health-improving measures, it is not possible to use impact machines (grain remotes, etc.), but to create conditions for shock mitigation when cleaning and moving grain legumes.

Sowing qualities of seeds with high humidity during storage deteriorate or are lost due to low temperatures. The higher the content of free moisture in the seeds, the more noticeable the effect of temperature below 0 °C. If the seeds of all crops with a humidity below the critical temperature can withstand a temperature of minus 20-25 °C for a long time, then with increasing humidity, its stability decreases sharply. Many seeds, having a humidity of 20-22%, lose germination at a temperature of minus 5-10 °C for a short time of storage. As the shelf life extends, grain germination gradually decreases. Therefore, during long-term storage, the germination of legume seeds is maintained for up to 1.5-2.5 years.

Thus, ensuring the required quality of grain without deterioration of consumer and seed properties is a rather difficult task faced by legume producers, as recently there has been a tendency to organize the storage of grain directly on farms. The efficiency of the organization of the grain storage process is based on the knowledge of the physiological and biochemical properties of the grain mass, as well as on the development of recommendations for post-harvest processing.

The fight against losses and reduction of consumer properties of grain and grain products can be carried out only on the basis of deep knowledge of their chemical composition and complex biological and chemical processes occurring in products, the intensity of which depends on the characteristics of the object and storage conditions.

7. Development of technological schemes and recommendations for post-harvest processing of legumes

Post-harvest processing of most legumes is the most difficult in the production of these crops. Due to the high content of protein, fat and the vulnerability of the shell to damage, legumes under adverse conditions (the presence of organic impurities, high humidity) spoil quickly. It is very important that the grain is stored thoroughly cleaned of broken and crushed parts, from beans damaged by pests, garbage that provides additional moisture, as well as castor seeds.

Wet and raw legumes must be cleaned of impurities and dried before storage in order to prevent deterioration. For reliable storage of legumes must meet the following requirements: humidity – no more than 14-16%; clogging – no more than 4%.

It is expedient to clean the grain of legumes on lattice-free (aerodynamic) separators. Aeroseparators allow you to clean the grain from impurities and divide it into several fractions according to aerodynamic properties. Productivity of separators like GARDEN makes from 4 to 150 t/ha. The technological scheme of the aeroseparator is shown in Figure 1.

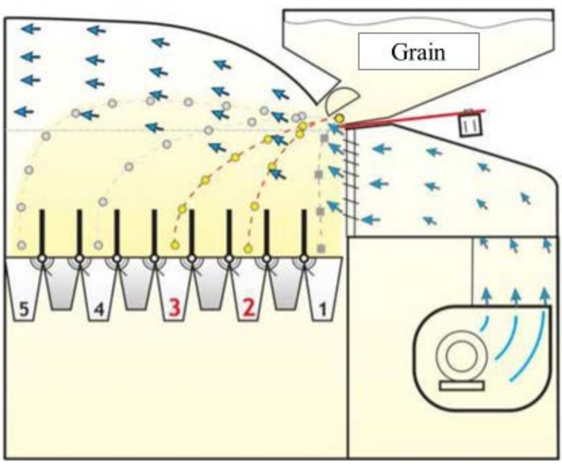

Figure 1. Technological scheme of the aerodynamic separator: 1 – large impurities; 2, 3 – cleaned grain; 4, 5 – light impurities, thin and broken grain

In the separation chamber, the grain is separated and separated by specific gravity due to the action of air currents generated by a high-pressure fan prepared by a jet generator. After separation, the grain is diluted into fractions and sent to receiving hoppers or packed in bags. A cyclone built into the separator is designed to trap dust, light impurities and fine particles that enter the separation together with the grain mass. Purification of grain of legumes can also be carried out on existing in the industry sieve-air separators and grain-cleaning stationary complexes ZAV.

When legumes arrive at elevators and storage points, it is necessary to ensure timely acceptance, batch formation and necessary processing – cleaning, drying and active ventilation, ie bringing grain to the established industrial quality standards and sowing, export or special conditions.

All operations performed with grain are associated with the need for transport (internal movement) of grain, which uses continuous machines (conveyors, conveyors) and self-flowing pipes. The grain is processed on continuously operating equipment (grain cleaning machines, grain dryers). The relationship of technological equipment, as well as tanks (bunkers, silos), connected by transport equipment, is a technological process of grain processing in grain harvesting enterprises.

Thus, each operation is characterized by a certain sequence of grain movement through silos, hoppers and equipment, which largely depends on the schematic diagram of the elevator.

8. Practical value

The introduction of research results will increase the attractiveness of the market for high-protein products due to cheaper production costs due to the recommendation of domestic varieties of legumes by at least 20-25% while reducing the cost of production in the pre-calculated range by 20-33%. The proposed system of using domestic varietal resources will stimulate revenues to local budgets by further expanding the production of recommended biological products by regional enterprises by at least 8-10%. This, in turn, will stimulate the reduction of exports of raw materials and create conditions for the organization of in-depth processing, which will contribute to: meeting the needs of intensive animal husbandry with high-protein feed; providing the population with food, creating additional jobs; increase in tax revenues; ensuring food and environmental security of Ukraine. Scientific development will contribute to the effective European integration of Ukraine and the overall improvement of agricultural products that meet international standards, will increase the effectiveness of Ukraine's state policy in organic and organic farming, contribute to the stabilizing slowdown in natural soil fertility, increase humus and chemical state for subsequent generations. To do this, we focus on optimizing the structure of sown areas of leading crops, development and implementation of science-intensive, innovative technologies for their cultivation, which will be based on the effective use of life factors (light, heat, moisture, nutrients), which will promote maximum synthesis of organic matter and protein.

9. Conclusions

The scientific work theoretically substantiates and practically develops a competitive bioorganic varietal technology for growing legumes, which provides for the development of regulations for the use of a set of alternative types of biofertilizers for their cultivation in terms of short-term and long-term action. enterprises, the ecological state of the region.

Effective regulations for the use of different types of biofertilizers for their vegetation and biosoil preparations by classical types in the system of agrotechnologies for growing legumes are presented. A comprehensive strategy for the transition to bioorganically adapted varietal technologies for growing legumes, taking into account the resource supply of the enterprise and hydrothermal supply of the territory.

The research of the authors is aimed at solving current problems of technological renewal and development of the agro-industrial complex on the basis of substantiation of energy-efficient and resource-saving modes of operation of the vibrating disc crusher during grinding of feed grain by experimental evaluation of the process.

As a result of research, environmental, economic and social effects have been achieved. The long-term economic effect is achieved due to the general growth of both the culture of agricultural technologies and the growth of the sales share of varietal potential of legumes with a simultaneous increase in market attractiveness and liquidity of products and processing grown by new technologies and improving the investment climate. Short-term ecological effect is achieved due to stabilization of agrochemical degradation of arable land soil, significant reduction of agrochemical load on technologies while minimizing the impact of tillage equipment. The social effect is to stimulate domestic organic production, create additional jobs, improve the quality of life, form and implement sustainable development goals, form and promote healthy nutrition and health of the nation, and so on. Economic, environmental and social effect obtained from research that exceeds the planned costs. The result of research is a convenient system of technological methods of cultivation, which leads to an increase in the level of realization of the varietal potential of the main legumes, increasing the profitability of their production in combination with environmental and social effects.

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