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Scientific editor and project director: Anita Jankovska

Authors: Natalia Voroshylova, Nelia Melnikova, Nataliia Hryntsova, Inna Honcharuk, Hanna Pantsyreva, Victor Mazur, Ihor Didur, Olexander Tkachuk, Nataliia Telekalo, Andrew Bulashenko, Stepan Piltyay, Yuriy Gutsalenko, Tetyana Tretyak, Vladimyr Meish, Yuliia Meish, Oleksandr Obodovych, Oleksandr Solovey, Zhanna Petrova, Yurii Sniezhkin, Kateryna Slobodianiuk, Kateryna Samoilenko, Anna Kharchenko, Ylia Khrutba, Vitalii Tsybulskyi, Djamalutdin Chalaev, Nina Silnyagina, Alexandra Shyshkina

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The collective monograph describes the integration of traditional and innovation processes of development of modern science. The general issues of the biological sciences, engineering and technical support and AIC management, information, computing, and automation, etc. are considered. The publication is intended for scholars, teachers, postgraduate students, and students, as well as a wide readership.

Contents

CHAPTER «AGRICULTURAL SCIENCES»

EFFICIENCY OF GROWING LEGUMES CROPS IN UKRAINE

Inna Honcharuk[1]
Hanna Pantsyreva[2]

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Abstract. The research presented in the monograph is aimed at solving current socio-environmental problems of Ukraine, as well as the implementation of priority areas of sustainable development, namely energy efficiency and environmental safety, which will be provided through the development and implementation of the latest concept of environmentally sound and energy efficient rural development. The implementation of environmentally friendly direction will involve the development of measures for efficient waste management, rational use of bioresources by increasing the area and volume of energy crops, as well as improving cultivation technologies, use of new varieties and hybrids and land reclamation, taking into account the concepts of environmental management. Implementation of the proposed measures for energy efficient development of rural areas will involve the formation of technical and technological basis for the use of waste and processing of organic raw materials for energy purposes, development of energy cooperation, land use optimization, biologization of agriculture. The monograph presents a competitive bioorganic varietal technology for growing legumes, which provides for the development of regulations for the use of a set of alternative fertilizers for their cultivation in terms of short-term and long-term action and the basic superstructure of factor assessment of soil fertility, ecological conditions. The scientific and methodological value of the monograph lies in the presentation of the results

[1] Candidate of Economic Sciences,
Associate Professor of the Department Economy,
Vinnytsia National Agrarian University, Ukraine
[2] Candidate of Agricultural Sciences, Associate Professor,
Vinnytsia National Agrarian University, Ukraine

of research conducted on the basis of the Research Farm «Agronomiche» of Vinnytsia National Agrarian University, Agronomichne village, Vinnytsia district, Vinnytsia region. Scientific substantiation of technological methods of growing 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.

1. Introduction

Protein economy plays a key role in the state's economy. To ensure the efficient operation of the protein economy, it is important to fully meet the country's domestic needs in legumes and increase the volume of possible exports. For Ukraine, increasing grain production is of strategic importance for the rise of the national economy, because its successful development creates conditions for the effective operation of a number of related industries. To ensure the efficient operation of the protein economy, it is important to fully meet the country's domestic grain needs and increase possible exports.

An actual and effective way to increase the efficiency of crop production now and in the near future perspective will be the use of the latest advances in science in the biological, technological and information fields.

In modern conditions of agricultural production, the priority area of research is the justification and improvement of modern agricultural technologies for growing legumes on the basis of energy and resource conservation and environmental safety. In this regard, special attention should be paid to legumes, which have important fodder, agronomic, economic importance.

Natural and climatic conditions of our state are favorable for growing all known cereals and legumes. Combined with the high agricultural skills of the Ukrainian peasantry, this led the country at the end of the last century to one of the leading places in Europe for the production of high quality grain for various purposes. It was famous as one of the largest and most reliable granaries, as well as protein regions. And if today our state, for a number of objective and subjective reasons, is experiencing difficulties in the development of legumes, it should be considered a temporary phenomenon.

Protein production plays a key role in the state's economy. To ensure the efficient operation of the protein economy, it is important to fully meet the country's domestic protein needs and increase possible exports. For Ukraine, increasing the production of protein from legumes is of strategic importance for the rise of the national economy, because its successful development creates the conditions for the effective operation of a number of related industries. Improving the efficiency of protein production is one of the most important tasks on which the country's food security depends. It should be carried out at both the state and regional levels, where the issues of providing the population with food and livestock with highly nutritious feed are addressed.

Of all crops, legumes contain the most protein. Their grain and green mass in terms of protein content exceeds cereals more than twice, in terms of amino acid composition their proteins are much better digested, give the cheapest protein, include in the biological cycle nitrogen air, which is not available for other crops. Today, vegetable protein is highly valued in the food and feed industry.

Today in Ukraine 325 thousand hectares are sown for legumes and 8325 thousand hectares for oilseeds, 1850 thousand hectares are soybeans. In 2019, 508 thousand tons of legumes, 3.9 million tons of soybeans were produced with yields of 2 t/ha and 1.8 t/ha, respectively.

Strategically, Ukraine must take a course to reduce volumes export of raw materials and creating conditions for the organization in-depth processing, which will contribute to: meeting the needs of intensive animal husbandry with high-protein feed; creation of new jobs; increase in taxes; ensuring food and environmental security of Ukraine.

Intensification of legume production should to become one of the strategic directions of accelerated development of all agro-industrial production of Ukraine for the next 10 years. To do this, it is necessary to focus on the development of cost-effective technologies, namely the creation of high-yielding varieties of legumes of different maturity groups with clarification of the stable production zone, optimization of the sown area of leading crops, development and implementation of science-intensive technologies based on resource saving. In addition, in the context of climate change, it will be necessary to form a common agricultural policy for the production of high-protein feed with the EU. This is an urgent and important task that will be solved significant contribution to solving the problem of vegetable protein, the formation of its own protein resources, increasing soil fertility and strengthening the economy of Ukraine.

2. Analysis of recent research and publications

One of the main branches of material production is agriculture. Crop products are extremely important – one of the leading branches of agricultural production. Over investigate the issue of economic efficiency of legumes such known scientists and economists as Kaletnik G. (2018), Honcharuk I. (2019). Development of technological methods of cultivation, improvement efficiency of legumes use in agriculture, as well as its selection and biology in Ukraine were engaged in such scientists as Babych A. (1993), Petrychenko V. (2014), Chynchyk O. (2019), Kalenska S. (2015), Cherenkov A. (2016), Bakhmat O. (2018), Pantsyreva H. (2017).

Rational use of nature, development of rural areas and issues related to solving current problems of environmentally friendly and energy efficient development have been studied in the works of both domestic and foreign scientists. Thus, G. Hartt and E. Larson explored theoretical approaches to the definition of «rural areas» used in the EU; American scientist K. Johnson, studying the theoretical aspects of rural development, noted that the development of rural areas is associated not only with the development of agriculture, but also with the development of industry and other industries.

The works of Datta A., Hossain A., Roy S., Tiseo I., Uslu A., Detz R., Mozaffarian H. The study of rural development in the context of energy V. Andriychuk, B. Panasyuk, G. Zabolotny, G. Kaletnik, I. Kyrylenko, A. Lisovy, M. Malik and others dedicated their works to environmental protection. In particular, V. Mesel-Veselyak researched the basic principles that should be used in the development of rural development in Ukraine. Sustainable rural development and ecology are closely linked, as confirmed by European research. Thus, in December 2015, the EU Commission paved the way for a resource-saving society and a sustainable economy in Europe. In addition to developing an action plan, it was suggested that key waste legislation be reviewed in order to reduce the generation and reuse and recycling of more waste in the future.

The basis of sustainable development of rural areas is the effective conduct of agriculture. Petrychenko V., Kaminsky V., Patyka V., Babych O., Shevnikov M. devoted their works to the development of ecological and adaptive models of growing crops with ensuring the preservation of high levels of varietal bioproductivity and mobilization of soil fertility conditions

Kots S., Kaminsky V., Bakhmat O., Sherstoboeva O., Elsheikh E., Tagore G., Mishra A. and other.

Technical aspects and problems that arise during the primary processing of organic products are devoted to the works of Nanka O., Ievlevva I., Sementsova V., Boyko D., Kosse V., Mathew J. and many other domestic and foreign scientists. In their research, the authors emphasize the imperfections of traditional methods of impact grinding and determine the positive effect of sharp edges of the hammer on the energy performance of the destruction of organic material.

The research is of considerable scientific interest. However, in the context of Ukraine's European integration and orientation to European standards, further research requires a comprehensive approach to rural development based on the development of the latest concept of environmentally friendly and energy efficient development. The scientific work is focused on achieving a comprehensive effect in ensuring sustainable agro-industrial production while ensuring the necessary levels of food and bioenergy security of the state in order to reproduce soil fertility potential, as well as improving living conditions, public health by increasing access to production and consumption of organic agricultural products.

Thus, the production of legumes occupies a special place among other branches of crop production, because grain is not only the basis of human nutrition, but also is a source of livestock production, an export product that determines the foreign economic position of the state. Despite the fact that our country has good climatic conditions and fertile chernozems for growing legumes, in recent years, feed production has not been stable. Therefore, the primary task of producers of protein crops is to increase the fertility and economic efficiency of legume production. More attention should be paid to achieving highly efficient management, improving the quality of agricultural products. Improving the economic efficiency of agriculture involves increasing production and improving the quality of agricultural products while reducing labor costs and material resources per unit of output. The solution of this problem is inextricably linked with the further comprehensive intensification of agricultural production, in the process of which increases the yield of crops and productivity of livestock and poultry. In modern conditions, agriculture is developing mainly on the basis of intensification, which is the main source of increasing its economic efficiency.

Today, the development and efficient functioning of rural areas in Ukraine should be based on the following priority areas: environmental friendliness, energy saving and alternative energy. The monograph has a socio-environmental and energy focus and focuses on addressing global issues reflected in the Energy Strategy of Ukraine until 2035 «Security, Energy Efficiency, Competitiveness», «On Waste and Repeal of Certain Directives» and the UN Framework Convention on Climate Change, Cabinet Resolution Ministers of Ukraine «On combined heat and power generation (cogeneration) and use of waste energy potential»; will promote the sustainable development of the agro-industrial complex, which is one of the strategic goals of the Draft Strategy for Sustainable Development of Ukraine until 2030.

3. Literature review

The most pressing problems of modern society and rural development include the organization of rational nature management, energy consumption with minimal negative impact on the environment, careful use of energy resources for reasonable and sufficient satisfaction of technological and household needs of citizens in all types and forms of energy.

Currently in the world and in Ukraine an extremely important problem is the development of organic farming, development of environmentally friendly technologies for growing legumes, expanding areas for growing high-protein legumes and studying their impact on soil fertility, improving its condition and preservation in general under climate change. In this regard, it is important to find alternative systems for fertilizing crops, selection of legumes for different areas using microbiological fertilizers and growth stimulants allowed for use, in order to preserve soil fertility, improve its physicochemical properties and particle size distribution, stability of soil development. The system of using domestic biological fertilizers as a factor in increasing competitive agriculture and adapting organic technologies for growing legumes is to be studied.

Growing legumes will increase the attractiveness of the market for organic production due to cheaper basic components of biofertilizers due to the recommendation of domestic counterparts by at least 20-25% while reducing the cost of production in the pre-calculated range by 15-27%. Such a system of purchasing biologicals will stimulate revenues to local budgets by further expanding the production of recommended biologicals by regional enterprises by at least 8-10%.

In today's conditions, the development of effective models of bioorganic fertilizers of the studied crops in the region with the formulation of basic principles of such fertilizers and guidelines for options for effective use of biological products in both single-component and combined applications is crucial. Improving the technological regulations for the use of biofertilizers in terms of their classification groups – biodestructors, element fixers, biofertilizers, biostimulators of growth, chelated microbiocomplexes can guarantee the effective conduct of sustainable organic production. Also, research has shown that with the related effects of biological products on the relevant soil nutrients, the dynamics of macro-and micronutrients in the soil, its microbiological activity and microbiological potential, especially in soil applications of the studied drugs will increase the overall efficiency of arable land and Ukraine environmental safety of the products and increase the level of environmental sustainability of the region, provide an overall increase in crop productivity by at least 15% while saving production resources by at least 18-27%, promote marketing advantages of domestic producers of organic products and related technological components.

Therefore, the development of effective models of bioorganic fertilizers for legumes in the region with the formulation of basic principles of such fertilizers and guidelines for options for effective use of biological products in both single-component and combined applications is extremely important and requires appropriate scientific justification.

4. Conditions, objective and methods of research

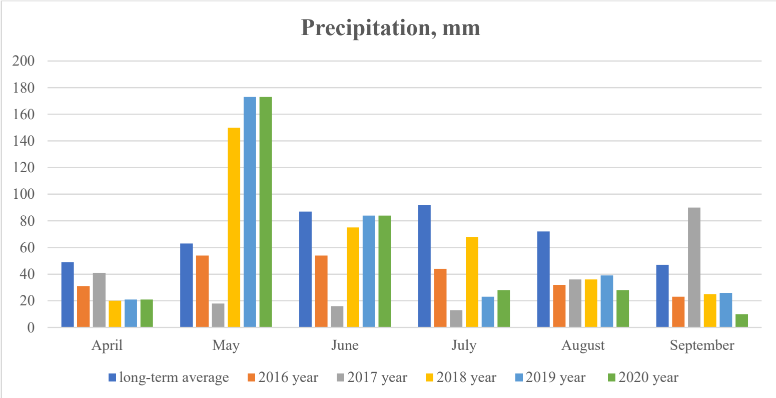
Field experiments were conducted during 2016–2020 on the basis of the Research Farm «Agronomiche» of Vinnytsia National Agrarian University in the village of Agronomichne of Vinnytsia district of Vinnytsia region. The territory of the right-bank Forest-Steppe of Ukraine, the place of research, is characterized by a favorable agro-climatic potential for growing most crops, including legumes. In particular, there are sufficient amounts of active air temperatures and rainfall per year and their distribution over the growing season. However, the real bioclimatic resources of the region are not enough to better realize the productivity potential of legumes. Therefore, there is a need to develop new and improve existing models of technologies for growing legumes. Clarification of these issues is relevant and requires detailed studies, especially on the development of zonal cultivation technologies, which take into account the specifics of soil and climatic potential of the growing region.

The Forest-Steppe is characterized by a temperate continental climate and belongs to the zone of sufficient moisture. According to meteorological observations, the main indicators of climatic conditions in the years of research were close to the average long-term data, but also revealed deviations that were reflected in the production process of legumes (Figure 1).

The absence of high mountain elevations contributes to the free movement of air of various origins, which causes significant variability of weather processes in certain seasons. The main climatic indicators of the central zone of Vinnytsia region, where they were conducted studies are shown in the table 1.

Vinnytsia district is located in the central part of Vinnytsia region, which is characterized by a moderately warm and humid climate typical of the Right-Bank Forest-Steppe. Hydrothermal coefficient – 1.7-1.8. Average number precipitation is up to 930 mm per year. The highest amount of precipitation (up to 75%) is from April to September. Humidity factor up to 14.

The Right-Bank Forest-Steppe is a zone of temperate zone, which is characterized by alternation of forest and steppe vegetation. Soils are formed under conditions of unstable moisture, in which the podzolic process of soil formation is combined with turf. Plants growing on these soils receive a high amount for the consumption of mobile phosphorus 214 mg / kg and metabolic potassium 104 mg / kg (according to Chirikov). However, the content of easily hydrolyzed nitrogen is very low and is 43.5 mg / kg (according to Cornfield). Gray forest soils occupy an intermediate position between light gray forest and dark gray podzolic soils. As a rule, soil-forming rocks are forests and forest-like loams. They are characterized by coarse-grained medium-loam mechanical composition. The absorbing complex of gray forest soils is saturated with Ca2 +, Mg2 + and H +. Soils capable of structure formation, prone to swimming, crusting and plowing, susceptible to erosion, are not always characterized by a stable water regime, which in turn reduces their productivity. Gray forest soils have a clearly visible division of their profile into horizons. The research included the study of the



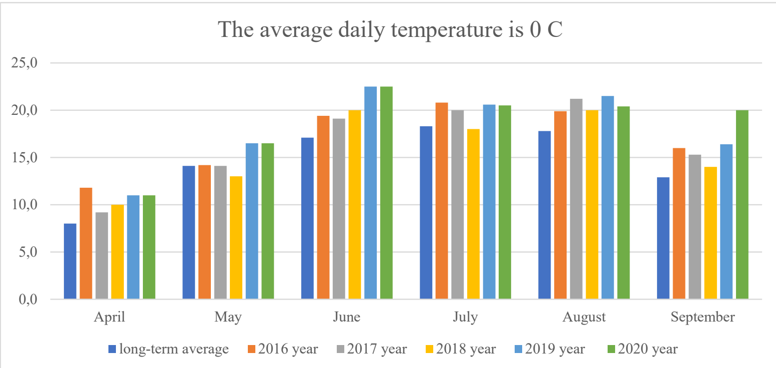


Figure 1. Average daily air temperature and precipitation for 2016–2020 (according to the Vinnytsia Regional Center for Hydrometeorology)

action and interaction of 3 factors: A – grade; B – pre-sowing treatment of seeds with a bacterial preparation; C – is the concentration of the retardant.

The levels of yield of legume seeds grown in the Right Bank Forest-Steppe of Ukraine – soybeans, peas, white lupine and narrow-leaved lupine are given (Figure 2).

Object of research: legumes and the effectiveness of biological fertilizers on their crops and the growth of regulatory substances and their impact on changes in the natural fertility of the soil and its mycosis.

Table 1

Climatic indicators of the central zone of Vinnytsia region

Climatic indicators	Central area
The sum of positive temperatures (more than 0 °C)	2671-2780
Duration of frost-free period (days)	141-147
Average annual air temperature (0 °C)	7,3
The average of the absolute minimums of air temperature (0 °C)	- 25
Absolute maximum air temperature (0 °C)	+38
Average date of the first frost (autumn)	17.09
Average date of the last frost (spring)	24.04
Duration of the growing season (days)	190-215
Average rainfall per year (mm)	930
Precipitation during the growing season (mm)	328
Length of the period with snow cover (days)	86
Average depth of soil freezing (cm)	55
Maximum depth of soil freezing (cm)	84
Minimum depth of soil freezing (cm)	21
The sum of active temperatures (0 °C)	2500
The prevailing wind direction	Northwestern

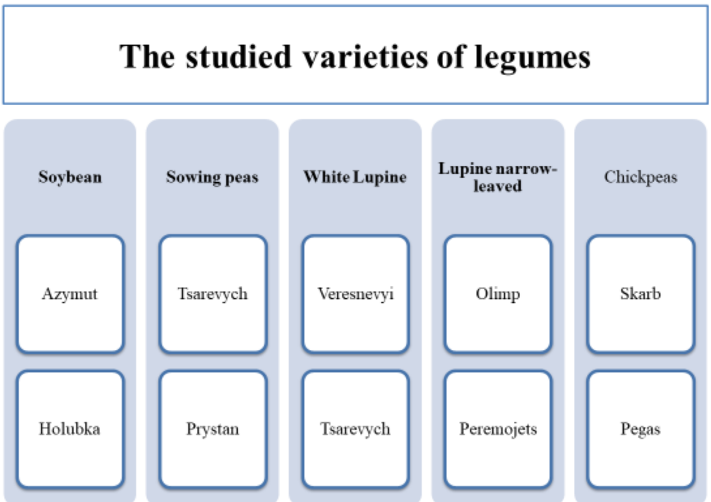


Figure 2. The studied varieties of legumes

Subject of research: increase of productivity of grain legumes and subsequent crops of crop rotation due to application of system of organic fertilizer and growth of regulating substances in technologies of their cultivation, influence on changes of fertility and preservation of soil.

The aim of the study is to develop competitive technologies for growing legumes, which involves the development of elements of application of a set of alternative fertilizers for their cultivation in terms of short-term and long-term action and basic superstructure of factor assessment of soil fertility, hydrothermal conditions, resource provision of enterprises, ecology.

The objectives of the study include:

– formation of a new method of assessing the bioadequate productivity of arable land to determine the possibility of adaptation of the enterprise to bioorganic technologies for growing legumes;

– development of effective regulations for the use of different types of biofertilizers for the growing season by classical types in the system of agrotechnologies for growing legumes;

– development of a system of application of bioorganic agrochemicals in the system of soil use on the basis of mobilization agrochemical approaches;

– development of a comprehensive strategy for the transition to bioorganically adapted varietal technologies for growing basic legumes.

Scientific approaches were used during the research:

– a systematic approach that will allow to consider varietal agricultural technologies as a multi-factor regulated system, which has the main regulated criteria and falls under the natural principles of factorial analysis;

– analytical approach, which involves the use of correlation-regression approaches in the evaluation of optimized technology options, forecasting the development of results and evaluation of the average periodic final results;

– activity approach that will allow to consider the developed models of bioorganic technologies in view of the social factor and demography of the territory in dynamics to the specialization of the relevant agricultural formations and ecological and agrochemical condition of the territory;

– information approach, which is based on a reliable and balanced collection of source data, a comprehensive assessment of the real state of affairs, general collection and systematization of the information obtained with regard to the object of study.

This comprehensive approach will identify effective models of biofertilizer, taking into account the cost of compensating for reduced yields for the abandonment of conventional fertilizers and will predict the positive impact on the soil-plant system in the short and long term given soil conservation.

5. Economic efficiency of technological methods of growing legumes

In modern conditions of agriculture, an important requirement for the elements of technology that are developed and implemented in production is to reduce the unit cost, reduce energy costs, and as a result – increase profits. Modern technologies for growing crops should be developed on the principles of saving money, material and energy resources. In addition, they must be competitive in the technology market.

Energy analysis is important in modern agronomic research. This method is widely used in the United States, Canada, Britain, Australia and other developed countries. Energy analysis of technological elements of growing crops allows you to objectively determine their energy intensity and identify ways to reduce energy consumption.

Technological aspects of growing legumes, along with ensuring a higher level of yield and quality of grain should be characterized by economic and energy indicators that would exceed the control, thereby ensuring the competitiveness and profitability of the products grown.

Varieties, bacterial preparations, growth stimulants, mineral nutrition, crop protection system against pests, diseases and weeds, and other factors play a key role in the components of technological methods that determine the indicators of economic and energy efficiency of growing annual legumes for grain.

The application of the latest scientific developments is accelerating and this allows to obtain higher profits, which increases the production of legumes. That is why the question of the effectiveness of scientific research is very important. However, the economic efficiency of the elements of technology for growing new varieties has not been studied enough. Based on this, there is a need to determine the economic efficiency of each studied element of technology in order to identify the most effective of them.

It is established that the studied elements of cultivation technology significantly influenced the indicators of economic efficiency of growing legumes (Table 2).

Table 2

Economic efficiency of cultivation legumes (average for 2016–2020)

№	Culture	Variety	Pre-sowing seed treatment	Retardant concentration,%	Yield, t/ha	Cost, dollars / t	Relatively net profit, dollars / ha	Profitability level, %
1	Sowing peas	Tsarevych	without p.s.t.	without treatment (C)	2,05	75,22	185,75	72
				0,5	2,14	71,42	203,57	78
			Rhyzogumin	0,75	2,53	71,88	214,28	82
				1	2,46	67,85	235,71	91
		Prystan	without p.s.t.	without treatment	2,15	75,17	186,89	72
				0,5	2,25	71,46	203,64	78
			Rhyzogumin	0,75	2,65	71,57	214,28	82
				1	2,54	68,64	235,45	91
2	White lupine	Veresnevyi	without p.s.t.	without treatment (C)	2,74	138,89	402,28	101
				0,5	2,94	133,57	438,92	107
			Rhyzogumin	0,75	3,33	133,78	456,07	108
				1	3,07	138,78	487,85	106
		Chabanskyi	without p.s.t.	without treatment	2,88	141,14	457,85	102
				0,5	3,05	138,77	487,85	106
			Rhyzogumin	0,75	3,44	148,45	558,00	119
				1	3,22	136,46	500,01	109
3	Lupine narrow-leaved	Olimp	without p.s.t.	without treatment (C)	2,04	144,89	375,64	92
				0,5	2,26	146,28	358,50	90
			Rhyzogumin	0,75	2,57	146,64	346,92	90
				1	2,48	152,28	325,85	83
		Peremojets	without p.s.t.	without treatment	2,18	148,23	392,07	88
				0,5	2,35	149,71	374,92	86
			Rhyzogumin	0,75	2,60	151,75	346,21	84
				1	2,52	156,75	352,22	83

(End of Table 2)

№	Culture	Variety	Pre-sowing seed treatment	Retardant concentration,%	Yield, t/ha	Cost, dollars / t	Relatively net profit, dollars / ha	Profitability level, %
4	Chickpeas	Pegas	without p.s.t.	without treatment (C)	2,11	146,74	582,14	111
				0,5	2,45	149,22	667,85	125
			Rhyzogumin	0,75	2,85	152,38	646,42	119
				1	2,74	151,12	632,14	116
		Skarb	without p.s.t.	without treatment	2,25	191,14	594,14	87
				0,5	2,64	166,03	679,52	115
			Rhyzogumin	0,75	3,08	149,35	691,02	139
				1	2,9	118,21	664,54	123
5	Soybean	Holubka	without p.s.t.	without treatment (C)	3,04	187,60	488,46	113
				0,5	3,23	182,46	524,35	119
			Rhyzogumin	0,75	3,42	174,10	610,53	129
				1	3,31	169,60	582,75	135
		Azymut	without p.s.t.	without treatment	3,12	172,14	666,10	132
				0,5	3,43	160,67	670,07	148
			Rhyzogumin	0,75	3,66	157,39	693,89	154
				1	3,55	165,32	638,32	142

Over the years of experimental research, the maximum indicators of grain and fodder productivity in the varieties of the proposed legumes have been determined. The best indicators of economic efficiency, namely the level of profitability – 154% were observed for the technology of growing soybeans of the Azimuth variety, where the bacterial preparation Rhizohumin was used in pre-sowing seed treatment and in combination with retardant treatment (0.75%). The cost and profit were $ 157.39 / t and $ 693.89 / ha, respectively.

Slightly lower indicators of economic efficiency, namely the level of profitability – 139% were observed for the technology of growing chickpeas variety Skarb, where used in pre-sowing seed treatment bacterial drug Rhizohumin and in combination with retardant treatment (0.75%). The cost and profit were $ 149.35 / t and $ 691.02 / ha, respectively.

The lowest indicators of economic efficiency, namely the level of profitability – 72% were observed for the technology of growing peas of the sowing variety Tsarevych, in the control version without treatments. The cost and profit were $ 75.22 / t and $ 185.75 / ha, respectively.

In white lupine Chabanskyi indicators of economic efficiency, namely the level of profitability – 119% was observed for cultivation technology, where the bacterial preparation Rhizohumin was used in pre-sowing seed treatment and in combination with retardant treatment (0.75%). The cost and profit were – 148.45 dollars / ton and 558.00 dollars / ha.

In areas of narrow lupine plant varieties Skarb economic efficiency indicators such as profitability – 84% noted for the cultivation technology, which applied in pre-sowing seed processing Ryzohumin bacterial drug and in combination with processing retardants (0.75%). The cost and profit were – 151.75 dollars / t and 346.21 dollars / ha.

Therefore, 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.

6. Practical value

Improving the efficiency of alternative fertilizer systems for legumes (peas, soybeans, chickpeas, lupines) and their impact on soil fertility, its physicochemical composition and high yields using fertilizers of microbiological and biologically stimulating nature allowed for use in safe and organic cultivation technologies.

In modern agriculture, the cultivation of legumes has become widespread, which are characterized by high productivity, liquidity in the market. However, their cultivation is associated with the use of high rates of mineral fertilizers with an acid reaction to the soil, intensive use of soil pesticides and tillage methods that promote development of erosion processes, creation of a subsoil microbiological condition of a sole, deterioration of physical and chemical indicators of soil because of limited receipt in soil organic residues. Crops such as corn, sunflower, rapeseed and sugar beet create tensions in agrocenoses. At the same time, legumes require low rates of phosphorus-potassium fertilizers, and nitrogen enters them due to the symbiotic activity of microorganisms, a significant number of which remains for subsequent crops. The root system of legumes is well developed and able to withstand drought and well drains the soil and restores its structure and has a positive effect on the soil microbiota.

The development of the principles of alternative fertilizers, green manures, taking into account the change in the structure of sown areas in the direction of intense crops on these principles of legumes will improve the dynamics of physical and chemical parameters of the soil and their physical and mechanical structure.

Based on the obtained research results, their economic analysis and in order to grow high grain yields of legumes at the level of 3.66 t/ha by agricultural formation of the right-bank Forest-Steppe of Ukraine, it is recommended:

– sow intensive soybean variety Azimuth;

– carry out pre-sowing treatment of seeds with bacterial preparation Rhizohumin (600 g per hectare of seeds) and treatment with retardant at a concentration of 0.75% in two terms: the first – in the budding phase, the second – in the phase of grain filling (15 ml / ha).

7. Conclusions

Calculations of the economic efficiency of the experimental variants showed that the cost of growing legumes at prices at the end of 2020 ranged from 72 to 154% depending on the studied variants. However, in all variants of the experiment, soybeans provided a high net profit and high profitability. All economic indicators largely depended on the variety of legumes studied, pre-sowing treatment and retardant concentration. From the economic point of view, it is most expedient to grow soybean of the Azimuth variety with the use of the bacterial preparation Rhizohumin and retardant with a concentration of 0.75% in the pre-sowing treatment of seeds. Although other retartant concentrations had higher economic performance than controls, they were inferior in that the retardant concentration was 0.75%.

References:

1. Albinus M. (2008) Effects of land use practices on livelihoods in the transboundary sub-catchments of the Lake Victoria Basin. *African Journal of Environmental Science and Technology*, vol. 2, no. 10, pp. 309–317.

2. Bandura V., Mazur V., Yaroshenko L., Rubanenko O. (2019) Research on sunflower seeds drying process in a monolayer tray vibration dryer based on infrared radiation. *INMATEN – Agricultural Engineering*, vol. 57, no. 1, pp. 233–242.

3. Bakhmat O.M. (2010) Influence of agrotechnical measures on soybean productivity in the conditions of the western region of Ukraine. Feed and feed production: interdepartmental. topic. science. zb. / [editor: V.F. Petrichenko (ed.) and others]. Vinnytsia: Marushchak A.I., issue 66, pp. 103–108.

4. Begey S.V., Shuvar I.A. (2007) Ecological Agriculture: Textbook. Lviv: Novyi Svit-2000, 429 p.

5. Bransby D.I. Compatibility of switchgrass as an energy crop in farming systems of the southeastern USA. D. I. Bransby, R. Rodriguez-Kabana.

6. Bulgakov V., Adamchuk V., Kaletnik G., Arak M., Olt J. (2014) Mathematical model of vibration digging up of root crops from soil. Agronomy Research, no. 12(1), pp. 41–58.

7. Bulgakov V. et al. (2019) Research of the movement of agricultural aggregates using the methods of the movement stability theory. *Agronomy Research*, 17, 5: 1846–1860. DOI: https://doi.org/10.15159/AR.19.189

8. Bulgakov V., Kaletnik H., Goncharuk I., Ivanovs S., Usenko M. (2019) Results of experimental investigations of a flexible active harrow with loosening teeth. *Agronomy Research*, no. 17(5), pp. 1839–1845.

9. Chinchyk O.S. (2012) Influence of fertilizer on yield of legumes in the conditions of the Western Forest-Steppe. Feed and feed production: interdepartmental. topic. science. zb. NAAS; [editor: V.F. Petrichenko (ed.) and others]. Vinnytsia, vol. 72, pp. 64–67.

10. Cholovskyi Yu.M. (2010) Osoblyvosti vodospozhyvannia posivamy liupynu vuzkolystoho zalezhno vid zastosuvannia mineralnykh dobryv. *Kormy i kormovyrobnytstvo – Forage and feed production*, vol. 66, pp. 146–147.

11. Datta A., Hossain A., Roy S. (2019) An Overview on Biofuels and Their Advantages and Disadvantages. *Asian Journal of Chemistry*, 31(8), 1851–1858. DOI: 10.14233/ajchem.2019.22098

12. Didur I., Bakhmat M., Chynchyk O., Pantsyreva H., Telekalo N., Tkachuk O. (2020) Substantiation of agroecological factors on soybean agrophytocenoses by

analysis of variance of the Right-Bank ForestSteppe in Ukraine. *Ukrainian Journal of Ecology*, no. 10(5), pp. 54–61.

13. Didur I., Pantsyreva H., Telekalo N. (2020) Agroecological rationale of technological methods of growing legumes. *The scientific heritage*, 52, pp. 3–14.

14. Dospekhov B.A. (1985) Metodyka polevoho орыта (s osnovamy statystycheskoi obrabotky rezultatov yssledovanyi). Yzd. 5-e dop. y pererab. Moscow: Ahropromyzdat, 351 p.

15. Environmental Issues of Agriculture. I.D. Prymak, Y.P. Manko, N.M. Ridey et al.; Ed. I.D. Primak. Kyiv: Center of Educational Literature, 2010. 456 p.

16. Egli D.B. (1999) Variation in leaf starch and sink limitations during seed filling in soybean. *Crop Science*, 39, pp. 1361–1368.

17. Environmental Problems of Agriculture: Tutorial: V.P. Gudz, M.F. Rybak, S.P. Tanchyket al.; Ed. V. Gudz. Zhytomyr National Agroecological University Press, 2010. 708 p.

18. Jiang G. H. (1993) Shade induced changes in flower and pod number and fruit abscission in soybean / G. H. Jiang, D. B Egli // *Agronomy Journal*, 85, pp. 221–225.

19. G. A. Esbroeck, M. A. Hussey, M. A. Sanderson. Crop Sci, 1997. No. 37, pp. 864–870.

20. Honcharuk I., Kovalchuk S. (2020) Agricultural Production Greening Management in the Eastern Partnershipcountries with the EU. Theoretical and practical aspects of the development of the European Research Area. Riga, Latvia: Publishing House «Baltija Publishing», pp. 42-68

21. Honcharuk, I. Tomashuk I. (2017) Vplyv ekoloho-ekonomichnoho faktoru na osoblyvosti orhanizatsiino-ekonomichnoho mekhanizmu vykorystannia resursnoho potentsialu silskykh terytorii [Influence of ecological and economic factor on peculiarities of organizational and economic mechanism of utilization of the resource potential of rural territories]. *In Ekonomika. Finansy. Menedzhment: aktualni pytannia nauky i praktyky* [Economy. Finances. Management: topical issues of science and practice], no. 4, pp. 52–62.

22. Honcharuk, I. (2020) Use of wastes of the livestock industry as a possibility for increasing the efficiency of aic and replenishing the energy balance. *Visegrad Journal on Bioeconomy and Sustainable Development*, vol. 9, no. 1, pp. 9–14.

23. Honcharuk I., Kovalchuk S. (2020) Agricultural Production Greening Management in the Eastern Partnershipcountries with the EU. The oretical and practical aspects of the development of the European Research Area: monograph. Riga, Latvia: Publishing House «Baltija Publishing», pp. 42–68.

24. Honcharuk I., Babyna O. (2020) Dominant trends of innovation and investment activities in the development of alternative energy sources. *East European Scientific Journal*, no. 2(54), pp. 6–12.

25. Honcharuk I.V., Branitsky Yu.Yu., Tomashuk I.V. (2017) The main aspects of effective formation and use of resource potential in agricultural enterprises (on the example of Vladovo-Lyulinetska DSS IBK and the Central Bank of NAAS of Ukraine). *Economy. Finances. Management: current issues of science and practice*, no. 10(26), pp. 54–68.

26. Kaletnik G.M., Zabolotnyi, G.M. Kozlovskyi S.V (2011) «Innovative models of strategic management economic potential within contemporary economic systems». *Actual Problems of Economics*, vol. 4(118), pp. 11.

27. Kaletnik G. Honcharuk, I. (2013) Innovatsiine zabezpechennia rozvytku biopalyvnoi haluzi: svitovyi ta vitchyznianyi dosvid [Innovative support for the development of the biofuel industry: world and national experience]. *Biznes Inform* [Business Inform], no. 9, pp. 155–160.

28. Kaletnik G., Honcharuk I., Okhota Yu. (2020) The Waste-Free Production Development for the Energy Autonomy Formation of Ukrainian Agricultural Enterprises. *Journal of Environmental Management and Tourism*, vol. XI, Summer, 3(43): 513–522. DOI:10.14505/jemt.v11.3(43).02

29. Kaletnik G., Honcharuk I., Yemchyk T., Okhota Yu. (2020) The World Experience in the Regulation of the Land Circulation. *European Journal of Sustainable Development*, no. 9(2), pp. 557–568.

30. Kaletnik G., Shubravska O., Ibatullin M., Krysanov D., Starychenko Y., Tkachenko K., Varchenko O. (2019) Features of Food Security of the Country in Conditions of Economic Instability. Int. J. Manag. Bus. Res, 9(4): 176–186.

31. Kaletnik G. (2018) Production and use of biofuels: Second edition, supplemented: textbook. Vinnytsia: LLC «Nilan-Ltd», 336 p.

32. Kaletnik G., Pryshliak N. (2019) Bioenergy potential development of the agrarian sector as a component of sustainable development of Ukraine. Management mechanisms and development strategies of economic entities in conditions of institutional transformations of the global environment: collective monograph / edited by M. Bezpartochnyi, in 2 vol. / ISMA University. Riga: «Landmark» SIA, vol. 1, pp. 96–104.

33. Kaletnik G. (2018) Diversification of production of biofuel – as the basis of maintenance of food, power, economic and environmental safety of Ukraine. [Diversification of production of biofuel – as the basis of maintenance of food, power, economic and environmental safety of Ukraine]. *Visnyk ahrarnoi nauky – Bulletin of agrarian science*, 11, 169–176. Retrieved from: http://agrovisnyk.com/pdf/en_2018_11_21. pdf (in English)

34. Kaletnik, G., & Lutkovska, S. (2020) Innovative Environmental Strategy for Sustainable Development. *European Journal of Sustainable Development*, 9(2), 89. https://doi.org/10.14207/ejsd.2020.v9n2p89

35. Kaletnik G., Honcharuk I., Okhota Yu. (2020) The Waste-Free Production Development for the Energy Autonomy Formation of Ukrainian Agricultural Enterprises. *Journal of Environmental Management and Tourism,* vol. XI, Summer, 3(43): 513–522. DOI: 10.14505/jemt.v11.3(43).02

36. Kaletnik G.M., Yanovych V.P. (2017) Substantiation of operating and design parameters of a gyration mill for the production of highly active premixes, Vibrations in engineering and technology, 84, no. 1, pp. 15–21.

37. H. Kaletnik, V. Mazur, I. Gunko, V. Ryaboshapka, V. Bulgakov, V. Raide, R. Ilves and J. Olt (2020) Study on performance of compression engine operated by biodiesel fuel. *Agronomy Research,* 18(X). DOI: https://doi.org/10.15159/AR.20.027

38. Kantolic A. G. (2007) Development and seed number in indeterminate soybean as affected by timing and duration of exposure to long photoperiods after flovering. *Annals of Botany*, 99, pp. 925–933.

39. Kosse V., Mathew J. (2017) Design of hammer mills for optimum performance. Proceeding of the Institution of Mechanical Engineers, no. 215, pp. 87–94.

40. Kupchuk I.M., Solona O.V., Derevenko I.A., Tverdokhlib I.V. (2018) Verification of the mathematical model of the energy consumption drive for vibrating disc crusher, Inmateh – Agricultural Engineering, 55, no. 2, pp. 111–118.

41. Kukharchuk V.V., Kazyv S.S., Bykovsky S.A. (2017) Discrete wavelet transformation in spectral analysis of vibration processes at hydropower units, Przeglad Elektrotechniczny, 93, no. 5, pp. 65–68.

42. Li J., Wang E., Chen W., Chen X. (2008) "Genetic diversity and potential for promotion of plant growth detected in nodule endophytic bacteria of soybean grown in Heilongjiang province of China. *Soil Biology & Biochemistry*, vol. 40, pp. 238–246.

43. Mazur V., Didur I., Myalkovsky R., Pantsyreva H., Telekalo N., Tkach O. (2020) The productivity of intensive pea varieties depending on the seeds treatment and foliar fertilizing under conditions of right-bank forest-steppe Ukraine. *Ukrainian Journal of Ecology*, no. 10(1), pp. 101–105.

44. Mazur V.A., Didur I.M., Pantsyreva H.V., Telekalo N.V. (2018) Energy-economic efficiency of growth of grain-crop cultures in conditions of Right-Bank Forest-Steppe of Ukraine. *Ukrainian Journal of Ecology*, no. 8(4), pp. 26–33.

45. Mazur V.A., Mazur K.V., Pantsyreva H.V. (2019) Influence of the technological aspects growing on quality composition of seed white lupine (Lupinus albus L.) in the Forest Steppe of Ukraine. *Ukrainian Journal of Ecology*, vol. 9, pp. 50–55. Retrieved from: https://www.ujecology.com/archive.html

46. Mazur V.A., Mazur K.V., Pantsyreva H.V., Alekseev O.O. (2018) Ecological and economic evaluation of varietal resources Lupinus albus L. in Ukraine. *Ukrainian Journal of Ecology*, vol. 8, pp. 148–153.

47. Mazur V.A., Pantsyreva H.V. (2020) «Rid Lupinus L. v Ukraini: henofond, introduktsiia, napriamy doslidzhen ta perspektyvy vykorystannia». *VNAU*, p. 235.

48. Mazur V.A., Pantsyreva H.V., Didur I.M., Prokopchuk V.M. (2018) Liupyn bilyi. Henetychnyi potentsial ta yoho realizatsiia u silskohospodarske vyrobnytstvo. *VNAU,* p. 231.

49. Mazur V.A., Pantsyreva H.V., Mazur K.V., Didur I.M. (2019) Influence of the assimilation apparatus and productivity of white lupine plants. *Agronomy Research,* 17(X), 206–209. DOI: https://doi.org/10.15159/AR.19.024

50. Mazur V.A., Pantsyreva H.V., Mazur K.V., Didur I.M. (2019) Influence of the assimilation apparatus and productivity of white lupine plants. *Agronomy Research*,17(X), 206–209. DOI: https://doi.org/10.15159/AR.19.024

51. Mazur V.A., Pantsyreva H.V., Mazur K.V., Myalkovsky R.O., Alekseev O.O. (2020) Agroecological prospects of using corn hybrids for biogas production. *Agronomy Research,* 18(1), 177–182.

52. Mazur, V. A., & Pantsyreva, H. V. (2017) Vplyv tekhnolohichnykh pryiomiv vyroshchuvannia na urozhainist i yakist zerna liupynu biloho v umovakh Pravoberezhnoho Lisostepu. *Silske hospodarstvo i lisivnytstvo*, 7, 27–36.

53. Mazur, V. A., Myalkovsky, R.O., Mazur, K. V., Pantsyreva, H. V., Alekseev, O.O. (2019) Influence of the Photosynthetic Productivity and Seed Productivity of White Lupine Plants. *Ukrainian Journal of Ecology*, 9(4), 665–670.

54. Mazur, V.A., Branitskyi, Y.Y., Pantsyreva, H.V. (2020) Bioenergy and economic efficiency technological methods growing of switchgrass. *Ukrainian Journal of Ecology*, 10(2), 8–15.

55. Mazur, V.A., Didur, I.M., Pantsyreva, H.V., & Telekalo, N.V. (2018) Energy-economic efficiency of grain-crop cultures in the conditions of the right-bank Forest-Steppe of Ukraine. *Ukrainian J Ecol*, 8(4), 26–33.

56. Mazur, V.A., Mazur, K.V., Pantsyreva, H.V., Alekseev, O.O. (2018) Ecological and economic evaluation of varietal resources Lupinus albus L. in Ukraine. *Ukrainian Journal of Ecology*, 8(4), 148–153.

57. Mazur, V.A., Pantsyreva, H.V., Mazur, K.V. & Didur, I.M. (2019) Influence of the assimilation apparatus and productivity of white lupine plants. *Agronomy research*, 17(1), 206–219.

58. Melnychuk, T., Patyka, V. (2011) Microbial preparations bioorganic farming system. Collected articles "Third All-Ukrainian Congress of Ecologists with international participation". Vinnytsya, tom 2, 423–426.

59. Metodologiya i praktyka vykorystannya mikrobnyx preparativ u texnologiyax vyroshhuvannya silskogospodarskyx kultur [Methodology and practice of microbial drugs use in crop growing technologies] / V. V. Volkogon, A. S. Zaryshnyak, I. V. Grynyk ta in. (2011). Kyiv: Agrarna nauka, 153.

60. Mohamed Z., El-Sayed S., Radwan T., El-Wahab G. (2009) "Potency evaluation of Serratiamarcescens and Pseudomonas fluorescens as biocontrol agents for root-knot nematodes in Egypt". *Journal of Applied Sciences Research*, vol. 4, no. 1, pp. 93–102.

61. Monarkh Veronika Valentynivna, Pantsyreva Hanna Vitaliivna (2019) Stages of the Environmental Risk Assessment. *Ukrainian Journal of Ecology*, 9(4), 484–492. DOI: 10.15421/2019_779

62. Muir J. P. (2001) Biomass production of Alamo switchgrass in response to nitrogen, phosphorus, and row spacing. J. P. Muir, M. A. Sanderson, W. R. Ocumpaugh at all. Agron J., no. 93, pp. 896–901.

63. Mohammad, N. K., & Mohammad, F. (2013) Effect of GA3, N and P ameliorate growth, seed and fibre yield by enhancing photosynthetic capacity and carbonic anhydrase activity of linseed. *Integrative Agriculture*, 12(7), 1183–1194.

64. Muhammad, I., & Muhammad, A. (2013) Gibberellic acid mediated induction of salt tolerance in wheat plants: Growth, ionic partitioning, photosynthesis, yield and hormonal homeostasis. *Environmental and Experimental Botany*, 86, 76–85.

65. Naum Raichesberg (2000) Adolphe Quetelet, His Life and Research Activities. Moscow: Elibron Classics, 98 p.

66. Osoro N., Kawaka F., Naluyange V. (2014) "Effects of water hyacinth (Eichhornia crassipes [mart.] solms) compost on growth and yield of common beans (Phaseolus vulgaris) in Lake Victoria Basin». *European International Journal of Science and Technology*, vol. 3, no. 7, pp. 173–186.

67. Ovcharuk V.I., Mulyarchuk O.I., Myalkovsky R.O., Bezvikonnyi P.V., Kravchenko V.S., Klymoych N.M. (2019) Parameters of beet plants. *Bulletin of the Uman National University of Horticulture*, no. 1, pp. 70–75.

68. Palamarchuk V., Honcharuk I., Honcharuk T., Telekalo N. (2018) Effect of the elements of corn cultivation the technology on bioethanol production under conditions of the rightbank forest-steppe of Ukraine. *Ukrainian Journal of Ecology*, vol. 8(3), pp. 47–53.

69. Palamarchuk, V. & Telekalo, N. (2018) The effect of seed size and seeding depth on the components of maize yield structure. *Bulgarian Journal of Agricultural Science*, 24(5), pp. 785–792.

70. Palamarchuk, V., Telekalo, N. (2018) The effect of seed size and seeding depth on the components of maize yield structure. *Bulgarian Journal of Agricultural Science*, 24(5), pp. 785–792.

71. Pantsyreva H.V. (2018) Research on varietal resources of herbaceous species of Paeonia L. in Ukraine. *Scientific Bulletin of the NLTU of Ukraine*, 28(8), 74–78. DOI: https://doi.org/10.15421/40280815

72. Pantsyreva H.V., Myalkovsky R.O., Yasinetska I.A., Prokopchuk V.M. (2020) Productivity and economical appraisal of growing raspberry according to substrate for mulching under the conditions of podilia area in Ukraine. *Ukrainian Journal of Ecology*, vol. 10(1), pp. 210–214.

73. Pantsyreva, H.V. (2019) Morphological and ecological-biological evaluation of the decorative species of the genus Lupinus L. *Ukrainian Journal of Ecology*, 9(3), 74–77.

74. Pantsyreva H.V. (2019) Technological aspects of biogas production from organic raw materials. *Bulletin of KhNTUSG them. P. Vasilenko*. Kharkiv, pp. 276–290.

75. Pantsyreva, H. V., Mykoliuk, O. O., & Semchuk, V. V. (2019) Suchasnyi stan kolektsii pivonii na bazi botanichnoho sadu «Podillia» Vinnytskoho natsionalnoho ahrarnoho universytetu. *Scientific Bulletin of UNFU*, 29(8), 46–50. DOI: https://doi.org/10.36930/40290806

76. Pruvot E.B., Claeys-Kulik A.L., Estermann T. (2015) Designing strategies for efficient funding of universities in Europe. DEFINE Project Paper. Brussels: European University Association, pp. 20-22.

77. Puyu V. L. (2014) Modern Design of Cultivated Pastures in the Western Forest Steppe. Seminar Program of Uman NUS "Varietal Technologies as a Factor in the Implementation of Agrocenoses Biopotentials in the Programming System of Field and Forage Crops Yield". Uman, 15-16 May 2014.

78. Puyu V. L., Bakhmat M. I., Rykhlivskyi I. P., Shcherbatiuk N. V. (2019) Optimization of Conveyor Production of Green Fodder. *World Science*, no. 7(47), vol. 1. DOI: 10.31435/rsglobal_ws/31072019/6587

79. Rai R. K., Tripathi N., Gautam D., & Singh P. (2017) Exogenous application of ethrel and gibberellic acid stimulates physiological growth of late planted sugarcane with short growth period in subtropical India. *Journal of Plant Growth Regulation*, 36(2), 472–486.

80. S. E. Sladden (1993) Biomass Conf. of the Americas. Burlington, pp. 229–234.

81. Razanov S.F. Tkachuk O.P., Mazur V.A., Didur I.M. (2018) Effect of bean perennial plants growing on soil heavy metal concentrations. *Ukrainian Journal of Ecology*, 8(2). 294–300 DOI: 10.15421/2018_341

82. Razanov S.F., Tkachuk O.P., Bakhmat O.M., Razanova A.M. (2020) Reducing danger of heavy metals accumulation in winter wheat grain which is grown after leguminous perennial precursor. *Ukrainian Journal of Ecology*, 10(1), 254–260. DOI: 10.15421/2020_40.

Razanov S.F., Tkachuk O.P., Razanova A.M., Bakhmat M.I., Bakhmat O.M. (2020) Intensity of heavy metal accumulation in plants of Silybum marianum L. in conditions of field rotation. *Ukrainian Journal of Ecology*, 10(2), 131–136. DOI: 10.15421/2020_75

83. Rohach V.V., Rohach T.I., Kylivnyk A.M., Polyvanyi S.V., Bayurko N.V., Nikitchenko L.O., Tkachuk O.O, Shevchuk O.A., Hudzevych L.S., Levchuk N.V. (2020) The influence of synthetic growth promoters on morphophysiological characteristics and biological productivity of potato culture. *Modern Phytomorphology,* 14, 111–114.

84. Solona O., Kupchuk I. (2020) Dynamic synchronization of vibration exciters of the three-mass vibration mill. *Przeglad Elektrotechniczny*, 96(3), 161–165. DOI: 10.15199/48.2020.03.35

85. Telekalo N.V. (2016) Economic evaluation of the efficiency of pea growing technology. *Collection of scientific works of VNAU "Agriculture and forestry"*, 4, pp. 63–71.

86. Varchenko O., Krysanov D., Shubravska O., Khakhula L., Gavryk O., Byba V., Honcharuk I. (2020) Supply Chain Strategy in Modernization of State Support Instruments for Small Farms in Ukraine. *International Journal of Supply Chain Management*, vol. 9, no. 1, pp. 536–543. Retrieved from: https://ojs.excelingtech.co.uk/index.php/IJSCM/article/view/4326

87. Vdovenko S.A., Prokopchuk V.M., Palamarchuk I.I., Pantsyreva H.V. (2018) Effectiveness of the application of soil milling in the growing of the squash (Cucurbita pepo var. giraumontia) in the right-benk forest stepp of Ukraine. *Ukrainian Journal of Ecology*, 8(4), 1–8.

88. Vdovenko, S.A., Pantsyreva, G.V., Palamarchuk, I.I., & Lytvyniuk, H.V. (2018) Symbiotic potential of snap beans (Phaseolus vulgaris L.) depending on biological products in agrocoenosis of the right-bank forest-steppe of Ukraine. *Ukrainian J Ecol,* 8(3), 270–274.

89. Vitalii Palamarchuk, Inna Honcharuk, Tetiana Honcharuk, Natalia Telekalo (2018) Effect of the elements of corn cultivation technology on bioethanol production under conditions of the right- bank forest-steppe of Ukraine. *Ukrainian Journal of Ecology*, no. 8(3), pp. 47–53.

90. Wolters D., Beste A. (2000) Biomasse – umweltfreundlicher Energieträger? Ökologie und Landbau.116, 4, s. 12–14.

91. Yanovych, V., Honcharuk, T., Honcharuk, I. & Kovalova, K. (2017) Design of the system to control a vibratory machine for mixing loose materials. *Eastern-European Journal of Enterprise Technologies*, 6(3-90), 4–13.

92. Yanovych, V., Honcharuk, T., Honcharuk, I. & Kovalova, K. (2018) Engineering management of vibrating machines for targeted mechanical activation of premix components. *INMATEH - Agricultural Engineering*, 54(1), 25–32.

93. Yanovych V., Kupchuk I. (2017) Determination of rational operating parameters for a vibrating disk-type grinder used in ethanol industry, *Inmateh – Agricultural Engineering*, 52, no. 2, pp. 143–148

94. Yhurber J.A. (1958) Inhibitory effect of gibberellins on nodulation in dwarf beans, Phaseolus vulgaris. *Nature*, vol. 181, pp. 1082–1083.

95. Yowling W.A., Buirchell B.J., Tarta M.E. Lupin. Lupinus L. (1998) Promoting the conservation and use of underutilized and neglected crops 23. Institute of Plant lyenetis and crop Plant Research, yatersleben. International Plant lyenetic Resources Institute. Rome, pp. 112–114.

96. Zhao, H., Cao, H., Ming-Zhen, P., Sun, Y., & Liu, T. (2017) The role of plant growth regulators in a plant aphid parasitoid tritrophic system. *Journal of Plant Growth Regulation*, 36(4), 868–876.

97. O.A. Shevchuk, O.O. Tkachuk, V.G. Kuryata, O.O. Khodanitska, S.V. Polyvanyi (2019) Features of leaf photosynthetic apparatus of sugar beet under retardants treatment. *Ukrainian Journal of Ecology*, 9(1), pp. 115–120.

98. O.O. Khodanitska, V.G. Kuryata, O.A. Shevchuk, O.O. Tkachuk, I.V. Poprotska (2019) Effect of treptolem on morphogenesis and productivity of lin seed plants. *Ukrainian Journal of Ecology*, 9(2), 9–126.

LEGUMES ARE A STRATEGIC FACTOR IN REGULATING PROTEIN BALANCE AND SOIL FERTILITY

Victor Mazur[1]
Ihor Didur[2]

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Abstract. The monograph is aimed at solving current problems that guarantee food security of the state as the potential of Ukraine and intensive development of various options of new technologies, which will be provided through the development and implementation of the latest bioorganic model of varietal technology of legumes, taking into account climatic changes. on the basis of organic farming. From these positions, the studies are systemic in nature and focused on the long term in the format of natural factors of symbiotic nitrogen fixation and active stabilization of humification processes by reducing the rate of dominant processes of mineralization of the organic part of soils. Implementation of environmentally friendly direction will involve the development of measures for efficient waste management, rational use of biological resources by increasing the area and volume of grown cereals, as well as improving cultivation technologies, use of new varieties and hybrids of crops and land reclamation, taking into account the concepts of rational nature aimed at optimizing land use, biologization of agriculture. The implementation of the proposed measures is aimed at increasing the level of realization of the yielding varietal potential of the main legumes, increasing the profitability of their production in combination with environmental and social effects, ensuring reduction of soil degradation processes in Ukraine.

1. Introduction

An urgent problem for Ukraine is the development of alternative farming systems in the direction of developing new organic technologies for growing

[1] Candidate of Agricultural Sciences, Professor, Rector of Vinnytsia National Agrarian University, Ukraine
[2] Candidate of Agricultural Sciences, Associate Professor, Vinnytsia National Agrarian University, Ukraine

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.

The monograph has a complex multidisciplinary and systemic nature in the combination of adaptive farming systems and adaptive fertilizer systems given the current trends of climate change in the context of: 1) implementation of the national program «Grain of Ukraine», which provides for 80 million tons of grain annually; 2) creation of effective mechanisms to increase soil fertility based on the accumulation of atmospheric nitrogen and the accumulation of organic matter in order to enhance the processes of humification; 3) providing a qualitatively new feed base to improve the conversion of high-protein feed into livestock products.

The subject of research is a set of theoretical, methodological and practical factors for the development of bioorganic components of varietal technology for growing legumes on the factors of preserving soil conditions of soil fertility, taking into account changes in climatic factors and changes in the spectrum of crop production.

The monograph is a significant contribution to solving current issues of promising strategic direction of development of the agro-industrial complex of Ukraine. Scientific work is aimed at achieving a comprehensive effect in ensuring sustainable agro-industrial production while guaranteeing the necessary levels of food and bioenergy security of the state while preserving and reproducing soil fertility potential and improving living conditions and public health by increasing access to production and consumption of organic agricultural products.

The monograph presents a competitive bioorganic varietal technology for growing legumes, which provides for the development of regulations for the use of a set of alternative fertilizers for their cultivation in terms of short-term and long-term action and the basic superstructure of factor assessment of soil fertility, ecological conditions.

The scientific novelty of the obtained results is presented by an innovative method of assessing the bioadequate productivity of arable land to determine the possibility of adaptation of the enterprise to bioorganic technologies for growing legumes; 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 this group of crops; developed 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. Scientific researches of the team of authors are directed on the decision of actual problems of technological updating and development of an agro-industrial complex on the basis of development of bioorganic models of varietal technology of cultivation of legumes.

As part of joint research work of Vinnytsia National Agrarian University and the Institute of Bioenergy Crops and Sugar Beets of the National Academy of Agrarian Sciences of Ukraine, the authors of the monograph – Victor Mazur, Ihor Didur and Hanna Pantsyreva are executors 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» (Mazur V., Didur I., Ivanina V., Tkachuk O., Pantsyreva H., Vradiy O.), state registration number 0120U102034. According to the results of the applied research, which is carried out at the expense of the state budget, it is envisaged to scientifically substantiate the agro-ecological aspects of technological methods of growing legumes, which are covered in the submitted monograph. The data presented in the monograph are the result of joint research work between ESIC «Ukrainian scientific-educational consortium» and Vinnytsia National Agrarian University, confirmed by the implementation of economic contract «Development of a control system for C-carbon and N-nitrogen and their impact on the operation of biogas plants running on multicomponent raw materials» (state registration number 0118U100523).

The scientific and methodological value of the monograph lies in the presentation of the results of research conducted on the basis of the Research Farm «Agronomic» Vinnytsia National Agrarian University, the village of Agronomiche, Vinnytsia district, Vinnytsia region. Scientific substantiation of technological methods of growing 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 monograph is a significant contribution to solving the problems of increasing the level of realization of the yielding varietal potential of legumes, increasing the profitability of their production in combination with environmental and social effects. The peer-reviewed 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, as well as on the synthesis of different concepts of domestic and world practice. This, according to the authors of the study, allows us to approach the understanding of a complex, multifaceted and holistic assessment of technological methods of growing legumes.

2. Analysis of recent research and publications

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. (2016), Shevchenko M. (2016). 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 Petrychenko V. (2014), Chynchyk O. (2019), Kalenska S. (2015), Cherenkov A. (2016), Bakhmat O. (2018), Pantsyreva H. (2017). Studies of the effectiveness of biofertilizers and biostimulants have been actively conducted in Ukraine since the 1990s. These issues have been fruitfully discussed over the past 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), Dubovyka D. (2016), Sokol S. (2016), Koltunova V. (2018) and others. Implementation of bioorganic methods of cultivation have dedicated their works Petrychenko V. (2018), Mazur V. (2017), Patyka V. (2015), Babych O. (2017), Kolisnyk S. (2015); Shevnikov M. (2019), Kots S. (2016), Kaminsky V. (2017), Bakhmat O. (2018), Sherstoboeva O. (2016), Elsheikh E. (2016), Tagore G. (2016), Mishra A. (2016) and others. In the works of Dubovyk D. (2016) highlights the results of studying the impact of individual biological products of microbial nature on the formation of yield and quality of legumes. Similar studies on cereals and industrial crops are given in the works of Sokola S. (2016), Koltunova V. (2018) and others. Some aspects of biological fertilizer for soybeans were published in the studies of Grigorieva O. (2014), Hungry A. (2015). General recommendations for the use of biofertilizers and biostimulants by groups of crops are reflected in the work of Volkogon V. (2015). Among foreign scientists, the generalization of the results of studying the effectiveness of biofertilizers of various origins was carried out in the works of J.D.S. Panwar (2016), H. Panda (2017), on some crops – soybeans and corn – M.A. Laditi1, O.C. Nwoke, M. Jemo, R.C. Abaidoo, A.A. Ogunjobi (2015), D. Matthew (2017).

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. According to the authors of the monograph, the expected scientific solutions, namely technological modernization of agriculture, the involvement of artificial means of regulating plant productivity, significant climate change, it is important to determine through innovative landmarks in land use, crop area, fertilizers and organic residues legislative consolidation of scientifically substantiated positions.

3. Literature review

In the period of development of European integration and globalization of the domestic economy, the production of legumes requires a flexible approach to international competition, ensuring solutions to food and environmental security. Legumes play an important role in the grain and fodder balance of agricultural formations in Ukraine. Of all crops, legumes contain the most protein. Their grain and green mass in terms of protein content exceeds cereals more than twice, in terms of amino acid composition their proteins are much better digested, give the cheapest protein, include in the biological cycle nitrogen air, which is not available for other crops. Today, vegetable protein is highly valued in the food and feed industry.

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 animal husbandry with high-protein feed; creation of additional jobs; increase in tax revenues; ensuring food and environmental security of Ukraine.

In Ukraine and the world there are problems with soil fertility, which results in a gradual reduction of soils with a high content of humus, as well as phosphorus and potassium. At the same time, the areas of soils with a low level of supply of these substances are increasing. According to rough estimates, since the beginning of Ukraine's independence, the total area of nutrient-depleted soils is hundreds of thousands of hectares. Against this background, the total area of legumes in Ukraine has more than halved, and in the global dimension by 25-32%. Due to this, in the opinion of scientists, soils do not receive more than a third of the potentially possible symbiotically fixed nitrogen. For these reasons, the problem of oversaturation with industrial and grain crops, in particular wheat and corn, is acute. This creates the danger of intensive monocultural production, which in the end is a real threat to both Ukraine and the world in terms of food security.

The authors' developments are aimed at solving a defined range of problems by adapting existing technologies to the dominant global trends in fertilizers, the range of bioorganic drugs, trends in the intensive formation of the market for organic products.

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. For this purpose it is necessary to focus on creating high-yielding varieties with clarification of 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. The oil and fat subcomplex of our state on the way to European integration needs to be modernized. In addition, in the context of climate change, it will be necessary to form a common agricultural policy for the production of high-protein crops with the EU. 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 resources, increasing soil fertility and strengthening the economy of Ukraine.

The working hypothesis of the research is based on an effective system of gradual effective replacement of classical agrochemicals with complex bioorganic chelate complexes capable of efficiently and point-by-point regulation of physiological processes of the plant organism. In the case of legumes, this will not only significantly reduce the agrochemical load on the soil cover, but also contribute to the gradual restoration of soil fertility by increasing the area under legumes and attracting biologically fixed nitrogen. As a result, it will contribute to the ecological and economic stabilization of agricultural areas and will form sustainable adaptive agricultural landscapes with projected levels of yield and production volumes.

The unstable situation in general in the domestic economy and its agricultural sector leads to the production of insufficient amounts of mineral fertilizers. Ukraine's dependence on their imports is growing, and after the recent devaluation of the hryvnia for domestic farmers, this product is becoming more expensive. According to the results of 2019, we are among the twenty countries with the largest volumes of fertilizer imports. At the same time, the issue of preserving and restoring soil fertility is acute, because the maximum efficiency of agricultural production can be ensured only through the rational use of the environment, scientifically sound application of fertilizers and the use of crop by-products. As a result of agricultural production, the structure was disrupted and the typical properties of Ukrainian chernozems changed.

In recent years, low levels of application of organic and mineral fertilizers for crops have been recorded in Ukraine. Thus, in 2019, 0.5 t/ha of organic fertilizers were applied, this figure remains virtually unchanged. And mineral fertilizers last year were applied in the amount of 96 kg/ha, their use tends to gradually increase.

At the same time, it is noted that the issue of soil quality and fertility has become very acute today, because these resources are not limitless. Intensive farming technologies, which have been widely used by farmers in recent decades, have led to a significant reduction in soil fertility, deterioration of their condition and basic properties. Therefore, the moment has come when it is necessary to change the principles of management. One of the main tasks of organic farming is to improve the condition of soils. It is noted that the planning of crop rotations for 5-7 years ahead with the mandatory inclusion of 30% of legumes. Planning crop rotations for such a long period can be a difficult task, because there are certain market needs that farmers want to track and take into account. However, it is necessary to learn to work with long-term planning to get good yields of legumes, and the need for adapted, modern technologies for growing crops such as chickpeas, lentils, rank, lupines is extremely acute, especially given current trends in fertilizers and alternative minimized tillage systems.

It should not be forgotten that the intensive chemicalization of the crop sector of agriculture in Ukraine is manifested primarily in the use of high rates of mineral fertilizers and repeated use of pesticides. This contributes to a significant increase in the yield of major crops. But at the same time, mineral fertilizers, especially nitrogen, cause mineralization of humus and acidification of the soil solution. Therefore, to further maintain existing crop levels, it is necessary to increase the rates of mineral fertilizers. In order to preserve and increase soil fertility, as well as increase their agroecological resistance to adverse anthropogenic factors, it is necessary to accumulate organic matter in the soil. Due to the sharp decline in livestock in Ukrainian farms, it is almost impossible to solve this problem by applying manure. Therefore, it is necessary to find ways to restore and maintain the optimal level of soil fertility through alternative ways of accumulating organic matter in the soil. One of the main resources and a promising direction in solving this problem may be the cultivation of legumes.

Legumes in crop rotation are one of the factors that can be used to stabilize the processes occurring in the soil-plant-animal-human system. The large phytomeliorative role of legumes on arable land, the optimal ratio of plowed land, hayfields and pastures will eliminate the destructive processes occurring in agricultural landscapes, reduce erosion and increase soil fertility and crop yields.

Today in Ukraine and the world promising competitive adaptive technologies for growing legumes based on the characteristics of growth, development and yield formation with a comprehensive study and differentiated combination in the technological process of basic elements: varieties, fertilizers, tillage, crop protection from weeds , pests and diseases, as well as studies their biologized models, involving the introduction of low doses of mineral fertilizers in combination with by-products (non-commercial) products of predecessors. These technologies make it possible to obtain a yield of peas – 3.5-4.0, white lupine – 3.2-3.5, yellow lupine – 2.0-2.2, narrow-leaved lupine – 3.0-3.2, beans – 2.5-2.8 t/ha. However, the weak point of such technologies is the binding to specific types of soils, unidirectional application of classical mineral fertilizers, focus on the standard format of microfertilizers, lack of tactics of concomitant control over changes in soil fertility, conflicting data on the effectiveness of such technologies for tillage and exposure to stressors. As a result, the efficiency of the real realization of the yield potential of the outlined range of legumes by 30-55%, and for a number of promising valuable legumes chickpeas, lentils – up to 60-68%. Such aspects confirm the relevance, innovation and production significance of the objectives and its national research and production relevance for the agro-industrial complex of Ukraine and world agricultural practice.

4. Conditions, objective and methods of research

Field experiments were conducted during 2016–2020 on the basis of the Research Farm «Agronomiche» of Vinnytsia National Agrarian University in the village of Agronomichne of Vinnytsia district of Vinnytsia region.

Based on the data of the Vinnytsia Regional Center for Hydrometeorology, hydrothermal conditions were assessed. The climate of the Forest-Steppe zone is temperate-continental. The average annual air temperature is at 13.1 °C. The absolute minimum and maximum temperature are 36.0 °C, respectively. The number of days and the height of snow cover, respectively, are in the range of 70-110 days and 20-60 cm. The amount of precipitation varies from 125 to 369 mm per year and falls mainly in the summer-autumn period.The soil cover is represented by gray forest soils. Depth of humus-eluvial horizon up to 30 cm, gray. According to the soil survey of the Vinnytsia Regional State Design and Technology Center for Soil Protection and Product Quality «Regional State Fertility» it is noted that the soils of the study area are characterized by low humus content – 1.97%. Agrochemical characteristics of gray forest soils are given in table 1.

Growing technology is generally accepted for the Forest-Steppe zone of Ukraine, except for the envisaged technological methods of cultivation. The research included the study of the action and interaction of 3 factors: A – grade; B – pre-sowing treatment of seeds with a bacterial preparation; C – is the concentration of the retardant.

On the day of sowing legume seeds were treated with the bacterial drug Rhizohumin (600 g per hectare of seeds). During the growing season of sown peas, soybeans, white lupins and narrow-leaved lupins (budding phase) on the variants of experiments according to the scheme used a

Table 1

Agrochemical characteristics of the soil of the experimental field (according to «Regional State Fertility»)

Depth of sampling, cm	Humus content,%	pH salt	Hydrolytic acidity, mg.-eq. per 100 g of soil	The amount of absorbed bases, mg.-eq. per 100 g of soil	The degree of saturation of the bases,%
0 – 20	1,97	5,1	3,44	14,38	86
30 – 40	1,39	4,9	3,48	14,06	88
65 – 75	0,66	4,6	3,45	13,10	86
95 – 105	not specified	4,4	3,32	13,63	85
125 – 135	not specified	4,4	3,37	13,49	88

retardant – chlormequat chloride, v.r. (750 g/l) f. BASF CE, Germany, in different concentrations (working solution rate 200 l/ha), which belongs to the group of Quaternary ammonium compounds.

During 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.

During the scientific experiment, the following approaches were used: a) system approach, which will allow to consider ecologically safe agrotechnologies as a multicomponent system based on the principles of energy saving with the achievement of economic effect; b) analytical approach, which involves the use of correlation regression approaches in the assessment of models of transition to bioorganic tillage technologies in terms of classical, surface and minimized schemes; c) activity approach that will allow to carry out production inspection of the developed models of agrotechnologies; d) information approach, which provides for information and consulting practice with the involvement of a network of agricultural formations of various forms of ownership in order to implement reliable source data and systematize the information obtained. This integrated approach will separate and implement unified models of agrobiological and ecological-economic assessment of efficient production of high-protein crops in terms of resource conservation, restoration of soil fertility and stable microbiological condition in climate change. Within the framework of the proposed research model, it is planned to use both traditional and new tested methods. The new ones include:

– determination of the factor influence of bioorganic fertilizer variants on the growth and physiological processes of plants based on the analysis of phytosynthetic activity and induction indicators of chlorophyll;

– conducting modular and vitality studies using regression-correlation models of the formation of legume yields for different variants of biological systems for their cultivation;

– application of non-traditional approaches to phytoindication of soil fertility conditions and appropriate fertilizer levels in order to find the optimal ratio between the preservation of optimized soil processes and the appropriate economically feasible levels of their yield;

– assessment of stress-regulating levels of developed technologies by studying the peculiarities of plasticity and yield stability of basic legumes at different levels of bioorganic fertilizer systems based on criteria such as asymbatics of plant morphotypes, idiotypic structure of agrophytocenosis, modular and morphological aspects of productivity formation;

– analysis of growth curves, application of mathematical modeling and forecasting methods based on computer modeling system;

– systematic concomitant approach in the study of soil fertility parameters for different technologies used for growing legumes and the creation of soil-plant models in search of the optimal model for growing legumes according to the principles of ecological and economic feasibility;

– determination of parameters of organic matter content, absorption capacity, content of mobile forms of basic nutrients, biological potential of soil, optimized parameters of physical properties of soil, etc.

Objectives of the study:

1) to develop a competitive bioorganic varietal technology for growing legumes with the achievement of economic effect from the introduction of energy-intensive resources;

2) to form effective regulations for the use of different types of biofertilizers for the growing season according to their different types in the system of agrotechnologies for growing legumes;

3) to develop optimized and adapted systems of application of bioorganic agrochemicals in the system of soil use on the basis of mobilization agrochemical approaches (taking into account the soil fertility potential and the system of microbiological and chemical transformations in the soil-plant system);

4) to develop and implement stage models of transition to bioorganic technologies of tillage in the context of classical, surface and minimized schemes.

As a result of research, it is expected to develop effective new technological regulations for growing legumes on the basis of partial and complete biologization, taking into account soil fertility conditions and climatic resource potential of the region. It is planned to develop models of such technologies on the basis of correlation-regression estimates and simulation factor modeling taking into account modern technological trends of tillage: classical system, differentiated and surface systems. The effective implementation of the results of the developed technologies and their scientific zonal testing is expected.

It is planned to introduce unified models of agrobiological and ecological-economic assessment of efficient production of high-protein crops in view of resource conservation, restoration of soil fertility and stable microbiological condition in the conditions of climate change. Theoretical and practical data of the monograph will be useful in the formation of the Concept of the State target program for the development of the agricultural sector for the period up to 2030, amendments to the Law of Ukraine «On production and circulation of organic agricultural products and raw materials» from 03.09.2013 № 425-VII, Concepts of the state program of development of organic production in Ukraine, effective formation of «Strategy of economic development of Ukraine 2030», formation of trend and target development of agro-industrial production at the national level for the period till 2050.

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

Yield is a complex complex feature, which is manifested on the basis of the functional activity of various plant organs that make up their morphological and physiological structure. Each organ (root, stem, leaf, bean) is formed at a certain stage of ontogenesis. Their activity is limited to different time periods and are regulated by the genetic apparatus of organisms in a complex interaction with environmental conditions.

The stem of dicotyledons, in contrast to annual cereals, does not form a terminal inflorescence and is actually unlimited in growth. The need for stable access to basic mineral elements during evolution has led to the formation of additional adaptations characteristic of individual species or entire families of a particular class of plants. First of all, it is the release into the soil of a complex of organic acids and various forms of symbiotic relationships with fungi and bacteria. In modern crop production, only one of the following types of symbiosis is effectively used: between legumes and nitrogen-fixing bacteria. Management of this process involves the use of specialized breeding strains of microorganisms, a set of measures to optimize the conditions of symbiosis.

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 forming their high grain productivity. The results of research indicate a significant impact of the studied technological methods of cultivation on the level of yield of legumes (Table 2).

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 – Chabanskyi (yield – 3.47 t/ha, crude protein yield – 1.33 t/ha), narrow-leaved lupine – Peremojets (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.

6. Content and yield of crude grain protein of legumes depending on technological methods of cultivation

Due to the high protein content in the plant and its adaptation to different soil and climatic conditions, lupine is an indispensable forage crop. The criterion for assessing the activity of the functioning of symbiotic systems can be not only the seed productivity of legumes, but also the content of crude protein in the grain.

Table 2

Grain yield of legumes depending on technological methods of cultivation, t/ha (average for 2016–2020)

№	Culture	Variety	Pre-sowing seed treatment	Retardant concentration,%	Yield, t/ha	Increase from p.s.t., t/ha	Increase from the concentration of the retardant, t/ha
1	Sowing peas	Tsarevych	without p.s.t.	without treatment (C)	2,05	-	-
				0,5	2,14	-	0,1
			Rhyzogumin	0,75	2,53	-	0,5
				1	2,46	-	0,4
		Prystan	without p.s.t.	without treatment	2,15	0,1	-
				0,5	2,25	0,2	0,2
			Rhyzogumin	0,75	2,65	0,6	0,5
				1	2,54	0,5	0,4
2	White lupine	Veresnevyi	without p.s.t.	without treatment (C)	2,74	-	-
				0,5	2,94	-	0,2
			Rhyzogumin	0,75	3,33	-	0,6
				1	3,07	-	0,3
		Chabanskyi	without p.s.t.	without treatment	2,88	0,1	-
				0,5	3,05	0,3	0,2
			Rhyzogumin	0,75	3,44	0,7	0,6
				1	3,22	0,5	0,4
3	Lupine narrow-leaved	Olimp	without p.s.t.	without treatment (C)	2,04	-	-
				0,5	2,26	-	0,2
			Rhyzogumin	0,75	2,57	-	0,5
				1	2,48	-	0,4
		Peremojets	without p.s.t.	without treatment	2,18	0,1	-
				0,5	2,35	0,3	0,2
			Rhyzogumin	0,75	2,60	0,6	0,5
				1	2,52	0,5	0,4

(Continuation of Table 2)

№	Culture	Variety	Pre-sowing seed treatment	Retardant concentration,%	Yield, t/ha	Increase from p.s.t., t/ha	Increase from the concentration of the retardant, t/ha
4	Chickpeas	Pegas	without p.s.t.	without treatment (C)	2,11	-	-
				0,5	2,45	-	0,3
			Rhyzogumin	0,75	2,85	-	0,7
				1	2,74	-	0,6
		Skarb	without p.s.t.	without treatment	2,25	0,1	-
				0,5	2,64	0,5	0,4
			Rhyzogumin	0,75	3,08	0,9	0,8
				1	2,9	0,8	0,7
5	Soybean	Holubka	without p.s.t.	without treatment (C)	3,04	-	-
				0,5	3,23	-	0,2
			Rhyzogumin	0,75	3,42	-	0,4
				1	3,31	-	0,3
		Azymut	without p.s.t.	without treatment	3,12	0,1	-
				0,5	3,43	0,3	0,3
			Rhyzogumin	0,75	3,66	0,5	0,5
				1	3,55	0,4	0,4

$HIP_{0,05}$ т/га (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-0,03; B-0,05; C-0,03; AB-0,02; AC-0,08; BC-0,09; ABC-0,14
2020 $HIP_{0,05}$ t/ha: A-0,05; B-0,03; C-0,04; AB-0,02; AC-0,07; BC-0,10; ABC-0,17
$HIP_{0,05}$ т/га (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

(End of Table 2)

2019 $HIP_{0,05}$ t/ha: A-0,05; B-0,06; C-0,06; AB-0,04; AC-0,08; BC-0,11; ABC-0,16
2020 $HIP_{0,05}$ t/ha: A-0,04; B-0,06; C-0,05; AB-0,04; AC-0,07; BC-0,10; ABC-0,14
$HIP_{0,05}$ т/га (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-0,03; B-0,04; C-0,03; AB-0,02; AC-0,08; BC-0,09; ABC-0,15
2020 $HIP_{0,05}$ t/ha: A-0,05; B-0,05; C-0,04; AB-0,02; AC-0,07; BC-0,10; ABC-0,17
$HIP_{0,05}$ т/га (chickpeas): A-0,04; B-0,07; C-0,08; AB-0,06; AC-0,09; BC-0,2 ABC-0,08
2016 $HIP_{0,05}$ t/ha: A-0,05; B-0,04; C-0,03; AB-0,05; AC-0,04; BC-0,07; ABC-0,09
2017 $HIP_{0,05}$ t/ha: A-0,06; B-0,05; C-0,05; AB-0,06; AC-0,08; BC-0,08; ABC-0,10
2018 $HIP_{0,05}$ t/ha: A-0,07; B-0,04; C-0,02; AB-0,08; AC-0,03; BC-0,04; ABC-0,13.
2019 $HIP_{0,05}$ t/ha: A-0,03; B-0,05; C-0,03; AB-0,02; AC-0,08; BC-0,09; ABC-0,18
2020 $HIP_{0,05}$ t/ha: A-0,04; B-0,03; C-0,03; AB-0,04; AC-0,07; BC-0,11; ABC-0,17
$HIP_{0,05}$ т/га (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-0,03; B-0,05; C-0,03; AB-0,02; AC-0,08; BC-0,09; ABC-0,18
2020 $HIP_{0,05}$ t/ha: A-0,04; B-0,05; C-0,05; AB-0,05; AC-0,07; BC-0,10; ABC-0,17

The study of the peculiarities of the formation of crude protein content in legumes and its yield per unit area depending on the elements of cultivation technology is important theoretical and practical value to substantiate the possibilities and feasibility of growing this legume in the Right-Bank Forest-Steppe. As a result of the conducted researches it is established that with increase in grain yield the yield of crude protein also increased (Table 3).

Due to the increase in yield, the highest yield of crude protein (0.93 – 1.19 t/ha) was in white lupine plants. Thus, in pea sowing the yield of crude protein was the highest in the variety Prystan (0.59 t/ha), white lupine – Chabanskyi (1.19 t/ha), narrow-leaved lupine – Peremozhets (0.87 t/ha), chickpeas – Skarb (0.82 t/ha) and in soybeans – Azimuth (0.98 t/ha). The largest increases in crude protein yield per unit area were obtained by seed treatment with the bacterial preparation Rhizohumin and spraying of crops with chlormequat chloride retardant in the budding phase.

7. Practical value

The introduction of the results of the monograph will increase the attractiveness of the market for high-protein production due to cheaper production costs by recommending 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

Table 3

Content and yield of crude grain protein of legumes depending on technological methods of cultivation, t/ha (average for 2016–2020)

№	Culture	Variety	Pre-sowing seed treatment	Retardant concentration,%	Crude protein,%	Yield of crude protein, t/ha
1	Sowing peas	Tsarevych	without p.s.t.	without treatment (C)	19,8	0,40
				0,5	20,2	0,42
			Rhyzogumin	0,75	21,3	0,53
				1	20,7	0,49
		Prystan	without p.s.t.	without treatment	21,0	0,44
				0,5	21,5	0,47
			Rhyzogumin	0,75	22,8	0,59
				1	22,1	0,55
2	White lupine	Veresnevyi	without p.s.t.	without treatment (C)	34,6	0,93
				0,5	35,1	1,02
			Rhyzogumin	0,75	36,3	1,20
				1	35,8	1,07
		Chabanskyi	without p.s.t.	without treatment	36,1	1,01
				0,5	36,5	1,09
			Rhyzogumin	0,75	38,2	1,30
				1	37,2	1,19
3	Lupine narrow-leaved	Olimp	without p.s.t.	without treatment (C)	30,7	0,61
				0,5	31,1	0,68
			Rhyzogumin	0,75	32,0	0,80
				1	31,5	0,75
		Peremojets	without p.s.t.	without treatment	31,7	0,67
				0,5	32,3	0,74

(End of Table 3)

№	Culture	Variety	Pre-sowing seed treatment	Retardant concentration,%	Crude protein,%	Yield of crude protein, t/ha
3			Rhyzogumin	0,75	33,5	0,87
				1	32,8	0,82
4	Chickpeas	Pegas	without p.s.t.	without treatment (C)	24,8	0,52
				0,5	25,2	0,60
			Rhyzogumin	0,75	26,2	0,73
				1	25,7	0,69
		Skarb	without p.s.t.	without treatment	26,1	0,57
				0,5	26,4	0,67
			Rhyzogumin	0,75	27,5	0,82
				1	27,0	0,78
5	Soybean	Holubka	without p.s.t.	without treatment (C)	33,3	0,67
				0,5	34,2	0,75
			Rhyzogumin	0,75	36,2	0,87
				1	35,4	0,81
		Azymut	without p.s.t.	without treatment	34,2	0,72
				0,5	35,6	0,85
			Rhyzogumin	0,75	37,8	0,98
				1	36,1	0,90

on the effective use of life factors (light, heat, moisture, nutrients), which will promote maximum synthesis of organic matter and protein.

8. Conclusions

Based on the research, it was found that the indicators of grain productivity are directly influenced by soil and climatic conditions of the years of the study and the factors that were put to the study. The best conditions for the maximum realization of the potential of legumes are created by treating the seeds with the bacterial preparation Rhizohumin and spraying the crops with a retardant of chlormequat chloride in the budding phase. Our improved model of bioorganic varietal technology for growing legumes using the proposed bioorganic and technological measures will increase the production of quality grain of the studied crops, increase the total harvest of crude protein and increase the level of biological nitrogen fixation in the Forest-Steppe Right Bank.

References:

1. Babych A.O. (1993). Problemy bilka i vyroshchuvannia zernobobovykh na korm. Problems of protein and growth of legumes for feed. 3-ye vyd., pererobl. i dopov. Kyiv, 429 p.
2. Bakhmat O.M. (2012). Modeliuvannia adaptyvnoi tekhnolohii vyroshchuvannia soi. Modeling adaptive technology of soybean cultivation Monohrafiia. Kamianets-Podilskyi: Vydavets: PP Zvolenko D. H.
3. Bandura V., Mazur V., Yaroshenko L., Rubanenko O. (2019). Research on sunflower seeds drying process in a monolayer tray vibration dryer based on infrared radiation. *INMATEN – Agricultural Engineering*, vol. 57, no. 1, pp. 233–242.
4. Begey S.V., Shuvar I.A. (2007). Ecological Agriculture: Textbook. Lviv: Novyi Svit-2000, 429 p.
5. Bransby D.I. Compatibility of switchgrass as an energy crop in farming systems of the southeastern USA. D.I. Bransby, R. Rodriguez-Kabana.
6. Bulgakov V., Adamchuk V., Kaletnik G., Arak M., Olt J. (2014). Mathematical model of vibration digging up of root crops from soil. *Agronomy Research*, no. 12(1), pp. 41–58.
7. Cholovskyi Yu.M. (2010). Osoblyvosti vodospozhyvannia posivamy liupynu vuzkolystoho zalezhno vid zastosuvannia mineralnykh dobryv. *Kormy i kormovyrobnytstvo – Forage and feed production*, vol. 66, pp. 146–147.
8. Cultural Pasture: Patent No 40618 / V. L. Puyu, M. I. Bakhmat, S. A. Tsvigun; Podillya State Agrarian Engineering University, UA. Application dated 01.07.2008; published 27.04.2009. *Industrial Property*. Kyiv, 2009. Bulletin No 8.
9. Didur I., Bakhmat M., Chynchyk O., Pantsyreva H., Telekalo N., Tkachuk O. (2020). Substantiation of agroecological factors on soybean agrophytocenoses by

analysis of variance of the Right-Bank ForestSteppe in Ukraine. *Ukrainian Journal of Ecology*, no. 10(5). pp. 54–61.

10. Didur I., Pantsyreva H., Telekalo N. (2020). Agroecological rationale of technological methods of growing legumes. *The scientific heritage,* 52, pp. 3–14.

11. Dospekhov B.A. (1985). Metodyka polevoho opyta (s osnovamy statystycheskoi obrabotky rezultatov yssledovanyi). Yzd. 5-e dop. y pererab. Moscow: Ahropromyzdat, 351 p.

12. Environmental Issues of Agriculture (2010) / I.D. Prymak, Y.P. Manko, N.M. Ridey et al.; Ed. I.D. Primak. Kyiv: Center of Educational Literature, 456 p.

13. Environmental Problems of Agriculture: Tutorial: V.P. Gudz, M.F. Rybak, S.P. Tanchyket al.; Ed. V. Gudz. Zhytomyr National Agroecological University Press, 2010. 708 p.

14. Ermakov, A., Arasymovych, V., Yarosh, N. et al. (1987). Methods Studies biochemically plants. L.: Agropromizdat, P. 430.

15. G.A. Esbroeck, M.A. Hussey, M.A. Sanderson. Crop Sci, 1997. No. 37, pp. 864–870. URL: http://journals.nubip.edu.ua/index.php/Dopovidi/article/view/13901/12328

16. Ishchenko, V. Belyakov, A. (2009). Efficiency of micronutrients, growth regulator and ryzohuminu in increasing productivity varieties of peas without leaves type. *Steppe Bulletin*, 6: 37–41.

17. Kaletnik G.M., Zabolotnyi, G.M. Kozlovskyi S.V (2011). “Innovative models of strategic management economic potential within contemporary economic systems”. *Actual Problems of Economics*, vol. 4(118), pp. 11.

18. Kaletnik, G., & Lutkovska, S. (2020). Innovative Environmental Strategy for Sustainable Development. *European Journal of Sustainable Development*, 9(2), 89. https://doi.org/10.14207/ejsd.2020.v9n2p89

19. Kolesnik, S. (2012). Bacterial fertilizer to optimize nitrogen and phosphorus nutrition soybeans, chickpeas, peas, lentils and commit. Feed and fodder, 73: 145–151.

20. Ma Z. (2001). Impact of row spacing, nitrogen rate, and time on carbon partitioning of switchgrass Z. Ma, C. W. Wood, D. I. Bransby. Biomass Bioenergy, no. 20, pp. 413–419.

21. Malchevskaya, E., Mylenkaya, G. (1981). The comments and Animal Husbandry quality forage analysis. Minsk . *Harvest*, p. 143.

22. Mazur O.V., Kolisnyk O.M., Telekalo N.V. (2017). Genotypic differences in varieties of common beans by manufacturability. *Collection of scientific works of VNAU «Agriculture and forestry»*, 7. (T. 2), pp. 33–39.

23. Mazur V., Didur I., Myalkovsky R., Pantsyreva H., Telekalo N., Tkach O. (2020). The productivity of intensive pea varieties depending on the seeds treatment and foliar fertilizing under conditions of right-bank forest-steppe Ukraine. *Ukrainian Journal of Ecology*, no. 10(1), pp. 101–105.

24. Mazur V.A., Didur I.M., Pantsyreva H.V., Telekalo N.V. (2018). Energy-economic efficiency of growth of grain-crop cultures in conditions of Right-Bank Forest-Steppe of Ukraine. *Ukrainian Journal of Ecology*, no. 8(4), pp. 26–33.

25. Mazur V.A., Mazur K.V., Pantsyreva H.V. (2019). Influence of the technological aspects growing on quality composition of seed white lupine (Lupinus

albus L.) in the Forest Steppe of Ukraine. *Ukrainian Journal of Ecology*, vol. 9, pp. 50–55. URL: https://www.ujecology.com/archive.html

26. Mazur V.A., Mazur K.V., Pantsyreva H.V., Alekseev O.O. (2018). Ecological and economic evaluation of varietal resources Lupinus albus L. in Ukraine *Ukrainian Journal of Ecology*, vol. 8, pp. 148–153.

27. Mazur, V. A., Prokopchuk, V. M., & Pantsyreva, G. V. (2018). Primary introduction assessment of decorative species of the lupinus generation in Podillya. *Scientific Bulletin of UNFU*, 28(7), 40–43. https://doi.org/10.15421/40280708

28. Mazur V.A., Pantsyreva H.V. (2020). «Rid Lupinus L. v Ukraini: henofond, introduktsiia, napriamy doslidzhen ta perspektyvy vykorystannia». *VNAU*, p. 235.

29. Mazur V.A., Pantsyreva H.V., Didur I.M., Prokopchuk V.M. (2018). Liupyn bilyi. Henetychnyi potentsial ta yoho realizatsiia u silskohospodarske vyrobnytstvo. *VNAU*, p. 231.

30. Mazur V.A., Pantsyreva H.V., Mazur K.V., Didur I.M. (2019). Influence of the assimilation apparatus and productivity of white lupine plants. *Agronomy Research,* 17(X), 206–209. URL: https://doi.org/10.15159/AR.19.024

31. Mazur V.A., Pantsyreva H.V., Mazur K.V., Didur I.M. (2019). Influence of the assimilation apparatus and productivity of white lupine plants. *Agronomy Research*, 17(X), 206–209. URL: https://doi.org/10.15159/AR.19.024

32. Mazur V.A., Pantsyreva H.V., Mazur K.V., Myalkovsky R.O., Alekseev O.O. (2020). Agroecological prospects of using corn hybrids for biogas production. *Agronomy Research,* 18(1), 177–182.

33. Mazur, V.A., & Pantsyreva, H.V. (2017). Vplyv tekhnolohichnykh pryiomiv vyroshchuvannia na urozhainist i yakist zerna liupynu biloho v umovakh Pravoberezhnoho Lisostepu. *Silske hospodarstvo i lisivnytstvo*, 7, 27–36.

34. Mazur,V.A.,Myalkovsky,R.O.,Mazur,K.V.,Pantsyreva,H.V.,Alekseev,O.O. (2019). Influence of the Photosynthetic Productivity and Seed Productivity of White Lupine Plants. *Ukrainian Journal of Ecology*, 9(4), 665–670.

35. Mazur, V.A., Myalkovsky, R.O., Mazur, K.V., Pantsyreva, H.V., Alekseev, O.O. (2019). Influence of the Photosynthetic Productivity and Seed Productivity of White Lupine Plants. *Ukrainian Journal of Ecology*, 9(4), 665–670.

36. Mazur, V.A., Branitskyi, Y.Y., Pantsyreva, H.V. (2020). Bioenergy and economic efficiency technological methods growing of switchgrass. *Ukrainian Journal of Ecology*, 10(2), 8–15.

37. Mazur, V.A., Didur, I.M., Pantsyreva, H.V., & Telekalo, N.V. (2018). Energy-economic efficiency of grain-crop cultures in the conditions of the right-bank Forest-Steppe of Ukraine. *Ukrainian J Ecol*, 8(4), 26–33.

38. Mazur, V.A., Mazur, K.V., Pantsyreva, H.V., Alekseev, O.O. (2018). Ecological and economic evaluation of varietal resources Lupinus albus L. in Ukraine. *Ukrainian Journal of Ecology*, 8(4), 148–153.

39. Mazur, V.A., Pantsyreva, H.V., Mazur, K.V. & Didur, I.M. (2019). Influence of the assimilation apparatus and productivity of white lupine plants. *Agronomy research*, 17(1), 206–219.

40. Melnychuk, T., Patyka, V. (2011). Microbial preparations bioorganic farming system. Collected articles «Third All-Ukrainian Congress of Ecologists with international participation». Vinnytsya, Tom 2, pp. 423–426.

41. Metodologiya i praktyka vykorystannya mikrobnyx preparativ u texnologiyax vyroshhuvannya silskogospodarskyx kultur [Methodology and practice of microbial drugs use in crop growing technologies] / V.V. Volkogon, A. S. Zaryshnyak, I.V. Grynyk ta in. (2011). Kyyiv: Agrarna nauka, 153.

42. Monarkh Veronika Valentynivna, Pantsyreva Hanna Vitaliivna (2019). Stages of the Environmental Risk Assessment. *Ukrainian Journal of Ecology*, 9(4), 484–492. DOI: 10.15421/2019_779

43. Muir J.P. (2001). Biomass production of Alamo switchgrass in response to nitrogen, phosphorus, and row spacing. J.P. Muir, M.A. Sanderson, W.R. Ocumpaugh at all. Agron J., no. 93, pp. 896–901.

44. Naum Raichesberg (2000). Adolphe Quetelet, His Life and Research Activities. Moscow: Elibron Classics, 98 p.

45. Ovcharuk V.I., Mulyarchuk O.I., Myalkovsky R.O., Bezvikonnyi P.V., Kravchenko V.S., Klymoych N.M. (2019). Parameters of beet plants. *Bulletin of the Uman National University of Horticulture*, no. 1, pp. 70–75.

46. Palamarchuk V., Honcharuk I., Honcharuk T., Telekalo N. (2018). Effect of the elements of corn cultivation the technology on bioethanol production under conditions of the rightbank forest-steppe of Ukraine. *Ukrainian Journal of Ecology*, vol. 8(3), pp. 47–53.

47. Palamarchuk, V. & Telekalo, N. (2018). The effect of seed size and seeding depth on the components of maize yield structure. *Bulgarian Journal of Agricultural Science*, 24(5), 785–792.

48. Palamarchuk, V., Telekalo, N. (2018). The effect of seed size and seeding depth on the components of maize yield structure. *Bulgarian Journal of Agricultural Science*, 24(5), 785–792.

49. Pancy`reva G.V. (2016). Doslidzhennya sortovy`x resursiv lyupy`nu bilogo (Lupinus albus L.) v Ukrayini. Vinnycya, 4, 88–93.

50. Pantsyreva H.V. (2018). Research on varietal resources of herbaceous species of Paeonia L. in Ukraine. *Scientific Bulletin of the NLTU of Ukraine*, 28(8), 74–78. https://doi.org/10.15421/40280815

51. Pantsyreva, H.V. (2016). Doslidzhennia sortovykh resursiv liupynu biloho (Lupinus albus L.) v Ukraini. *Silske hospodarstvo i lisivnytstvo*, 4, 88–93.

52. Pantsyreva, H.V. (2019). Morphological and ecological-biological evaluation of the decorative species of the genus Lupinus L. *Ukrainian Journal of Ecology*, 9(3), 74–77.

53. Pantsyreva, H.V. (2019). Technological aspects of biogas production from organic raw materials. *Bulletin of KhNTUSG them, pp. Vasilenko*. Kharkiv, pp. 276–290.

54. Puyu V.L. (2014). Modern Design of Cultivated Pastures in the Western Forest Steppe. Seminar Program of Uman NUS «Varietal Technologies as a Factor in the Implementation of Agrocenoses Biopotentials in the Programming System of Field and Forage Crops Yield». Uman, 15-16 May 2014.

55. Puyu V.L., Bakhmat M.I., Rykhlivskyi I.P., Shcherbatiuk N.V. (2019). Optimization of Conveyor Production of Green Fodder. *World Science*, no. 7(47), vol. 1. doi: 10.31435/rsglobal_ws/31072019/6587

56. Rai R.K., Tripathi N., Gautam D., & Singh P. (2017). Exogenous application of ethrel and gibberellic acid stimulates physiological growth of late planted sugarcane with short growth period in subtropical India. *Journal of Plant Growth Regulation*, 36(2), 472–486.

57. S.E. Sladden. (1993). Biomass Conf. of the Americas. Burlington, pp. 229–234.

58. Shatilov I.S., Chudnovskyi A.F. (1980). Agrophysical, Agrometeorological and Agrotehnical Crop Programming Fundamentals: ACS of TP Principles in Land Cultivation. Leningrad: Gidrometeoizdat, 320 p.

59. Telekalo N., Mordvaniuk M., Shafar H., Matsera O. (2019). Agroecological methods of improving the productivity of niche leguminous crops. *Ukrainian Journal of Ecology*, no. 9(1), pp. 169–175.

60. Telekalo N.V. (2016). Economic evaluation of the efficiency of pea growing technology. *Collection of scientific works of VNAU «Agriculture and forestry»,* 4, pp. 63–71.

61. Tymchuk, O. Shkvirko, H. Sakalova, M. Malovanyy, T. Dabizhuk, O. Shevchuk, O. Matviichuk , T. Vasylinych (2020). Wastewater a Source of Nutrients for Crops Growth and Development. *Journal of Ecological Engineering*, vol. 21, issue 5, pp. 88–96.

62. V.G. Kuryata, S.V. Polyvanyi, O.A. Shevchuk, O. Tkachuk (2019). Morphogenesis and the effectiveness of the production process of oil poppy under the complex action of retardant chlormequat chloride and growth stimulant treptolem. *Ukrainian Journal of Ecology*, 9(1), 127–134.

63. Vdovenko S.A., Prokopchuk V.M., Palamarchuk I.I., Pantsyreva H.V. (2018). Effectiveness of the application of soil milling in the growing of the squash (Cucurbita pepo var. giraumontia) in the right-benk forest stepp of Ukraine. *Ukrainian Journal of Ecology*, 8(4), 1–8.

64. Vdovenko S.A., Prokopnuk V.M., Palamarchuk I.I., Pantsyreva H.V. (2018). Effectiveness of the application of soil milling in the growing of the squash (Cucurbita pepo var. giraumontia) in the right-benk forest stepp of Ukraine. *Ukrainian Journal of Ecology*, 8(4), 1–5.

65. Vdovenko, S.A., Pantsyreva, G.V., Palamarchuk, I.I., & Lytvyniuk, H.V. (2018). Symbiotic potential of snap beans (Phaseolus vulgaris L.) depending on biological products in agrocoenosis of the right-bank forest-steppe of Ukraine. *Ukrainian J Ecol*, 8(3), 270–274.

66. Vdovenko, S.A., Prokopchuk, V.M., Palamarchuk, I.I., & Pantsyreva, H.V. (2018). Effectiveness of the application of soil milling in the growing of the squash (Cucurbita pepo var. giraumontia) in the right-benk forest stepp of Ukraine. *Ukrainian J Ecol*, 8(4), 1–5.

67. Vitalii Palamarchuk, Inna Honcharuk, Tetiana Honcharuk, Natalia Telekalo (2018). Effect of the elements of corn cultivation technology on bioethanol production under conditions of the right– bank forest-steppe of Ukraine. *Ukrainian Journal of Ecology*, no. 8(3), pp. 47–53.

68. Vitalii Palamarchuk, Inna Honcharuk, Tetiana Honcharuk, Natalia Telekalo (2018). Effect of the elements of corn cultivation technology on bioethanol production under conditions of the right– bank forest-steppe of Ukraine. *Ukrainian Journal of Ecology*, no. 8(3), 47–53.

69. Wolters D., Beste A. (2000). Biomasse – umweltfreundlicher Energieträger? Ökologie und Landbau. 116, 4, s. 12–14.

70. Xing, X., Jiang, H., Zhou, Q., Xing, H., Jiang, H., & Wang, S. (2016). Improved drought tolerance by early IAA – and ABA-dependent H2O2 accumulation induced by α-naphthaleneacetic acid in soybean plants. *Plant Growth Regulation*, 80(3), 303–314.

71. Yanovych, V., Honcharuk, T., Honcharuk, I. & Kovalova, K. (2017). Design of the system to control a vibratory machine for mixing loose materials. *Eastern-European Journal of Enterprise Technologies*, 6(3-90), 4–13.

72. Yanovych, V., Honcharuk, T., Honcharuk, I. & Kovalova, K. (2018). Engineering management of vibrating machines for targeted mechanical activation of premix components. *INMATEH – Agricultural Engineering*, 54(1), 25–32.

73. Yhurber J.A. (1958). Inhibitory effect of gibberellins on nodulation in dwarf beans, Phaseolus vulgaris. *Nature*, vol. 181, pp. 1082–1083.

74. Yowling W.A., Buirchell B.J., Tarta M.E. Lupin. Lupinus L. (1998). Promoting the conservation and use of underutilized and neglected crops 23. Institute of Plant lyenetis and crop Plant Research, yatersleben. International Plant lyenetic Resources Institute. Rome, pp. 112–114.

75. Zhao, H., Cao, H., Ming-Zhen, P., Sun, Y., & Liu, T. (2017). The role of plant growth regulators in a plant aphid parasitoid tritrophic system. *Journal of Plant Growth Regulation*, 36(4), 868–876.

76. O.A. Shevchuk, O.O. Tkachuk, V.G. Kuryata, O.O. Khodanitska, S.V. Polyvanyi (2019). Features of leaf photosynthetic apparatus of sugar beet under retardants treatment. *Ukrainian Journal of Ecology*, 9(1), 115–120.

77. O.O. Khodanitska, V.G. Kuryata, O.A. Shevchuk, O.O. Tkachuk, I.V. Poprotska (2019). Effect of treptolem on morphogenesis and productivity of lin seed plants. *Ukrainian Journal of Ecology*, 9(2), 9–126.

78. Cowling W.A. (1994). Plant breeding for stable agriculture: Presidential Address. Western Australia, 183–184.

AGROECOLOGICAL POTENTIAL OF LEGUMES IN CONDITIONS OF INTENSIVE AGRICULTURE OF UKRAINE

Olexander Tkachuk[1]
Nataliia Telekalo[2]

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Abstract. The ecological significance of leguminous crops grown in modern intensive crop rotation in Ukraine is considered. In particular, the sown areas of common leguminous crops in Ukraine and the level of their productivity have been analyzed. A comparison is made with the acreage of common field crops in Ukraine. The volume of accumulation of by-products in the form of their straw and stubble is calculated. A comparison is made for these indicators with the most widespread grain crops grown in Ukraine. The data on the content of the main nutrients in the by-products of leguminous crops – nitrogen, phosphorus, potassium are given. On the basis of these indicators, a calculation was made of the accumulation of the main nutrients in the soil, which can come with by-products of leguminous crops at their average yield. We also compared the obtained indicators with the input of nitrogen, phosphorus and potassium into the soil with by-products of the most common grain crops. Calculated symbiotic nitrogen fixation by leguminous crops. Based on this, a conclusion was made about the most effective leguminous crops, the cultivation of which in the modern intensive crop rotation of Ukraine will more contribute to the stabilization of the agroecological state of the soil.

It is proved that an increase in the areas of leguminous crops in the intensive crop rotation of Ukraine will have a positive effect on the agroecological state of the soil. In particular, growing beans allows you to get the highest mass of by-products, which can be buried in the soil – 3.5 t/ha. Also, the by-products of beans provide the input into the soil of all mineral

[1] Doctror of Agricultural Sciences, Associate Professor,
Vinnytsia National Agrarian University, Ukraine
[2] Candidate of Agricultural Sciences, Associate Professor,
Vinnytsia National Agrarian University, Ukraine

phosphorus – 12.6 kg/ha of all leguminous crops, as well as potassium – 16.5 kg/ha. By-products allow to accumulate more mineral nitrogen in the soil with by-products – 38.4 kg/ha. Also, soybeans are characterized by a high symbiotic nitrogen-fixing ability among all leguminous crops – 120 kg/ha.

1. Introduction

Modern field crop rotations of Ukraine, involved in commercial cultivation of agricultural crops, occupy an area of about 1994–1900 hectares. Of these, about 70% of the specified arable land area is occupied by intensive farming technologies used in agricultural enterprises processing leased land.

In Ukraine, such technologies are characterized by the cultivation of a limited number of crops in the rotation, among which winter wheat prevails, which occupies 31% in the structure of sown areas, sunflower – 30%, corn – 23% in the structure; intensive use of mineral fertilizers, the volumes of which for the cultivation of these crops reach 200–300 kg/ha in the active substance of the main nutrients of nitrogen, phosphorus and potassium, in the physical mass of mineral fertilizers reaches 1000 kg/ha; repeated use of synthetic pesticides, the amount of which during one growing season can be up to 10 times when growing one crop; frequent return to the same field of the cultivated crop can be in one to two years, and for corn – growing in a row for two to three years by a non-optimal alternation of crops in the crop rotation, when for corn and winter wheat, sunflower is the main precursor, and for sunflower – corn. With such high-tech conditions for growing crops in Ukraine, unfavorable conditions are formed for the growth and development of plants, which requires a further increase in the use of chemicals – mineral fertilizers and synthetic pesticides.

Considering the lack of organic fertilizers in the modern crop rotation of Ukrainian agriculture, when in 2019 the fertilized area of soil with manure was only 503 600 hectares, which is only 2.7% of the arable land area with an estimated application of organic fertilizers for the entire arable land area of Ukraine 0.5 t/ha at a scientifically grounded rate of 18.3 t/ha, which could partially stabilize the stability of such agroecosystems, an important problem arises of finding alternative ways to replenish the stock of organic matter in the soil, which will not only improve the agroecological state of soils, but will also lead to an increase in the stability of such monotonous agroecosystems to the impact of harmful organisms – pests, diseases and weeds, the number of which has increased dramatically.

In modern conditions of intensive agriculture in Ukraine, an alternative way of replenishing the stock of nutrients and organic matter in the soil is plowing by-products of common crops grown in crop rotation: straw, stalks and stubble of winter wheat, winter rape, corn, sunflower and others. In Ukraine, such an agro-ecological measure has not been used for a long time, since during the existence of the Soviet Union, grain straw, corn and sunflower stalks were used for animal husbandry as feed and bedding. Since the 2000s, a sharp decline in the livestock sector of Ukrainian agriculture has led to the abandonment of crop by-products in the field, followed by their burning. Only since the 2010s, agricultural enterprises began to grind plant residues and plow them as organic fertilizer. And in such conditions, a part of the by-products of winter wheat, corn, sunflower, winter rape is withdrawn from fields for biofuel production.

However, a more significant factor in increasing the accumulation of nutrients in the soils of agricultural land in Ukraine is the plowing of by-products of leguminous crops, which is characterized by a significantly higher content of nutrients in its chemical composition, symbiotic nitrogen fixation of leguminous crops during their cultivation, however, the agroecological significance of leguminous crops in modern intensive crop rotation in Ukraine is underestimated .

2. Analysis of recent research and publications

The use of by-products of legumes, cereals and cereals to increase the yield of subsequent crops in the crop rotation was studied at the National Scientific Center, Institute of Agriculture of the National Academy of Agrarian Sciences of Ukraine V.F. Kaminskiy (2014).

The study of the properties of straw as an organic fertilizer and the peculiarities of its use for fertilizing the soil and increasing the yield of subsequent crops in the crop rotation are covered in the works of the Sumy National Agrarian University and the Scientific Research Institute of Agriculture of the North-East of the National Academy of Agrarian Sciences of Ukraine (Butenko, A.A., 2020), National Research Center Institute of Agrarian Economics (Korchinsky, A.A., 2015).

The effect of plowing pea straw together with mineral fertilizers on the indicators of the agrochemical composition of gray forest soil, yield and grain quality of winter wheat were studied at the Institute of Agriculture of the Carpathian Region of the National Academy of Agrarian Sciences of Ukraine by scientists Sedilo, G.M., Dubitsky, A.A., Kachmar, O.I., Vavrinovich, A.V., (2018).

The study of the joint use of by-products of plants and green manure was studied at the Research Institute of Agriculture of Polissia of the National Academy of Agrarian Sciences of Ukraine Bovsunovskiy, A.M., 2009. Fertilization of field crops based on the maximum use of local organic resources, in particular, by-products of plant growing of common agricultural crops are covered in the works Kabanchik, V.M., Sobko, M.I. and Radchenko, A.V. in Institute of Agriculture of the North-East of the National Academy of Agrarian Sciences of Ukraine, 2015. All these scientists note the positive effect of the use of by-products of grain and leguminous crops on the indicators of soil fertility and increasing the yield of subsequent crops in the crop rotation.

3. Literature review

Traditional leguminous crops of agricultural land in Ukraine during the second half of the twentieth century was sown peas, which occupied at least 10% of the sown area of each farm. In those days, its straw was used for animal feed, so it was not scattered over the fields. The removal of nutrients from the soil by cultivated crops was compensated by significant amounts of organic fertilizers. The agroecological significance of peas at that time was determined by its symbiotic nitrogen fixation and the optimal characteristics of this crop as a steam predecessor of winter wheat.

At the same time, it is not uncommon for straw to be burned in the fields after harvest. At the same time, 1.5–2 tons of organic matter is irretrievably lost from one hectare, and the soil microflora is also disturbed. This leads to a decrease in soil fertility, which also affects the yield of agricultural crops. And although in Ukraine at the legislative level there is a ban on such burning of plant residues, it is still ignored by many enterprises from year to year.

In the 21st century, the acreage of peas in Ukraine has sharply decreased, and its agroecological significance has increased significantly. The decrease in the acreage of peas is due to economic and business factors and not too high intensification of the technology of its cultivation. At the same time, the sown areas of other, often rare leguminous crops, in particular soybeans, began to grow.

The straw of leguminous crops contains more organic matter than other organic fertilizers, and very valuable components for increasing soil fertility: cellulose, pentose, hemicellulose and lignin, which are carbon energy substrates for soil microorganisms. It is the main building material for soil humus.

Smelling of one ton of straw is equivalent to 3.5–4.0 t/ha of straw manure in its effect. This indicates that when 0.2–0.4 tons of legume straw are left in the soil, 0.3–2.6 tons of humus per hectare is formed. In the research of the Institute of Agriculture of the North-East, it was established that the use of straw as fertilizer during the rotation of a 4-field crop rotation contributed to an increase in the humus content by 0.13–0.17%. The calculations show that with its systematic plowing, it is possible to achieve a deficit-free humus balance in soils without additional costs.

On average, 4.2 kg of nitrogen, 1.7 kg of phosphorus, 8.3 kg of potassium, 4.2 kg of calcium, 0.7 kg of magnesium, and a number of trace elements are returned to the soil from one ton of straw of grain and leguminous crops. Fertilization with straw increases the availability of phosphorus and potassium in the soil, due to the dissolving action of acidic substances formed during its decomposition. When plowing straw in an amount of 5 t/ha, up to 40 kg/ha of potassium and up to 66 kg/ha of nitrogen, as the most essential components of mineral nutrition, are returned to the soil annually. Of course, the nutrients bound in the organic matter of the straw will be available to plants only 3–5 years after the decomposition of the straw. But with the systematic introduction of straw, this problem will disappear by itself.

The straw contains all the nutrients necessary for plants, which are easily available to plants after mineralization.

The wide C: N ratio in grain straw (70–80: 1) affects its decomposition in the soil. Cellulose-freezing microorganisms need nitrogen. When it is deficient in straw, microorganisms consume mineral nitrogen from the soil, that is, the process of nitrogen immobilization is in progress. It has been established that for the normal course of straw decomposition processes, the C: N ratio should be 20–30: 1. Therefore, the efficiency of straw fertilization of grain crops increases significantly when combined with additional sources of mineral nitrogen. Depending on the crop, which acted as a predecessor, the dose of mineral nitrogen can vary from 3 to 11 kg requires additional application of mineral nitrogen.

The annual application of straw improves the agrophysical properties of the soil. In particular, for 3–4 years, the number of valuable water-resistant aggregates larger than 0.25 mm in size increases and the permeability of soil increases.

Straw has a positive effect on the microbiological activity of the soil. The introduction of straw approximately doubles the amount of cellulolytic microflora in comparison with the control, and also leads to an increase in the activity of nitrogen fixation in the soil. The introduction of straw causes an increase in the «breathing» of the soil – the release of carbon dioxide, which is necessary for plants in the process of photosynthesis.

In the process of straw destruction, physiologically active substances are formed, which in low concentrations can positively affect the growth and development of plants.

The straw yield depends on the crop and its yield. The ratio between the main product and straw ranges from 1:0.8 to 1:2.0. Calculations show that the average annual output of straw for grain and leguminous crops in Ukraine's agriculture over the past five years is 56 million tons. Plowing this volume of straw can provide the return to the soil of about 280 thousand tons of nitrogen, 140 thousand tons of phosphorus and 448 thousand tons of potassium. This amount of nutrients is sufficient to obtain an increase in the grain yield of winter wheat in the amount of 3-3.5 million tons.

The largest sources of supply of plant residues in Ukraine in terms of their volumes, based on the sown area, are wheat straw – 30.3%, corn stalks for grain – 17.9%, barley straw – 12.0%, sunflower stalks – 23.8% and rapeseed – 12.6%. Making the most of plant residues for fertilizing agricultural crops, one can count on their annual application in favorable years of about 5 t/ha, in unfavorable years – up to 3.5 t/ha.

The decomposition of plant residues in the soil is slow and depends on the quality of plowing and weather conditions. It has been established that up to 46% of straw decomposes in 2.5–4 months, and up to 80% in one and a half to two years. For the decomposition of 1 ton of straw in the soil, after 3 months, about 50 kg of humus is formed, and after 2 years – about 90–100 kg.

Along with the specified properties of grain by-products, leguminous plants have a number of advantages, which can significantly increase their positive agroecological effect at lower economic costs. The growth of the agroecological value of leguminous crops in crop rotation is determined not only by their accumulation of organic matter with by-products for a more favorable ratio between nitrogen and carbon, but also by symbiotic nitrogen fixation, a taproot system, loosens the soil well, a variety of crops in crop rotation and an improvement in their rotation, after a short the growing season of leguminous crops – additional accumulation of moisture in the soil, cleaning the agroecosystem from pests, diseases and weeds. At the same time, the sown area of leguminous crops in Ukraine was unjustified and did not allow them to fully realize their agroecological potential.

At the same time, the main agroecological emphasis today is made on the traditional during the last years leguminous crops – peas and soybeans, but the sown areas of other leguminous crops, in particular chickpeas, lentils, beans, beans, are beginning to grow on farms. Very little is known about their agroecological significance in crop rotation.

4. Conditions, objective and methods of research

The research was carried out on the basis of processing the materials of the State Statistics Service of Ukraine concerning the sown areas and yield levels of leguminous crops in the farms of Ukraine, in particular soybeans, peas, chickpeas, lentils, beans, beans. On the basis of reference data, an assessment was made of the nitrogen-fixing ability of leguminous crops and the volume of accumulation of by-products in the form of their straw. We also used reference data on the content of nutrients in the straw of the studied leguminous crops: nitrogen, phosphorus, potassium. We used calculation methods for calculating the intake of nutrients into the soil. All these indicators were compared with traditional crops grown in intensive crop rotation.

The main objectives of the research were:

1. To analyze the sown area of leguminous crops in Ukraine and their structure;

2. Provide the actual level of productivity of the main leguminous crops grown in Ukraine;

3. Calculate the volume of possible formation of by-products of leguminous crops, which can be buried in the soil;

4. Give the chemical composition of the by-products of leguminous plants in terms of the content of the main inorganic substances necessary for plants: nitrogen, phosphorus and potassium;

5. Calculate the volume of input into the soil of the main elements of plant nutrition: nitrogen, phosphorus and potassium when plowing plant residues of leguminous crops;

6. To analyze the volumes of symbiotic nitrogen fixation of leguminous crops grown by intensive technologies in Ukraine;

7. Make a conclusion about leguminous crops that have the most positive agroecological impact on the supply of nutrients to the soil.

5. Research results

According to the State Statistics Service in Ukraine, in 2019 the sown area for leguminous crops was 566.0 thousand hectares, which is about 2.8% of the total sown area in Ukraine and a very low indicator (Figure 1).

According to scientifically grounded calculations, the minimum required sown area of leguminous crops in the structure of sown areas of field plants in Ukraine to stabilize the agroecological state of agroecosystems should be at least 10% of the arable land. For this, the sowing of leguminous crops

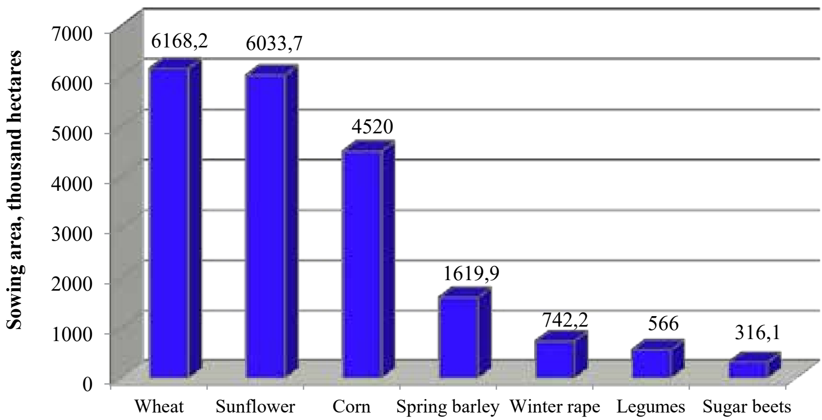

Figure 1. Sown areas of major crops in field crop rotations of Ukraine in 2019

in Ukraine must be brought to a total area of 1994,190 hectares that is, increased by 3.5 times from existing in 2019.

By the way, in 2015 in Ukraine, according to the State Statistics Service, the sown area of soybeans alone, excluding other leguminous crops, amounted to 1999.8 thousand hectares, which corresponded to the minimum agro-ecological requirements for stabilizing the state of agroecosystems. However, due to the change in climatic conditions, which is due to global warming, there was a significant decrease in the yield of soybeans and since then the sown areas of this crop began to decrease sharply.

The largest sown area among leguminous crops, according to the State Statistics Service in Ukraine in 2019, belonged to peas – 347.0 thousand hectares. The sown area of soybeans was 129.8 thousand hectares. The rest of leguminous crops have an insignificant sown area from 42.0 thousand hectares – in beans, up to 3.2 thousand hectares – in legumes (Table 1).

Table 1

Sown areas and yield level of legumes in Ukraine in 2019 (according to the State Statistics Service)

Culture	Sowing area, thousand hectares	Yield, t/ha
Soybeans	129.8	2.29
Peas	347.0	2.28
Chickpeas	36.0	1.40
Lentils	8.0	1.39
Beans	42.0	1.59
Fodder beans	3.2	2.32
Total	566.0	-

Structurally, the share of peas of all leguminous crops grown in Ukraine is 61.3%, the share of soybeans is 22.9%. Lentils and beans in the structure of sown areas among leguminous crops in Ukraine occupy the smallest share – 1.4% and 0.6%, respectively (Figure 2).

The average yield of leguminous crops, according to the State Statistics Service in Ukraine in 2019, varied within 1.39–2.32 t/ha. It was most found in beans, soybeans, and peas, while the lowest was found in lentils,

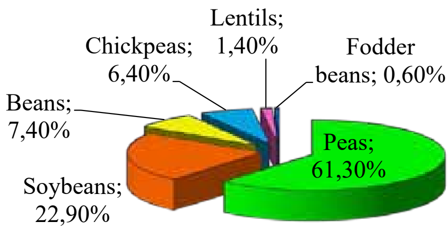

Figure 2. The structure of sown areas of leguminous crops in Ukraine in 2019

chickpeas, and beans. If we take barley, a grain ravine as a reference, the yield of leguminous crops was 0.7–2.4 times less than it.

The ratio of grain to by-products of all leguminous crops is similar and is in the range of 1:(1.2-1.5). Most of the by-products from the mass of seeds are formed by beans, and the least – by lentils (Table 2). In terms of the ratio of grain to by-products, legumes form more by-products than grain crops, and by this indicator they are close to winter rapeseed.

Table 2

Volumes of formation of by-products of legumes in intensive crop rotation

Culture	The ratio of grain to by-products	The average volume of by-products, t/ha
Soybeans	1 : 1.4	3.2
Peas	1 : 1.4	3.2
Chickpeas	1 : 1.3	1.8
Lentils	1 : 1.2	1.7
Beans	1 : 1.4	2.2
Fodder beans	1 : 1.5	3.5

Taking into account the average level of productivity of leguminous crops in Ukraine, we calculated the formation of vegetative mass of by-products (straw, stems) by them. Most of the by-products can be returned to the soil by beans – 3.5 t/ha, soybeans and peas – by 8.6% less, beans – by 37.1%, and least of all – chickpeas and lentils – 1.7–1.8 t/ha. In comparison with other field crops of intensive crop rotation, the return to the soil of by-products of leguminous crops is lower than from such crops as winter wheat, corn, sunflower, but the same as when forming by-products from spring barley.

The content of the main nutrients in the by-products of all leguminous crops is similar and is: nitrogen – 10.0–12.0 kg/t, phosphorus – 3.4–3.6 kg/t, potassium – 4.6–5.0 kg/t (Table 3).

Table 3

The content of basic elements in by-products of legumes, kg/t

Culture	N	P	K
Soybeans	12.0	3.6	5.0
Peas	10.0	3.5	4.6
Chickpeas	10.6	3.5	4.7
Lentils	10.8	3.4	4.6
Beans	10.6	3.5	4.7
Fodder beans	10.6	3.6	4.7

Soybeans have a somewhat high content of nutrients in by-products, while other crops have approximately the same indicators. In terms of nitrogen content, leguminous crops are dominated by cereals by 2.3–2.7 times, phosphorus by 1.5–1.6 times and are inferior in terms of potassium content.

With the vegetative mass of by-products of leguminous crops, 19.1–38.4 kg/ha of mineral nitrogen will come from it. Most of it will be accumulated for growing soybeans and beans, and least of all – for growing chickpeas and lentils. Smelling of soybean by-products ensures that the soil is supplied with almost twice as much mineral nitrogen as it will be supplied by prioritizing plant residues of winter wheat.

Most of the mineral phosphorus will enter the soil when growing beans – 12.6 kg/ha, as well as soybeans and peas – 11.2–11.5 kg/ha, which is 1.1–1.3 times more than it will receive into the ground with winter wheat straw. Less mineral phosphorus will enter the soil with lentil by-products – 5.8 kg/ha.

Potassium input into the soil with the by-product of beans and soybeans will be the largest and will amount to 16.0–16.5 kg/ha. At the same time, less will be received when growing lentils – 7.8 kg/ha.

Unlike other agricultural plants, leguminous crops fix symbiotic nitrogen with the help of nodule bacteria and additionally enrich the soil with it. Most of all, it is fixed by soybeans – 120 kg/ha, beans – by 10 kg/ha less, peas – by 20 kg/ha, beans – by 50 kg/ha, chickpeas – by 40 kg/ha and lentils – by 35 kg/ha less.

Taking into account the complex effect of growing leguminous crops on the optimization of the agroecological state of the soil, including the conversion of a part of the organic mass of by-products into humus, the accumulation of nutrients nitrogen, phosphorus and potassium from it, as well as the production of biological nitrogen by leguminous crops in symbiosis with nodule bacteria, we calculated the total the positive impact of all leguminous crops on the state of the soil, taking into account all the above factors and is presented in relative units in Figure 3.

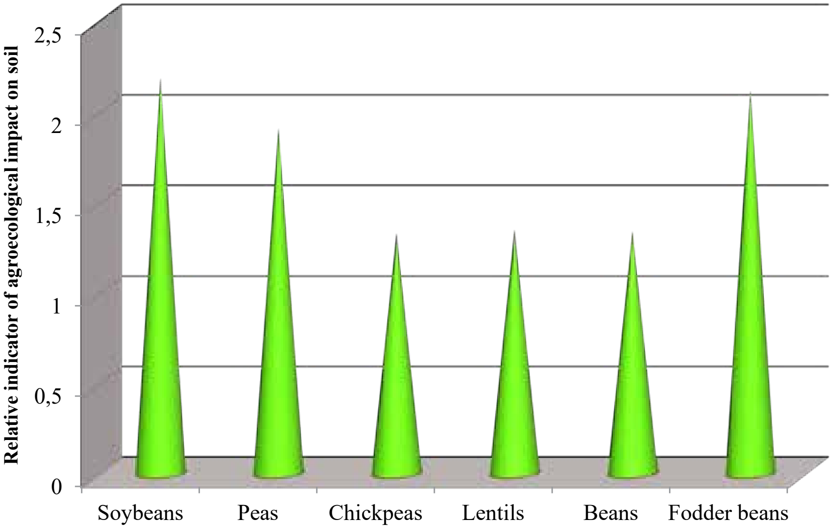

Figure 3. Relative agroecological effect of impact on the soil of growing leguminous crops

The greatest positive impact on the agro-ecological state of the soil is carried out by the cultivation of soybeans with a relative indicator of 2.18, as well as beans – 2.11. Pea cultivation has a slightly lower rate – 1.90. The rest of leguminous crops – chickpeas, lentils and beans have the lowest relative impact on the soil – 1.32–1.34.

6. Conclusions

It has been proven that an increase in the area of leguminous crops in an intensive crop rotation will have a positive effect on the agroecological state of the soil. In particular, growing beans allows you to get the highest mass of by-products, which can be buried in the soil – 3.5 t/ha. Also, by-products of beans are characterized by a high content of mineral phosphorus – 3.6 kg/t, which ensures the supply of all mineral phosphorus to the soil – 12.6 kg/ha of all leguminous crops, as well as potassium – 16.5 kg/ha.

Soybean by-products are characterized by high nitrogen content – 12.0 kg/t, phosphorus – 3.6 kg/t and potassium – 5.0 kg/t. This makes it possible to accumulate more mineral nitrogen in the soil with by-products after growing soybeans – 38.4 kg/ha. Also, soybeans are characterized by a high symbiotic nitrogen-fixing ability among all leguminous crops – 120 kg/ha.

The by-product of leguminous crops has a high nitrogen content by 2.3–2.7 times, phosphorus – 1.5–1.6 times compared to the by-product of grain crops. Also, when plowing soybean by-products into the soil, there will be 2 times more mineral nitrogen and 1.1–1.3 times more phosphorus than when plowing winter wheat by-products.

Among all leguminous crops grown in Ukraine, the greatest positive complex agroecological impact on the soil, taking into account the input of organic matter from by-products, mineral nitrogen, phosphorus and potassium with it and symbiotic nitrogen fixation, will be carried out by the cultivation of soybeans and beans.

References:

1. Bandura V., Mazur V., Yaroshenko L., Rubanenko O. (2019). Research on sunflower seeds drying process in a monolayer tray vibration dryer based on infrared radiation. *INMATEN – Agricultural Engineering*, vol. 57, no. 1, pp. 233–242.
2. Didur I., Bakhmat M., Chynchyk O., Pantsyreva H., Telekalo N., Tkachuk O. (2020). Substantiation of agroecological factors on soybean agrophytocenoses by analysis of variance of the Right-Bank ForestSteppe in Ukraine. *Ukrainian Journal of Ecology*, no. 10(5), pp. 54–61.
3. Didur I., Bakhmat M., Chynchyk O., Pantsyreva H., Telekalo N., Tkachuk O. (2020). Substantiation of agroecological factors on soybean agrophytocenoses by analysis of variance of the Right-Bank ForestSteppe in Ukraine. *Ukrainian Journal of Ecology*, no. 10(5), pp. 54–61.
4. Didur I., Bakhmat M., Chynchyk O., Pantsyreva H., Telekalo N., Tkachuk O. (2020). Substantiation of agroecological factors on soybean agrophytocenoses by

analysis of variance of the Right-Bank Forest-Steppe in Ukraine. *Ukrainian Journal of Ecology*, 10(5), 54–61.

5. Didur I., Pantsyreva H., Telekalo N. (2020). Agroecological rationale of technological methods of growing legumes. *The scientific heritage*, 52, pp. 3–14.

6. Didur I., Pantsyreva H., Telekalo N. (2020). Agroecological rationale of technological methods of growing legumes. *The scientific heritage*, 52, pp. 3–14. URL: https://www.ujecology.com/archive.html

7. Kaletnik G.M., Zabolotnyi G.M., Kozlovskyi S.V. (2011). "Innovative models of strategic management economic potential within contemporary economic systems". *Actual Problems of Economics*, vol. 4(118), pp. 11.

8. Kaletnik, G., & Lutkovska, S. (2020). Innovative Environmental Strategy for Sustainable Development. *European Journal of Sustainable Development*, 9(2), 89. https://doi.org/10.14207/ejsd.2020.v9n2p89

9. Kuryata, V.G., Poprotska, I.V., & Rogach, T.I. (2017). The impact of growth stimulators and retardants on the utilization of reserve lipids by sunflower seedlings. *Regulatory Mechanicms in Biosystems*, 8(3), 317–322.

10. Mazur O.V., Kolisnyk O.M., Telekalo N.V. (2017). Genotypic differences in varieties of common beans by manufacturability. *Collection of scientific works of VNAU «Agriculture and forestry»*, 7(2), pp. 33–39.

11. Mazur V., Didur I., Myalkovsky R., Pantsyreva H., Telekalo N., Tkach O. (2020). he productivity of intensive pea varieties depending on the seeds treatment and foliar fertilizing under conditions of right-bank forest-steppe Ukraine. *Ukrainian Journal of Ecology*, no. 10(1), pp. 101–105.

12. Mazur V., Didur I., Myalkovsky R., Pantsyreva H., Telekalo N., Tkach O. (2020). The productivity of intensive pea varieties depending on the seeds treatment and foliar fertilizing under conditions of right-bank forest-steppe Ukraine. *Ukrainian Journal of Ecology*, no. 10(1), pp. 101–105.

13. Mazur V.A., Didur I.M., Pantsyreva H.V., Telekalo N.V. (2018). Energy-economic efficiency of growth of grain-crop cultures in conditions of Right-Bank Forest-Steppe of Ukraine. *Ukrainian Journal of Ecology*, no. 8(4), pp. 26–33.

14. Mazur V.A., Didur I.M., Pantsyreva H.V., Telekalo N.V. (2018). Energy-economic efficiency of growth of grain-crop cultures in conditions of Right-Bank Forest-Steppe of Ukraine. *Ukrainian Journal of Ecology*, no. 8(4), pp. 26–33.

15. Mazur V.A., Mazur K.V., Pantsyreva H.V. (2019). Influence of the technological aspects growing on quality composition of seed white lupine (Lupinus albus L.) in the Forest Steppe of Ukraine. *Ukrainian Journal of Ecology*, vol. 9, pp. 50–55. URL: https://www.ujecology.com/archive.html

16. Mazur V.A., Mazur K.V., Pantsyreva H.V., Alekseev O.O. (2018). Ecological and economic evaluation of varietal resources Lupinus albus L. in Ukraine *Ukrainian Journal of Ecology*, vol. 8, pp. 148–153.

17. Mazur V.A., Pantsyreva H.V. (2020). «Rid Lupinus L. v Ukraini: henofond, introduktsiia, napriamy doslidzhen ta perspektyvy vykorystannia». *VNAU*, p. 235.

18. Mazur V.A., Pantsyreva H.V., Didur I.M., Prokopchuk V.M. (2018). Liupyn bilyi. Henetychnyi potentsial ta yoho realizatsiia u silskohospodarske vyrobnytstvo. *VNAU*, p. 231.

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