CHAPTER «AGRICULTURAL SCIENCES»

EFFICIENCY OF GROWING LEGUMES CROPS IN UKRAINE

Inna Honcharuk[1]
Hanna Pantsyreva[2]

DOI: https://doi.org/10.30525/978-9934-26-021-6-31

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

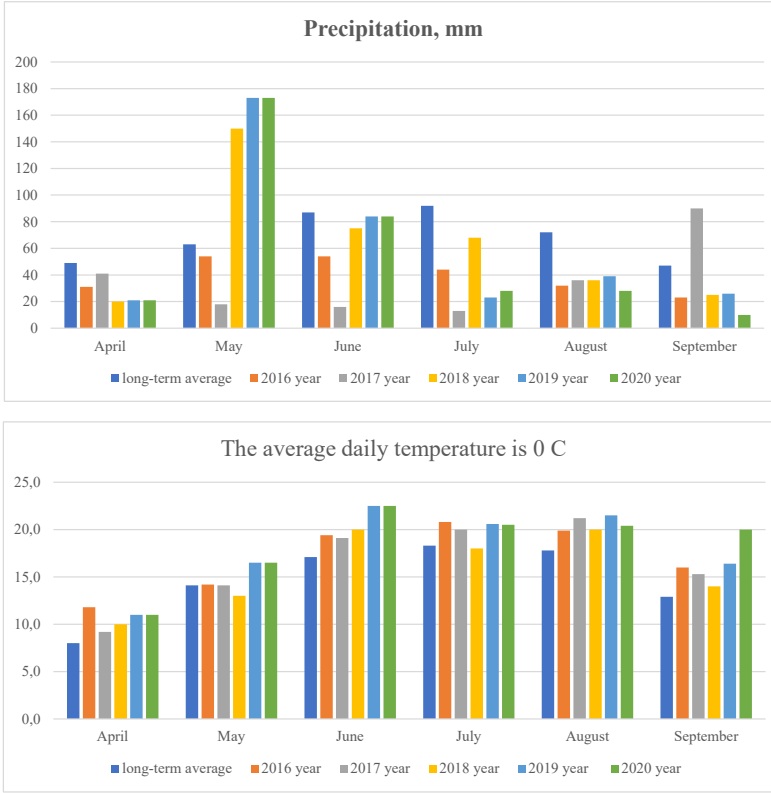

Figure 1. Average daily air temperature and precipitation for 2016–2020 (according to the Vinnytsia Regional Center for Hydrometeorology)

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

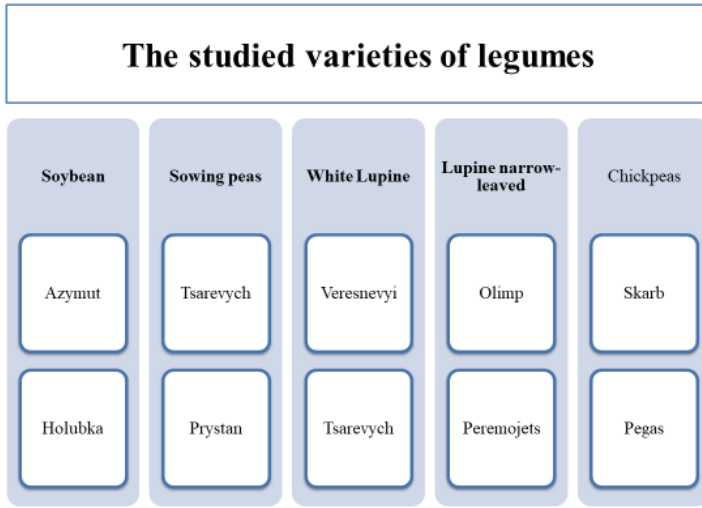

Figure 2. The studied varieties of legumes

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 opыta (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.