Journal of Ecological Engineering

ISSN 2299-8993

JEE Journal of Ecological Engineering
ISSN 2299-8993

Editorial Board

Influence of Irrigation Levels on Morphological Attributes and Yield of Tomato under Current and Climate Change Conditions

Roaya M. Abdoun, Omaima S. Darwish, Fadl A. Hashem, Said A. Shehata

J. Ecol. Eng. 2023; 24(12):1–15
DOI: https://doi.org/10.12911/22998993/171526

Abstract Article (PDF) Stats

Ozone Method Recycling Domestic Waste To Prevent Waste Water Pollution

Edi Rusdiyanto, Abdillah Munawir, Nurhasanah Nurhasanah, Imam Rozali Fathar, Jose Carlos Mierzwa

J. Ecol. Eng. 2023; 24(12):16–28
DOI: https://doi.org/10.12911/22998993/171805

Abstract Article (PDF) Stats

Water for Human Consumption in Rural Areas Worldwide: A Systematic Review of the Presence of *Cryptosporidium* spp. and *Giardia* spp.

Débora Pereira da Silva, Andressa Caroline de Sousa, Paulo Sergio Scalize

J. Ecol. Eng. 2023; 24(12):29–45
DOI: https://doi.org/10.12911/22998993/172052

Abstract Article (PDF) Stats

Comparative Assessment of Gamma-Polyglutamic Acid and Bacillus subtilis cells as Biostimulants to Improve Rice Growth and Soil Quality

Neti Ngearnpat, Orawan Chunhachart, Nuchnapa Kotabin, Kritchaya Issakul

J. Ecol. Eng. 2023; 24(12):46–59
DOI: https://doi.org/10.12911/22998993/172054

Abstract Article (PDF) Stats

Measurement of Exhaust Emissions from a Two-wheeler – an Experimental Validation of the Remote-Sensing Method

Łukasz Rymaniak, Monika Mąka, Natalia Szymlet, Michalina Kamińska, Aleksandra Kęska

J. Ecol. Eng. 2023; 24(12):60–71
DOI: https://doi.org/10.12911/22998993/171900

Abstract Article (PDF) Stats

Characterization of Chromium (VI) Interaction with Rivers Sediments-in Relation to the Composition

Sarah Azzouz, Boukhalfa Chahrazed

J. Ecol. Eng. 2023; 24(12):72–78
DOI: https://doi.org/10.12911/22998993/172088

Abstract Article (PDF) Stats

Distribution of Microplastics in Domestic Wastewater and Microplastics Removal Potential in Wastewater Treatment Plants

Mhd. Fauzi, Yeggi Darnas, Cut Rauzatun Muna, Muhammad Nizar

J. Ecol. Eng. 2023; 24(12):79–86
DOI: https://doi.org/10.12911/22998993/172293

Abstract Article (PDF) Stats

Assessment of Exposure to Particulate and Microbiological Contaminants in a Lecture Room

Łukasz Guz, Sławomira Maria Dumała, Anna Badora, Dariusz Gaweł

J. Ecol. Eng. 2023; 24(12):87–98
DOI: https://doi.org/10.12911/22998993/172058

Abstract Article (PDF) Stats

Assessment of Community Structure of Macroinvertebrates, Coral Cover and Water Quality in Sempu Strait, Malang Regency, East Java

Andik Isdianto, Andi Kurniawan, Agus Dwi Wicaksono, Muhammad Zaidan Taufik, Berlania Mahardika Putri, Aulia Lanudia Fathah, Arief Setyanto, Oktiyas Muzaky Luthfi, Dwi Candra Pratiwi, Nuddin Harahab

J. Ecol. Eng. 2023; 24(12):99–111
DOI: https://doi.org/10.12911/22998993/172353

Abstract Article (PDF) Stats

Analysis of Field Data for Risk Assessment of Vapor Intrusion at a Trichloroethylene-contaminated Site – A Case Study in Taiwan

Chiu-Shia Fen, Yi-Li Zhuang, Yu-Cheng Lee, Yuan Long Lin, Yangting Huang, Shu-An Lee

J. Ecol. Eng. 2023; 24(12):112–123
DOI: https://doi.org/10.12911/22998993/172505

Abstract Article (PDF) Stats

Ecological and Economic Aspects of the Formation of Highly Productive Soybean Crops

Victor Mazur, Olha Alieksieieva, Kateryna Mazur, Oleksii Alieksieiev

J. Ecol. Eng. 2023; 24(12):124–129
DOI: https://doi.org/10.12911/22998993/173008

Abstract Article (PDF) Stats

Possibility of Water Saving in Processing of Snack Pellets by the Application of Fresh Lucerne Sprouts: Selected Aspects and Nutritional Characteristics

Maciej Combrzyński, Agnieszka Wójtowicz, Beata Biernacka, Tomasz Oniszczuk, Marcin Mitrus, Jakub Soja, Renata Różyło, Karolina Wojtunik-Kulesza, Kamila Kasprzak-Drozd, Anna Oniszczuk

J. Ecol. Eng. 2023; 24(12):130–142
DOI: https://doi.org/10.12911/22998993/173009

Abstract Article (PDF) Stats

Catalytic Ozonation of Ponceau 4R Using Multifunctional Magnetic Biochar Prepared from Rubber Seed Shell

Hung Minh Nguyen, Tram Bao Truong, Hong-Hue Thi Nguyen, Phong Thanh Tran, Tuyet-Mai Tran-Thuy, Long Quang Nguyen, Dung Van Nguyen

J. Ecol. Eng. 2023; 24(12):143–151
DOI: https://doi.org/10.12911/22998993/172919

Abstract Article (PDF) Stats

Evaluation of the Efficiency of Energy Populus (Poplar) Growing Technology as an Alternative Source of Energy

Nadiia Lys, Nadiia Tkachuk, Andrii Butenko, Maksym Kozak, Anton Polyvanyi, Vitalii Kovalenko, Viktoriia Pylypenko, Serhii Andrukh, Yevheniia Livoshchenko, Ludmila Livoshchenko

J. Ecol. Eng. 2023; 24(12):152–157
DOI: https://doi.org/10.12911/22998993/173006

Abstract Article (PDF) Stats

Adsorption of Iron and Manganese Ions from Mine Acid Water Using Manganese Green Sand in Batch Process

Esthi Kusdarini, Putri Rizka Sania, Agus Budianto

J. Ecol. Eng. 2023; 24(12):158–166
DOI: https://doi.org/10.12911/22998993/173007

Abstract Article (PDF) Stats

Correlation Between Hydrochemical Component of Surface Water and Groundwater in Nida Valley, Poland

Cong Ngoc Phan, Andrzej Strużyński, Tomasz Kowalik

J. Ecol. Eng. 2023; 24(12):167–177
DOI: https://doi.org/10.12911/22998993/172424

Abstract Article (PDF) Stats

Effect of Biological Pretreatment on Anaerobic Sewage Sludge Digestion: Using Growth Media for Methanogenic Bacteria and Kinetic Studies for Biogas Yield

Khadija Lihi, Nabila Auajjar, Inass Hamdi, Benaissa Attarassi, Kaouatar Echchayeb

J. Ecol. Eng. 2023; 24(12):178–186
DOI: https://doi.org/10.12911/22998993/173063

Abstract Article (PDF) Stats

Fungal Treatment and Wheat Straw Blend for Enhanced Animal Feed from Olive Pulp

Mohamed Benaddou, Hassan Hajjaj, Mohammed Diouri

J. Ecol. Eng. 2023; 24(12):187–200
DOI: https://doi.org/10.12911/22998993/172423

Abstract Article (PDF) Stats

Analysis of the Solubility of a Support Filament Made of a Copolymer of Vinyl Alcohol and Butanediol in Aqueous Solutions with Variable pH

Magdalena Paśnikowska-Łukaszuk, Arkadiusz Urzędowski, Magda Wlazło, Dominika Mikušová, Jacek Zaburko

J. Ecol. Eng. 2023; 24(12):201–207
DOI: https://doi.org/10.12911/22998993/173568

Abstract Article (PDF) Stats

Innovations in Wastewater Treatment: Harnessing Mathematical Modeling and Computer Simulations with Cutting-Edge Technologies and Advanced Control Systems

Jakub Drewnowski, Bartosz Szeląg, Fabrizio Sabba, Magdalena Piłat-Rożek, Adam Piotrowicz, Grzegorz Łagód

J. Ecol. Eng. 2023; 24(12):208–222
DOI: https://doi.org/10.12911/22998993/173076

Abstract Article (PDF) Stats

Recent Developments in the Application of Ultrasonication in Pre-Treatment of Municipal Sewage Sludge

Aleksandra Szaja, Joanna Szulżyk-Cieplak, Sylwia Łagód, Elżbieta Kuzioła

J. Ecol. Eng. 2023; 24(12):223–234
DOI: https://doi.org/10.12911/22998993/173064

Abstract Article (PDF) Stats

Protein, Amino Acid and Carbohydrate Content of Fungal Treated Annual and Perennial Wheat Straw

Meruyert Kurmanbayeva, Zhaksylyk Makhatov, Adil Kusmangazinov, Dina Karabalayeva, Nurgul Yerezhepova

J. Ecol. Eng. 2023; 24(12):235–246
DOI: https://doi.org/10.12911/22998993/173065

Abstract Article (PDF) Stats

Impact of Pyrolysis Temperature on the Removal of Nutrients Using Coarse Rice-Husk Biochar

Tivany Edwin, Mas Mera, Puti Sri Komala, Zulkarnaini Zulkarnaini

J. Ecol. Eng. 2023; 24(12):247–257
DOI: https://doi.org/10.12911/22998993/173379

Abstract Article (PDF) Stats

Assessing a Low-Cost Multi-Media Filter with Biological Contact Aeration for Greywater Treatment in Domestic Applications

Abdelkader T. Ahmed, Md. Shafiquzzaman, Amimul Ahsan

J. Ecol. Eng. 2023; 24(12):258–267
DOI: https://doi.org/10.12911/22998993/173414

Abstract Article (PDF) Stats

Marine Microalgae Assemblages of the East Java Coast Based on Sub-Habitats Representatives and Their Relationship to the Environmental Factors

Mohammad Mahmudi, Sulastri Arsad, Muhammad Musa, Evellin Dewi Lusiana, Nanik Retno Buwono, Analicia Dwi Indahwati, Irmawati Irmawati, Nabilla Artanti Sukmaputri, Aisyah Lingga Prasasti, Alfina Pagita Larasati, Alma Alifah Syifa' Sharfina, Prayuda Rifqi Aldhiya, Rahmi Mutiara, Septania Gita Putri

J. Ecol. Eng. 2023; 24(12):268–281

DOI: https://doi.org/10.12911/22998993/173580

Abstract Article (PDF) Stats

Exploring Cacao Husk Waste: Surface Modification, Characterization, and its Potential for Removing Phosphate and Nitrate Ions

Nuraini Nuraini, Ilham Mufandi, Siti Jamilatun, Aster Rahayu

J. Ecol. Eng. 2023; 24(12):282–292

DOI: https://doi.org/10.12911/22998993/174003

Abstract Article (PDF) Stats

Modeling of Waste Vegetable Oil Biodiesel for Tractor Engine Utilization

Munaf D.F. Al-Aseebee, Ahmed Ketata, Ahmed E. Gomaa, Olfa Moussa, Zied Driss, Mohamed Salah Abid, Ahmed Samir Naje, Haitham H. Emaish

J. Ecol. Eng. 2023; 24(12):293–303

DOI: https://doi.org/10.12911/22998993/173564

Performance of Compact Bio-Contact Oxidation Reactors for Municipal Wastewater Treatment Under Different Hydraulic Retention Time

Ameera Mohamad Awad, Husham T. Ibrahim, Ali H. Al-Aboodi

J. Ecol. Eng. 2023; 24(12):304–318

DOI: https://doi.org/10.12911/22998993/173579

Abstract Article (PDF) Stats

Combined Effect of Silicon Dioxide and Titanium Dioxide Nanoparticles on Concrete Properties

Raed Al-Rbaihat, Mohammad Nour Ibrahim Al-Marafi

J. Ecol. Eng. 2023; 24(12):319–335

DOI: https://doi.org/10.12911/22998993/173210

Abstract Article (PDF) Stats

Application of the QuEChERS Method for the Analysis of Contamination by Pesticide Residues in the Sediments of Three Moroccan lagoons

Rachida Fegrouche, Hicham Dahak, Taha El Kamli, Mohammed Oussekour, Saida Zaza, Abdelkrim Ben Salem, Badreddine Benyacoub

J. Ecol. Eng. 2023; 24(12):336–345

DOI: https://doi.org/10.12911/22998993/173498

Abstract Article (PDF) Stats

JEE Journal of Ecological Engineering

Journal of Ecological Engineering 2023, 24(12), 124–129
https://doi.org/10.12911/22998993/173008
ISSN 2299–8993, License CC-BY 4.0

Received: 2023.09.06
Accepted: 2023.10.21
Published: 2023.11.04

Ecological and Economic Aspects of the Formation of Highly Productive Soybean Crops

Victor Mazur[1*], Olha Alieksieieva[1], Kateryna Mazur[1], Oleksiy Alieksieiev[1]

[1] Vinnytsia National Agrarian University, Sonyachna St. 3, 21008 Vinnytsia, Ukraine

* Corresponding author's e-mail: victormazur@ukr.net

ABSTRACT

For the successful development of the agricultural sector, one of the main tasks during the cultivation of agricultural crops is the rational use of land resources and obtaining the highest possible quality of products with low labor costs. The practical value of the scientific article lies in the improvement of the elements of the technology of growing soybean varieties that differ in groups of maturity. The development of ecological and economic technological parameters made it possible to ensure the seed yield, depending on the maturity groups of high-tech varieties, up to 2.91 t/ha with high production profitability. The object of researchinvolved the processes of growth, development and formation of the soybean seed crop, as well as its quality depending on the developed technological parameters. The subject of research comprised soybean varieties, pre-sowing treatment of seeds with a bacterial preparation and a growth regulator. It was determined that soybean belongs to the high-protein strategic agricultural crop of Ukraine and the world. Providing the population with protein food is a global problem, because the increase in population significantly exceeds the production of protein products. Soy, which is characterized by a rare chemical composition, plays an important role in solving this problem – its seeds contain 38–42% protein, 18–32% fat, 25–30% carbohydrates, enzymes, vitamins, minerals, many essential amino acids with a significant degree of solubility and nutrition. This feature has a positive effect on the environment and allows obtaining ecologically clean products. The cultivation of soybeans is of great agrotechnical importance, as it is a good precursor for the cultivation of the vast majority of agricultural crops. However, the determining factor for obtaining a high yield of soybeans is the variety. On the basis of the research results, their economic analysis and with the aim of growing high soybean yields at the level of 2.91 t/ha, the agro-forming of the right-bank forest-steppe of Ukraine recommended sowing the intensive soybean variety Sandra – carrying out pre-sowing treatment of soybean seeds with the bacterial preparation Rizotorphin in combination with the growth regulator Vermyst. Therefore, the scientific work is devoted to researching the yield and nutritional value of soybeans of different varieties depending on the inoculation of seeds with bacterial preparations and treatment with growth regulators, which is relevant as well as of scientific and practical interest in the field of ecologically oriented growing technologies.

Keywords: soybean, variety, seed inoculation, growth regulators, environmentalization of agriculture, economic efficiency.

INTRODUCTION

The demand for soybeans as a high-protein oilseed crop has been increasing over the years, as the spectrum of its use has been expanding over the years (Petrychenko et al., 2018). Among legumes and oilseeds, it is one of the highly productive crops and, at the same time, one of the most demanding growing conditions. Therefore, when introducing new varieties into production, it is important to develop varietal agricultural technology that would ensure highly profitable production of products (Pantsyreva et al., 2020; Bakhmat et al., 2023). The development of a complex of agronomic measures that ensure a high yield of agricultural crops must be evaluated according to economic indicators. It is insufficient to judge the effectiveness of any of the elements of a complex of agricultural measures only by the level of productivity, since the costs of obtaining it should also be taken into account. That is, it is necessary to improve agrotechnical elements,

but also determine the payback of these measures and their economic efficiency for crop cultivation (Hnatiuk et al., 2019; Honcharuk et al., 2022; Pryshliak et al., 2022).

The problem of biological nitrogen was and remains relevant in agriculture. Its role is especially important under the conditions of deteriorating ecological situation and insufficient supply of agriculture with nitrogen fertilizers. The ecological expediency of using the process of biological nitrogen fixation for economic purposes is one of the main directions of modern agriculture today. This approach finds its technological application in the cultivation of grain and leguminous crops, including soybeans (Mazur et al., 2021; Pantsyreva, 2019; Choudhury et al., 2015).

Therefore, soybean forms an increased yield mainly due to symbiotic nitrogen at the early formation of nodules and highly effective symbiosis. The amount of nitrogen, which is necessary for maintaining the growth and development of plants before being included in the process of nitrogen fixation, is small and can be provided by its soil reserves. The role of starting doses of nitrogen fertilizers, especially on poor soils, to protect plants against a possible lack of nitrogen in the event of a delay in the appearance of nodules, their slow development under adverse conditions, is not excluded (Monarkh and Pantsyreva, 2019). Considering that the presence of nitrogen in the ammonia form in plants is related to nitrogen fixation and nitrogen consumption from the soil, whereas the content of nitrate nitrogen is exclusively from mineral nutrition, a decrease in the ratio of ammonia nitrogen to nitrate indicates a decrease in the share of symbiotic nitrogen in soybean nutrition when nitrogen fertilizers are applied (Mazur et al., 2020; Choudhury et al., 2021).

MATERIAL AND METHODS

The research on the effect of pre-sowing seed treatment on the productivity of soybean varieties was conducted during 2021–2023 in the field experiment of the Vinnytsia National Agrarian University. The sown area of the plot was 25 m^2, and the accounting area was 20 m^2, the experiment was repeated four times. Two varieties of different maturity groups were chosen for the research: precocious Legenda, precocious Sandra. Soybean sowing rate was 650.000 similar seeds/ha. The experiment studied the effectiveness of the inoculant and growth regulator against the background of mineral fertilizer N30P60K60. The method of sowing is wide-row (45 cm), the depth of sowing seeds is 3–4 cm. The control option was the treatment of seeds with water at the rate of 8 l/t of seeds against the background of mineral fertilizer $N_{30}P_{60}K_{60}$. Mineral fertilizers were used in the form of ammonium nitrate (34.4%), granular superphosphate (19.8% P_2O_5) and kalimagnesia (28.0% K_2O) for pre-sowing cultivation. Inoculation of soybean seeds with a bacterial preparation based on a highly active strain of symbiotic nitrogen-fixing bacteria Bradyrhizobium japonicum with the preparation Rizotorfin (3 kg/t of seeds) was carried out on the day of sowing, according to the "Recommendations for the effective use of biological preparations of nitrogen-fixing and phosphorus-mobilizing bacteria in modern resource conservation of agriculture". The predecessor is winter wheat. The right-bank forest-steppe zone of Ukraine is located in the continental region of the climate zone of moderate latitudes and is characterized by a moderately continental climate with mild winters with little snow and hot, dry summers. The average temperature in January changes from the southwest to the northeast from –2 to –9°C; July – from +20 to +24°C. The annual amount of precipitation in some years decreases from 550 to 500 mm. The annual intake of total radiation is 115–116 kcal/cm^2, of which 94–95 kcal/cm^2 is received during the growing season. The arrival of photosynthetic active radiation during the vegetation period is equal to 45–50 kcal/cm^2. The plants growing on these soils receive a high amount for consumption of mobile phosphorus 214 mg/kg and exchangeable potassium 104 mg/kg (according to Chirikov). However, it was established that the content of easily hydrolyzed nitrogen is very low and amounts to 43.5 mg/kg (according to Kornfield) (Puyu et al., 2021; Ivanyshyn et al., 2021; Ivanov et al., 2019; Bulgakov et al., 2023; Kaletnik and Lutkovska, 2020).

RESULTS AND DISCUSSION

The increase in the area under soybean crops and the use of modern technology does not solve the current problems, because today the main task is to increase the yield of soybean grain by introducing modern elements of agricultural

technology (Honcharuk, 2020). Currently, many research institutions and agrarian universities of Ukraine are engaged in selection and research of elements of soybean cultivation technologies, including the Vinnytsia National Agrarian University. Soy is a valuable fodder crop. It can be fed to animals in the form of cake, soybean meal, grist, milk, protein concentrates, green fodder, hay, silage, straw. Cake can be used as a universal protein concentrate feed. It contains 1.26 feed units, 354 g of digestible protein, 28 g of lysine in 1 kg.

Through the conducted research, it was established that under the conditions of the right-bank forest-steppe, the duration of the growing season and individual phenological phases of growth and development of soybean plants was largely determined by the hydrothermal conditions of the year, varietal characteristics, and the effect of technological factors. In general, the vegetation period of the studied soybean varieties under the influence of fertilization, seed inoculation and weather conditions varied within 91–119 days, and the Legend variety ripened earlier than the Sandra variety (Table 1).

It was established that seed treatment contributed to the extension of the growing season of soybeans by 1–4 days, which ensured the accumulation of a larger amount of plastic substances and their better outflow into the reproductive organs and the formation of a high yield of soybean grains. It was the creation of an optimal nutritional regime in soybean crops of different maturity groups through pre-sowing treatment of seeds, application of mineral fertilizers in the norm of $N_{30}P_{60}K_{60}$ that contributed to more intensive development and slowing down of aging processes. The maximum height of the plants was recorded in the option of applying mineral fertilizer at the rate of $N_{30}P_{60}K_{60}$, and pre-sowing seed treatment with Rizotorfin and Vermistim, as a result of which it was greater than the height of the plants of the control option by 30.2 cm and 28.6 cm, respectively. Plants of the Sandra variety reached 86.5 cm, of the Legend variety –70.1 cm. Soybean varieties on the control variant had the lowest plant growth indicators. The lowest indicators on average were: Sandra variety 56.3 cm, Legend variety – 41.5 cm. The use of seed inoculation and growth regulator significantly increased this indicator in all variants throughout the growing season in both investigated soybean varieties, except for the initial period of development.

According to the research results, it was found that the more intensive growth of the leaf apparatus was observed in the phase of pouring beans. The highest indicators of the leaf surface area in the bean filling phase were recorded for the pre-sowing seed treatment of the bacterial preparation Rizotorfin and Vermystim, the area was 70.1 in the Sandira variety and 65.3 thousand m^2/ha. Under the control variant, the leaf surface area was 45.3 thousand m^2/ha (Table 2).

The maximum photosynthetic potential for the entire growing season, at the level of 2.86 million m^2 days/ha, was formed by sowing Sandra soybeans in the experimental variant with the application of $N_{30}P_{60}K_{60}$ fertilizer and seed inoculation with Rhizorthorphin in combination with the plant growth regulator Vermystym (Table 3).

When evaluating the effectiveness of technological methods of growing soybeans, an important criterion is the grain yield and its protein content. The highest yield of soybeans, depending on the pre-sowing seed treatment, was 2.91

Table 1. The duration of the main phases of growth and development of soybean plants

Pre-sowing treatment of seeds	Sowing – full ladder	The main periods of growth and development			
		Full emergence is the beginning of flowering	Beginning of flowering – the end of flowering	The end of flowering is full ripeness	Full growth means full maturity
Sandra					
1. No treatment control*	12	35	36	44	117
2. Risothorphine	12	35	37	45	118
3. Vermystym	11	35	37	45	118
4. Risothorphine + Vermystym	11	34	38	46	119
Legend					
1. No treatment	11	30	25	37	91
2. Risothorphine	11	30	25	38	92
3. Vermystym	10	30	26	38	92
4. Risothorphine + Vermystym	10	29	26	39	93

Table 2. Soybean leaf surface area, thousand m^2/ha

Pre-sowing treatment of seeds	Phases of growth and development		
	budding	flowering	pouring beans
Legend			
1. No treatment control*	14.7	29.9	45.3
2. Risothorphine	16.1	43.3	60.4
3. Vermystym	17.8	45.4	65.6
4. Risothorphine + Vermystym	21.9	49.5	70.1
Sandra			
1. No treatment	12.8	27.8	43.1
2. Risothorphine	15.2	33.9	54.5
3. Vermystym	16.7	36.7	59.9
4. Risothorphine + Vermystym	19.7	40.3	65.3

Table 3. Dynamics of formation of photosynthetic potential in soybean varieties, thousand m^2 days/ha

Pre-sowing treatment of seeds	Variety	
	Sandra	Legend
1. No treatment control*	2.40	2.14
2. Risothorphine	2.61	2.24
3. Vermystym	2.80	2.39
4. Risothorphine + Vermystym	2.86	2.45

t/ha in the middle-early soybean variety Sandra, and 2.51 t/ha in the early-maturing soybean variety Legend (Table 4).

When analyzing the yield of soybeans on the variants of the experiment with the combined application of the factors that were set to study the yield of inoculated plants on the variant without fertilizers, it is necessary to note the increase in grain yield when inoculating seeds with the strain Br.japonicum 71T with the drug Rizotorphin – 0.17 and 0.18 t/ha. Therefore, on average, over two years of research, the highest productivity indicators – 2.91 t/ha – were obtained by the Sandra variety, while the Legend variety achieved 2.51 t/ha. According to the results of dispersion analysis, it was found that pre-sowing seed treatment had a significant influence on the formation of high-yielding soybean crops – 56%, about 34% was allocated to varieties, and other factors took up to 10%.

The high content of protein and its extremely valuable balance in terms of amino acid composition make soy an excellent substitute for animal products in human nutrition (Mazur et al., 2019; Gundersen et al., 1994; Brzozowska et al., 2018). Sauces, milk, cheese, cutlets, egg powder substitutes, confectionery, sausages, canned food, etc. are made from soy. When consuming soy products, one should listen very carefully own body, because the specifics of assimilation of this food depend both on individual properties and on the production technology (Mazur, 2018; Didur et al., 2019).

As a result of the investigated technological aspects of soybean cultivation, photosynthesis occurs more intensively in the leaves and the prerequisites for biological nitrogen fixation by nodule bacteria are created, which in turn is the foundation for the synthesis of protein, fat, enzymes, amino acids, vitamins, carbohydrates

Table 4. Soybean seed yield depending on pre-sowing seed treatment, t/ha

Pre-sowing treatment of seeds	Variety	
	Sandra	Legend
1. No treatment control*	2.45	2.19
2. Risothorphine	2.67	2.29
3. Vermystym	2.85	2.44
4. Risothorphine + Vermystym	2.91	2.51
LSD 0.05 t/ha; 2021–2023 A – 0.03; B – 0.12; C – 0.02; AB – 0.09; AC – 0.08; VS – 0.09; ABC – 0.03. Grade – A; Pre-sowing treatment of seeds – B; Years of research – C.		

Table 5. Chemical composition of soybean seeds depending on pre-sowing seed treatment, %

Pre-sowing treatment of seeds	Variety			
	Sandra		Legend	
	Content in seeds, %		Content in seeds, %	
	protein	fat	protein	fat
1. No treatment control*	33.01	21.02	32.91	21.00
2. Risothorphine	33.29	21.21	33.24	21.16
3. Vermystym	33.42	21.34	33.40	21.29
4. Risothorphine + Vermystym	33.89	21.44	33.78	21.39
LSD 0.05 t/ha; 2021–2023 A – 0.03; B – 0.12; C – 0.02; AB – 0.09; AC – 0.08; BC – 0.09; ABC – 0.03. Grade – A; Pre-sowing treatment of seeds – B; Years of research – C.				

and other compounds. The chemical composition of soybean seeds, depending on the pre-sowing treatment of the seeds, is shown in Table 5.

It was found that the field studies confirmed the positive effect on the chemical composition of soybean seeds of the use of pre-sowing seed treatment with bacterial preparations and plant growth regulators. Depending on these factors, the protein content in the seeds varied from 32.91 to 33.89%, the fat content from 21.00 to 21.39%.

CONCLUSIONS

Studying the effect of pre-sowing seed treatment on soybean productivity allows drawing the following conclusions: the duration of the growing season was significantly influenced by weather conditions during the growing season of plants. The longest growing season of plants in all research variants was noted in 2023 and was 118–120 days in the Sandra variety, 92–94 days in the Lekenda variety. In 2022, under the influence of prolonged droughts, the growing season of plants was significantly shortened. The maximum height of the plants was recorded in the option of using mineral fertilizer in the norm $N_{30}P_{60}K_{60}$, and pre-sowing treatment of seeds with Rizotorfin and Vermistim, as a result of which it was greater than the height of the plants of the control option by 30.2 cm and 28.6 cm. Plants of the Sandra variety reached 86.5 cm, while those of the Legend variety – 70.1 cm. The highest values of the leaf surface area in the bean filling phase were recorded with the use of the bacterial drug Rizotorfin and Vermystim in the pre-sowing treatment of seeds, the area was 70.1 cm in the Sandira variety and – 65.3 thousand m^2 /ha. Under the control variant, the leaf surface area was 45.3 thousand m^2/ha. The maximum photosynthetic potential for the entire growing season, at the level of 2.86 million m^2 days/ha, was formed by the sowing of Sandira soybeans on the experimental variant with the application of $N_{30}P_{60}K_{60}$ fertilizer and seed inoculation with Rhizorthorphin in combination with the plant growth regulator Vermyst. The high photosynthetic potential of plants on the specified variant, compared to non-inoculated plants on a non-fertilized background (control) – 2.40 million m^2 days/ha. The highest yield of soybeans, depending on the pre-sowing seed treatment, was 2.91 t/ha in the medium-early soybean variety Sandra, and 2.51 t/ha in the early-maturing soybean variety Legend. It was found that the field studies confirmed the positive effect on the chemical composition of soybean seeds of the use of pre-sowing seed treatment with bacterial preparations and plant growth regulators. Depending on these factors, the protein content in the seeds varied from 32.91 to 33.89%, fat – from 21.00 to 21.39%.

REFERENCES

1. Puyu V., Bakhmat M., Pantsyreva H., Khmelianchyshyn Y., Stepanchenko V., Bakhmat O. 2021. Social-and-ecological aspects of forage production reform in Ukraine in the early 21st century. European Journal of Sustainable Development, 10(1), 221–228.
2. 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), 210–214. DOI: 10.15421/2020_33
3. Honcharuk I., Matusyak M., Pantsyreva H., Kupchuk I., Prokopchuk V., Telekalo N. 2022. Peculiarities of reproduction of Pinus nigra in Ukraine. Bulletin of the Transilvania University of Brasov,

Series II: Forestry, Wood Industry, Agricultural Food Engineering, 15(1), 33–42.

4. Mazur V., Didur I., Tkachuk O., Pantsyreva H., Ovcharuk V. 2021. Agroecological stability of cultivars of sparsely distributed legumes in the context of climate change. Scientific Horizons, 1(24), 54–60.
5. Mazur V.A., Myalkovsky R.O., Pantsyreva H.V., Didur I.M., Mazur K.V., Alekseev O.O. 2020. Photosynthetic productivity of potato plants depending on the location of rows placement in agrophytocenosis. Eco. Env. & Cons. 26(2), 46–55.
6. Ivanyshyn O., Khomina V., Pantsyreva H. 2021. Influence of fertilization on the formation of grain productivity in different-maturing maize hybrids Ukrainian Journal of Ecology. 11(3), 262–269.
7. Bakhmat M., Padalko T., Krachan T., Tkach O., Pantsyreva H., Tkach L. 2023. Formation of the Yield of Matricaria recutita and Indicators of Food Value of Sychorium intybus by Technological Methods of Co-Cultivation in the Interrows of an Orchard. Journal of Ecological Engineering, 24(8), 250–259. DOI: https://doi.org/10.12911/22998993/166553
8. Kaletnik G., Lutkovska S. 2020. Strategic Priorities of the System Modernization Environmental Safety under Sustainable Development. Journal of Environmental Management and Tourism, 11, 5(45), 1124–1131.
9. Pryshliak N., Pronko L., Mazur K., Palamarenko Y. 2022. The development of the state strategy for biofuel production from agrobiomass in Ukraine. Polityka Energetyczna. Vol. 25 (2). P. 163–178.
10. 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. DOI: 10.15421/2019_71
11. Hnatiuk T.T., Zhitkevich N.V., Petrychenko V.F., Kalinichenko A.V., Patyka V.P. 2019. Soybean Diseases Caused by Genus Pseudomonas Phytopathenes Bacteria. Mikrobiol. 81(3), 68–83. doi: https://doi.org/10.15407/microbiolj81.03.068
12. Petrychenko V.F., Kobak S.Ya., Chorna V.M., Kolisnyk S.I., Likhochvor V.V., Pyda S.V. 2018. Formation of the Nitrogen-Fixing Potential and Productivity of Soybean Varieties Selected at the Institute of Feeds and Agriculture of Podillia of NAAS. Mikrobiol. 80(5), 63–75.
13. Mazur, V.A., Pantsyreva, H.V., Mazur, K.V., Monarkh, V.V. 2019. Ecological and biological evaluation of varietal resources Paeonia L. in Ukraine. Acta Biologica Sibirica. 5(1), 141–146. https: //doi.org/10.14258/abs.v5.i1.5350
14. 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, 9(1), 9–14.
15. Gundersen D.E., Lee I-M., Rehner S.A., Davis R.E., Kingsbury D.T. 1994. Phylogeny of mycoplasma-like organisms (phytoplasmas), a basis for their classification. J. Bacteriol. 176, 5244–54. https://doi.org/10.1128/jb.176.17.5244–5254.1994
16. Mazur V.A. 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
17. Brzozowska A., Dacko M., Kalinichenko A., Petrychenko V., Tokovenko I. 2018. Phytoplasmosis of Bioenergy Cultures. Mikrobiol. Z. 80(4), 108–127. doi: https://doi.org/10.15407/microbiolj80.04.108
18. Didur I.M., Prokopchuk V.M., Pantsyreva H.V. 2019. Investigation of biomorphological and decorative characteristics of ornamental species of the genus Lupinus L. Ukrainian Journal of Ecology. 9(3), 287–290. DOI: 10.15421/2019_743
19. Monarkh V., Pantsyreva H. 2019. Stages of the Environmental Risk Assessment. Ukrainian Journal of Ecology. 9(4), 484–492. DOI: 10.15421/2019_779
20. Choudhury, M., Sharma, A., Singh, P., Kumar, D. 2021. Impact of climate change on wetlands, concerning Son Beel, the largest wetland of Northeast, India. Glob. Clim. Chang. 393–414. https://doi.org/10.1016/B978–0–12–822928–6.00006-X.
21. Chowdhury, P., Behera, M.R. 2015. A study on regional sea level variation along the Indian coast. Procedia Eng. 116, 1078–1084. https://doi.org/10.1016/j. proeng.2015.08.348.