Науково-технічний бюлетень Інституту олійних культур НААН, 2024, № 37: 76–86

УДК 633.3;631.5;631.8 DOI: 10.36710/IOC-2024-37-08

YIELD AND ECONOMIC EFFICIENCY OF SOYBEAN CULTIVATION IN DIFFERENT MODELS OF SHORT-ROTATION CROP ROTATIONS

Yu. V. Mashchenko, I. M. Sokolovska, O. M. Zvezdun
Institute of Agriculture of the Steppe NAAS,
Kherson State Agrarian and Economic University
Central Ukrainian National Technical University

The article highlights the current issues of soybean production as an important oilseed crop, presents ways to optimize the agro-technology of its cultivation in classical and crop rotations of mycorrhizal fungi with a short rotation period, provides an analysis of economic indicators, and offers recommendations for production. It was established that the highest soybean yield was obtained in a biologized crop rotation with a saturation of the crop up to 20% (1.72 t/ha). No significant difference was found between the yield levels in crop rotations with a saturation of 60% and 100%, which allows for the recommendation to use models with maximum soybean saturation or continuous cultivation in soybean crop rotations. The economic efficiency of soybean cultivation can be increased by using biopreparations in the combination of Mycofriend 1.5 l/t + Rizoline 2 l/t + Rizosave 1 l/t. and a cost-free element of technology – the crop rotation factor. The highest economic efficiency of soybean cultivation was found in a biologized crop rotation with a saturation of soybean up to 20%, where the gross product value amounted to 30503 UAH/ha, conditional net profit was 14299 UAH/ha, with a profitability of 88.6%.

Keywords: soybean, crop rotation models, crop rotations of mycorrhizal fungi, soybean yield, economic efficiency of oilseed cultivation.

Introduction. Soybean (Glycine max) is the most important oilseed crop among legumes in the world, accounting for 25% of global edible oil production. Soybean seeds are used for direct human consumption, as well as a source of oil and protein (Weiss 1983). Additionally, plant residues are of great importance as feed for cattle in many regions of the world (Rai et al. 2016).

According to the International Association of Vegetable Oils, commercial operations involving oilseed crops and fats worldwide include over 25 types of oilseeds, with more than 95% of global production concentrated in seven main types: soybean, rapeseed, cotton, sunflower, peanut, oil palm, and copra. The decline in soybean yields due to global factors such as climate change and outdated cultivation technologies may have implications for global food security due to reliance on soybean harvests, either directly or indirectly. The high nutritional value and versatile use of soybean products represent resources for addressing the world's food and energy challenges (Glen et al. 2011). Soybean is well-suited to help solve this problem.

Recently, there have been trends towards improving soybean processing technologies. These are aimed at increasing the efficiency of oil production and utilizing all other valuable components of the raw material (Ivashchuk et al. 2021; Kolyanovska et al. 2012).

Soybean processing products are known for their beneficial qualities and have

*Corresponding author

a wide range of uses: in food, feed, technical, and medical applications. In the food technology market, one can find soybean oil, lecithin, fermented or dairy products, non-fermented products, soybean additives, and more (Saleba 2022).

As soybean is a crop that supplies raw materials for various industries, processing technologies are crucial stages in the soybean value chain (Debaeke et al. 2022; Jablaoui et al. 2020; Kolianovska et al. 2024; Gasparetto et al. 2022; Hammond et al. 2005).

Researchers in different regions of Ukraine and across the continent are conducting scientific inquiries to address protein production issues, with a significant emphasis on soybean cultivation. The grains of this crop contain: 38–42% protein, 25–30% carbohydrates, and 18–23% fats (Mizernyk 2024).

The development of oil production significantly influences the increase in oilseed area, improved yields, and seed oil content. The main oilseed crops grown in Ukraine are sunflower, soybean, and winter rapeseed. In Ukraine, the area sown with soybeans is expanding, as this crop is a cost-effective source of protein that can replace meat and dairy products. In the context of global and local climate changes, significant shifts have occurred in the distribution of soybean sowing across soil-climatic zones: the share of soybean sowing has decreased in the Steppe zone while increasing in the Forest-Steppe and Polissya regions, particularly in areas where it was previously not cultivated. Both economic and agro-climatic factors have negatively impacted the volumes of this crop's production (Shpak 2023; Kostyukevich et al. 2021).

The implementation of short-rotation crop rotations with varying levels of legume saturation in modern agriculture allows not only for the optimization of agricultural crop cultivation technology but also for the preservation of soil fertility. In recent years, researchers at the Institute of Agriculture of the Steppe NAAS have actively studied the impact of crop rotation factors on crop productivity (Mashchenko et al. 2023a; Mashchenko et al. 2023b; Sokolovska et al. 2023a).

Achieving high results in agricultural production can also be accomplished through the active use of biotechnology. An important element of biological farming is the incorporation of leaf-stem mass and the use of biopreparations (Sokolovska et al. 2023b).

Research aim. Considering the relevance of soybean production as an oilseed crop, the aim of our research was to study the influence of classical and crop rotations of mycorrhizal fungi on the yield and economic efficiency of its cultivation in short-rotation crop rotations.

Materials and methods. Field studies were conducted from 2020 to 2024 in the fields of the agricultural laboratory of the Institute of Agriculture of the Steppe NAAS. Experiments were set up using a randomized complete block design.

Soybeans were grown in various short-rotation crop rotations with winter wheat as a predecessor. The experiment was two-factorial. Factor A – mycorrhizal fungi – seed inoculation with a combination of biopreparations: Mycofriend 1.5 l/t + Rizoline 2.0 l/t + Rizosave 1.0 l/t on the day of sowing; Factor B – short-rotation crop rotations with varying soybean saturation: 100%, 60%, 40%, and 20%.

In the experiment, the soybean variety Zlatoslava was cultivated. This variety was developed by breeders at the Institute of Agriculture of the Steppe NAAS, and has been included in the State Register of Plant Varieties of Ukraine since 2015. It is characterized by high resistance to drought, lodging, and shattering. Universal use variety (grain, feed, food). The recommended growing zones are the Steppe, Forest-

Steppe, and Polissya.

The technology for growing soybeans in crop rotations is generally accepted for the region, except for the practices that were studied. The general cultivation technology is as follows: the main tillage began with two times of peeling the stubble. The first peeling the stubble was done to a depth of 6–8 cm, followed by a second pass to a depth of 8–10 cm two to three weeks later (upon the emergence of weed seedlings). In the autumn, plowing was carried out to a depth of 25–27 cm. Pre-sowing soil preparation consisted of cultivation to a depth of 5 to 8 cm. If necessary, chemical weed control was applied using pre-emergent and post-emergent herbicides at recommended doses. Care for the crops included post-sowing rolling. Pest and disease control was conducted according to existing recommendations for the Steppe zone.

The establishment and conduct of the experiments were carried out according to the methodology of field research.

The weather conditions during the years of the study were not sufficiently favorable for achieving high soybean yield indicators.

The formation of productivity for late spring crops during 2020–2024 occurred under dry conditions. The hydrothermal coefficient from May to September 2020 was 0.75 (Figure 1).

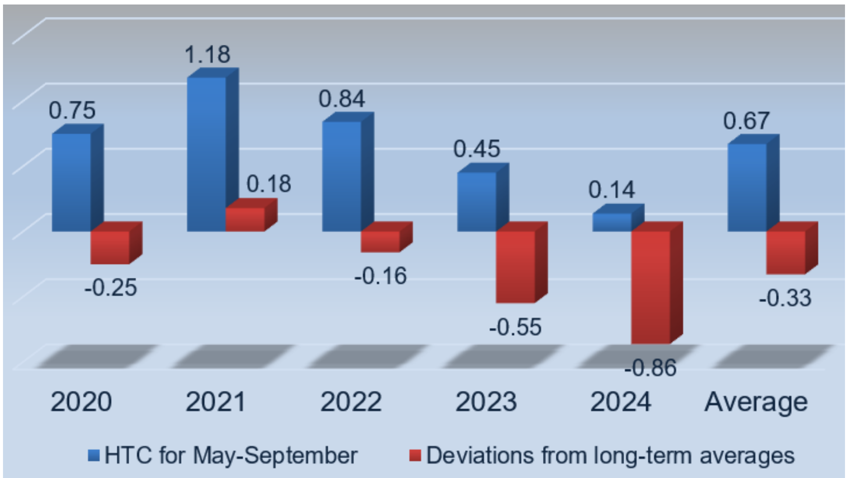

Fig. 1. **Hydrothermal indicators for the growing season of late spring crops, 2020-2024 (according to data from the Kirovohrad Hydrometeorological Center)**

The most favorable weather conditions (according to the hydrothermal coefficient) were observed in 2021. In May and June, the hydrothermal coefficient was 1.68, in August it was 1.18, and in September it was 1.59. From May to September, it averaged 1.37, which is 0.37 above the norm.

The hydrothermal indicator for 2022 during the growing season of late spring crops was 0.84 (with a norm of 1.0). Weather conditions in 2023 were generally dry and not sufficiently favorable for achieving high yield and productivity indicators. Analyzing the hydrothermal coefficient during the soybean growing season in 2024, it was found that in May it was 0.12 (norm 0.95), in June it was 0.25 (norm 1.18), in July it was 0.04 (norm 1.16), in August it was 0.16 (norm 0.80), and in September it was 0.13 (norm 0.86). The average hydrothermal coefficient from May to September was at a level of 0.14, with a norm of 1.0. Such challenging conditions during the growth, development, and formation of the generative organs of soybean plants had an extremely negative impact on yield and productivity levels.

Research results and their discussion. According to the results of the five-year study, higher soybean yields were achieved in 2021 when a sufficient amount of precipitation and optimal temperature conditions, especially during critical phases of development for the crop, contributed to the accumulation of a greater quantity of nutrients in the seeds. In that year, grain yield indicators ranged from 1.19 t/ha to 2.62 t/ha, with the variability of these indicators having the largest range – 1.43 t/ha. This indicates that favorable weather conditions for the crop enhance the effects of agrotechnical factors, and in our experiment, the difference in soybean yield between crop rotations with a saturation of 20% and 100% was 1.37 t/ha in classical rotations and 1.34 t/ha in biologized rotations (Figure 2). It should be noted that under such growing conditions, the effectiveness of biopreparations is somewhat reduced.

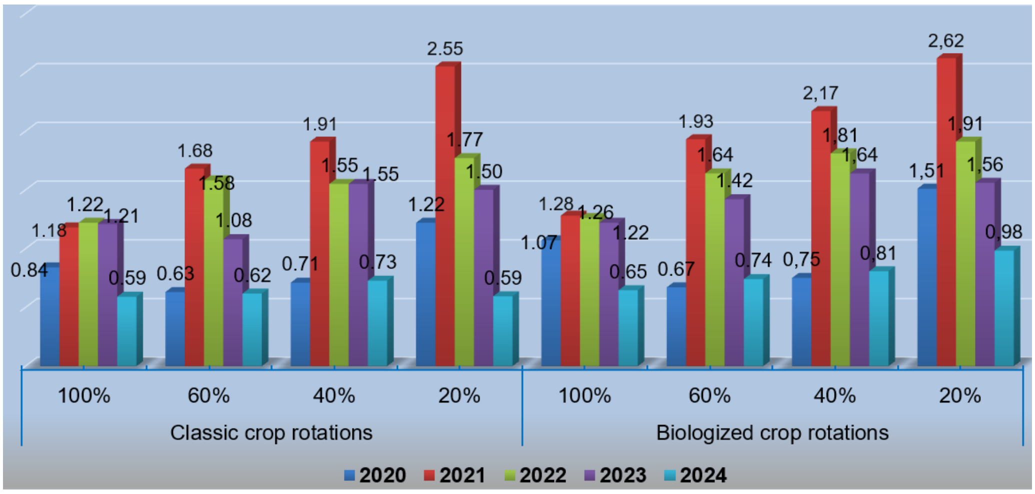

Fig. 2. **Soybean yield by year of study depending on the structure of crop rotation and use of biopreparations, t/ha**

In 2022, with a moisture coefficient of 0.84, soybean yield in the experiment ranged from 1.22 t/ha to 1.91 t/ha. Interestingly, in 2023 (with a hydrothermal coefficient of 0.45), despite moisture deficits during seed germination and at early growth stages (the amount of precipitation in May was 2.7 times less than normal and the air temperature was at 27–29°C), the rains that fell during the grain filling phase ensured soybean yields of 1.21 to 1.56 t/ha.

Confirmation that moisture and optimal temperature conditions during critical growth and development periods are essential for soybean plants to utilize their potential was evident in 2020. With a hydrothermal coefficient of 0.75, the grain yield was significantly lower than in 2022 and even in 2023, ranging from 0.84 t/ha to 1.22 t/ha in classical rotations and from 1.07 t/ha to 1.51 t/ha in biologized rotations. The weather and climatic conditions that year had a different impact on the productivity of plants in various crop rotations. For instance, the highest yield yields (0.84 t/ha in classical rotation and 1.07 t/ha in biologized rotation) were achieved with continuous soybean cultivation, while in the rotation with a 60% saturation of the crop, this figure was the lowest, at 0.63 t/ha and 0.67 t/ha, respectively. The cultivation of soybean in a biologized rotation with a 20% saturation of soybean achieved the highest grain yield in 2020 – 1.51 t/ha.

Particular attention is drawn to the results of soybean cultivation in 2024. The hydrothermal coefficient this year was at 0.14, with a moisture deficit from May to September amounting to 222.8 mm. Under such growing conditions, the grain yield ranged from 0.59 t/ha to 0.73 t/ha in classical rotations and from 0.65 t/ha to 0.98 t/ha in biologized rotations. This year, the effect of the crop rotation factor had the least effectiveness among the years of our research. The difference in yield when growing soybeans without the use of biopreparations was only 0.14 t/ha; moreover, it should be noted that for a 100 % and 20 % saturation of the rotation with soybean, the figures were identical – 0.59 t/ha. The rotation where soybean occupied two out of five fields was characterized by a higher yield level of the crop – 0.73 t/ha. Inoculating soybean seeds before sowing contributed to increased yield; furthermore, reducing the concentration of soybean in the rotation improved the indicators: 0.65 t/ha, 0.74 t/ha, 0.81 t/ha, and 0.98 t/ha for rotations with a saturation of soybean at 100%, 60%, 40%, and 20%, respectively.

We established a positive correlation between the hydrothermal coefficient and soybean grain yield. The closeness of the relationship between the indicators, according to the Cheddock scale, was moderate with $R^2 = 0.6507$, and the correlation coefficient was at the level of 0.80 (Figure 3).

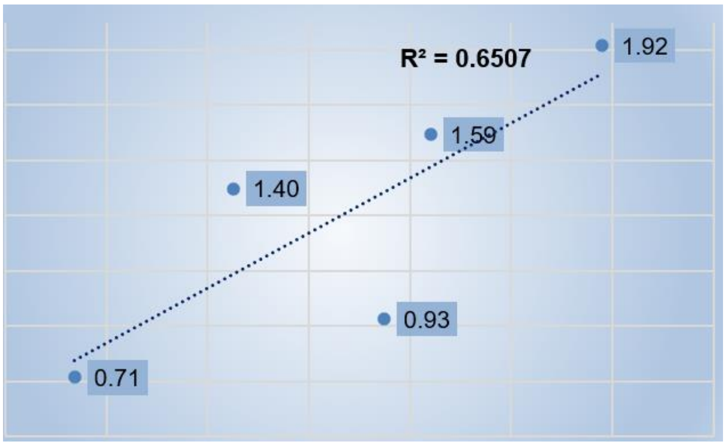

Fig. 3. **Correlation relationships between the natural moisture coefficient and soybean yield, 2020-2024**

Analysis of the average soybean yield in different crop rotation models indicates a significant influence of the factors we studied. For instance, the application of mycorrhizal fungi, such inoculation of seeds before sowing with biological preparations Mikofrend + Rizoline + Rizosave, provided a significant yield increase in crop rotations with 60%, 40%, and 20% saturation compared to the continuous soybean cultivation variant, yielding 0.16 t/ha (14.5%), 0.15 t/ha (11.03%), and 0.19 t/ha (12.4%) respectively. However, the difference between these crop rotation models for factor A at LSD_{05} of 0.13 t/ha was not significant, at 0.01-0.04 t/ha (Table 1).

The use combination of biopreparations Mikofrend + Rizoline + Rizosave in crop rotations with soybean saturation of up to 100% had no significant impact on the crop yield, with the difference between the crop rotation models amounting to 0.09 t/ha. The introduction of three, and especially two or one soybean fields into the crop rotation, that is, the crop rotation factor, had a more significant influence on the formation of soybean yield levels than element of mycorrhizal fungi. Nevertheless, higher yield increases were observed in biologized crop rotation. This indicates that the combined effect of the biopreparations and the structure of the crop rotation in our experiments was the most effective.

Table 1

Soybean yield in different crop rotation models, t/ha

Mycorrhizal fungi (factor A)	Crop rotation model (soybean saturation) (factor B)	Average, 2020-2024	Difference, factor A		Difference, factor B	
			t/ha	%	t/ha	%
Without biopreparations	100 %	1.01	-	-	-	-
	60 %	1.12	-	-	0.11	10.9
	40 %	1.29	-	-	0.28	25.2
	20 %	1.53	-	-	0.52	40.2
With use of a biopreparations	100 %	1.10	0.09	8.6	-	-
	60 %	1.28	0.16	14.5	0.18	16.9
	40 %	1.44	0.15	11.3	0.34	26.6
	20 %	1.72	0.19	12.4	0.62	43.3
LSD_{05} t/ha: factor A = 0,13; factor B = 0,19; factors AB = 0,27						

Thus, the highest yield level was achieved in the variant using a combination of biopreparations Mikofrend + Rizoline + Rizosave in a crop rotation with soybean saturation of up to 20%, yielding 1.72 t/ha.

Compared to continuous soybean cultivation, the yield increase amounted to 0.62 t/ha or 43.3%, which was the largest in the experiment. However, it should be noted that in biologized crop rotation where soybean made up 100% and 60% of the structure, no significant difference in yield was established, with yields of 1.10 t/ha and 1.28 t/ha respectively, LSD_{05} for factor B being 0.19 t/ha.

Without the use of biopreparations, the yield increase due to the crop rotation factor was somewhat lower, but the pattern observed was the same as in crop rotations of mycorrhizal fungi. Yield significantly increased in crop rotations with soybean saturation of 40% and 20%, with increases of +0.28 t/ha (25.2%) and +0.52 t/ha (40.2%) respectively. In classical crop rotations, soybean saturation of up to 100% and 60% did not significantly affect yield at the level of reliable difference, yielding 1.01 t/ha and 1.12 t/ha respectively.

Thus, all crop rotation models in 2021 were characterized by higher soybean yields when the hydrothermal coefficient in the research area were at a level of 1.18 units. Under such growing conditions, soybean yields ranged from 0.59 t/ha to 0.73 t/ha in classical rotations and from 0.65 t/ha to 0.98 t/ha in crop rotations of mycorrhizal fungi. In years when the combination of weather and climatic conditions was less favorable for the growth and development of soybean plants, yields decreased to 1.22-1.91 t/ha in 2022 and to 1.21-1.56 t/ha in 2023. Insufficient moisture and high air temperatures, especially during critical growth periods for the crop, negated the effects of agronomic measures, and the smallest difference between yield indicators was observed in 2024, with yields of 0.59-0.73 t/ha in classical rotations and 0.65-

0.98 t/ha in crop rotations of mycorrhizal fungi.

The highest soybean yield was obtained when used a combination of biopreparations Mikofrend + Rizoline + Rizosave in a crop rotation with a saturation of up to 20%, yielding 1.72 t/ha. The yield increase compared to the model with continuous soybean cultivation was 0.19 t/ha or 12.4% due to the influence of the mycorrhizal fungi, and 0.62 t/ha or 43.3% due to the crop rotation factor. Crop rotations with a concentration of the crop up to 100% and up to 60% did not differ significantly in soybean yield regardless of the use of biotechnology elements.

An important indicator that characterizes the results of the scientific work conducted, which can be used for practical implementation in production, is the economic analysis. To determine the economic efficiency of soybean cultivation, prices for services, seed, and harvested material that had formed in the Ukrainian market on October 20, 2024, were used.

For the average soybean yield established over five years of research, which was lowest in the variant of continuous cultivation (100% saturation of the crop rotation with soybean) without applying the mycorrhizal fungi (without using a biologically active preparation for seed treatment), the lowest production costs were incurred at 15451 UAH/ha (Table 2). However, in this variant, the lowest yield level resulted in the lowest value of produced goods – 17914 UAH/ha, and the least conditional net profit – 2426 UAH/ha, along with the lowest profitability of 15.7%.

Table 2

Economic efficiency of soybean cultivation depending on the element of mycorrhizal fungi and crop rotation model

Mycorrhizal fungi (factor A)	Crop rotation model (soybean saturation) (factor B)	Yield, t/ha	Production costs, UAH/ha	Cost of gross production, UAH/ha	Conditi-onal net profit, UAH/ha	Profitability, %
Without biopreparations	100	1.01	15451	17914	2426	15.7
	60	1.12	15473	19858	4351	28.1
	40	1.29	15507	22910	7326	47.2
	20	1.53	15555	27131	11526	74.1
With use of a biopreparations	100	1.10	16020	19460	3450	21.5
	60	1.28	16056	22746	6600	41.1
	40	1.44	16088	25508	9400	58.4
	20	1.72	16145	30503	14299	88.6

The use combination of biopreparations Mikofrend + Rizoline + Rizosave in the technological process of soybean cultivation, under conditions of continuous cultivation of the crop, contributed to an increase in profitability by 5.8% and a conditional net profit of 1024 UAH/ha.

In the absence of a biopreparations, it was found that reducing the concentration of soybeans in different crop rotation models contributed to an increase in economic indicators. For example, with 60% soybean saturation, the conditional net profit amounted to 4351 UAH/ha (profitability 28.1%), with 40% saturation – 7326

UAH/ha (profitability 47.2%), and with 20% saturation – 11526 UAH/ha (profitability 74.1%).

According to our research findings, in crop rotations of mycorrhizal fungi, as the soybean fields decreased from 60% to 20%, the conditional net profit increased the most under the influence of a combination of factors (biopreparations and crop rotation structure), rising from 6600 UAH/ha (60% soybean in the rotation) to 9400 UAH/ha (40% soybean in the rotation), reaching a maximum level of 14299 UAH/ha in the rotation where soybean constituted 20%.

In classical crop rotation models, the conditional net profit increased under the influence of the crop rotation factor, amounting to 4351 UAH/ha, 7326 UAH/ha, and 11526 UAH/ha for crop rotations with soybean saturations of 60%, 40%, and 20%, respectively.

The application of the mycorrhizal fungi in crop rotations contributed to an increase in conditional net profit compared to classical models with soybean saturation up to 60% by 2249 UAH/ha, with saturation up to 40% by 2074 UAH/ha, and with saturation up to 20% by 2773 UAH/ha.

Thus, the economic efficiency of soybean cultivation can be enhanced by using a biopreparation for pre-sowing seed treatment, which is a low-cost measure (400-500 UAH/ha), yielding a conditional net profit ranging from 1024 UAH/ha for continuous soybean cultivation to 2773 UAH/ha for crop rotation saturation up to 20%. The use of a cost-free technological element, namely the crop rotation factor, through optimizing soybean concentration to 20% and incorporating a classic set of crops for the Steppe zone, including fallow land, without the use of biopreparation to an increase in conditional net profit from 1925 to 9100 UAH/ha, and with the use of a biopreparations – from 3150 to 10849 UAH/ha. The highest economic efficiency of soybean cultivation was established with the use combination of biopreparations Mikofrend + Rizoline + Rizosev in a crop rotation model with soybean saturation up to 20%, where the gross product value amounted to 30503 UAH/ha, conditional net profit was 14299 UAH/ha with a profitability of 88.6%.

The study of the impact of biopreparations on soybean productivity was also conducted in the experimental field of the Central Ukrainian National Technical University (2017-2018). The biopreparations Rhizogumin and Rhizostim were investigated. The biopreparations contributed to a significant increase in the number of nodules per plant. The Rhizostim biopreparation provided a higher yield of soybean varieties—2.02-2.31 t/ha, with a yield increase of 9-10% compared to the variant without seed inoculation (Shepilova 2019).

The results of the studies on the impact of the biopreparation Rizotorfin in the fields of the Poltava State Agrarian Academy indicate that increasing soybean yield through the use of an inoculant was more effective than applying nitrogen fertilizers. This led to a yield of 1.40 t/ha, or a 7.8% increase in yield. The authors of the study emphasize that the symbiotic action of bacteria contributed to the growth and development of soybeans, mitigating the negative effects of unfavorable external conditions (Shevnikov 2011).

The results of studies conducted in the Forest-Steppe zone of Ukraine show that continuous soybean cultivation on gray forest soils led to a noticeable decrease in its productivity in the early years. By the fourth year in this crop rotation, the yield of the crop decreased even with the application of 15 t/ha of manure and mineral fertilizers at a rate of N45P60K60, from 1.74 to 1.61 t/ha, or by 7.5% (Panasyuk 2011).

The above results indicate the need for further research and improvement of the elements of soybean cultivation technology as an important oilseed crop, with the aim of increasing yield and seed quality.

Conclusions

The weather conditions during the years of the study were contrasting, with sufficiently favorable conditions for achieving high soybean yield indicators in 2021 (HTC May-September 1.18 against a norm of 1.0), while conditions were not sufficiently favorable in 2020, 2022, and 2023 (HTC May-September 0.75, 0.84, 0.45) and unfavorable in 2024 (HTC May-September 0.14).

The highest soybean yield was obtained when using seed inoculation with biopreparations Mikofrend + Rizoline + Rizosave in a crop rotation model with a saturation of the crop up to 20% (1.72 t/ha), with an increase in yield compared to the continuous cultivation model amounting to 0.19 t/ha or 12.4% due to the influence of the mycorrhizal fungi, and 0.62 t/ha or 43.3% due to the crop rotation factor. No significant difference was found between the yield levels of soybeans in crop rotations with a saturation of the crop at 60% and 100%, which allows for a recommendation for production to utilize models with maximum soybean saturation or continuous cultivation.

The studies established that the economic efficiency of soybean cultivation can be enhanced by using mycorrhizal fungi, achieving a conditional net profit ranging from 1024 UAH/ha for continuous soybean cultivation to 2773 UAH/ha for crop rotation saturation with soybean up to 20%. The crop rotation factor, with an optimization of soybean concentration to 20% and without inoculation, contributed to an increase in conditional net profit from 1925 to 9100 UAH/ha, while with the use of biological inoculants, it increased from 3150 to 10849 UAH/ha. The highest economic efficiency was established with the use of the mycorrhizal fungi in a crop rotation model with soybean saturation up to 20%, where the gross product value amounted to 30503 UAH/ha, conditional net profit was 14299 UAH/ha, with a profitability of 88.6%.

References

Debaeke P, Forslund A, Guyomard H, Schmitt B, Tib A (2022) Could domestic soybean production avoid Europe’s protein imports in 2050? OCL, 29:38. DOI: 10.1051/ocl/2022031

Gasparetto H, Castilhos F, Gonçalves Salau NP (2022) Recent advances in green soybean oil extraction: A review. Journal of Molecular Liquids. 361, 2022, 119684. DOI: 10.1016/j.molliq.2022.119684

Glen L., Hartman & Ellen D. West & Theresa K. Herman (2011) Crops that feed the World 2. Soybean – worldwide production, use, and constraints caused by pathogens and pests. Food Sec. 3:5–17. DOI:0.1007/s12571-010-0108-x

Hammond EG., Johnson LA, Su C, Wang T (2005) Soybean Oil. In book: Bailey's Industrial Oil and Fat Products. DOI:10.1002/047167849X.bio041

Ivashchuk O, Hlukhaniuk A, Semenyshyn Y, Chyzhovych R, Kuzminchuk T, Khomyak S (2021) Influence of Extraction Conditions on Qualitative Composition of Vegetable Oils. Chemistry & Chemical Technology. 15(2):233–238. DOI: 10.23939/chcht15.02.233

Jablaoui C, Besombes C, Université La R, Jamoussi B, Abdulaziz K (2020) Comparison of Expander and Instant Controlled Pressure-Drop DIC technologies as Thermomechanical Pretreatments in enhancing solvent extraction of vegetal soybean oil. Arabian Journal of Chemistry. 13(10):7235–7246. DOI:

10.1016/j.arabjc.2020.08.005

Kolianovska L, Nysterenko I (2024) Use of soybean processing technology in the production of health products. Vibrations in engineering and technology. 2(113):97–109. DOI: 10.37128/2306-8744-2024-2-11

Kolyanovska LM, Bandura VM (2012) The effect of electromagnetic field on oil extraction from soybean seeds. Herald of scientific works of Vinnytsia National Agrarian University. 10:1(58):137–141. http://socrates.vsau.org/b04213/html/cards/getfile.php/6618.pdf

Kostyukevich TK, Tolmachova AV, Kolosovska VV, Barsukova OA (2021) Agroecological assessment of soybean productivity in the Western Forest-Steppe of Ukraine under climate change. Ecological Sciences, 2(35):99–103. http://ecoj.dea.kiev.ua/archives/2021/2/19.pdf

Mashchenko YuV, Sokolovska IM (2023a) Yield, productivity, and economic efficiency of winter wheat cultivation depends on crop rotation link and fertilizer systems. Podolskyi visnyk, 3(40):21–27. DOI: 10.37406/2706-9052-2023-3.3.

Mashchenko YuV, Sokolovska IM, Tkach AF (2023b) Soybean productivity depending on its share in crop rotation and fertilization system in the conditions of the northern Steppe. Podolskyi visnyk, 1(38):26–32. DOI: 10.37406/2706-9052-2023-1.4

Mizernyk D (2024) Current state and prospects for soybean cultivation in the world and Ukraine. Foothill and Mountain Agriculture and Stockbreeding, 76(1):36–47. DOI:10.32636/01308521.2024-(76)-1-4

Panasyuk OYa (2011) Soybean productivity in permanent crops on different backgrounds of plant nutrition and protection in the forest-steppe of Ukraine. Bulletin of scientific papers of Vinnytsia National Agrarian University. 7(47):26–28. http://repository.vsau.org/getfile.php/3706.pdf

Rai SK, Charak D, Bharat R (2016) Scenario of oilseed crops across the globe. Plant Archives, 16(1):125–132. https://plantarchives.org/PDF%2016%20-%201/125-132%20(PA3-3149).pdf

Saleba L, Saribekova D, Melekhova N (2022) Investigation of soybean processing by forcing – extraction method. Herald of Khmelnytskyi national university. 2 (307):188-193. DOI: 10.31891/2307-5732-2022-307-2-188-193

Shepilova TP (2019) Influence of biological preparations on soybean productivity in the northern Steppe of Ukraine. Bulletin of scientific papers of the Uman National University of Horticulture. 94(1):255–264. DOI: 10.31395/2415-8240-2019-94-1-255-264

Shevnikov MY (2011) Effectiveness of using biological products and mineral fertilizers in growing soybeans in conditions of unstable moisture in the forest-steppe of Ukraine. Bulletin of the Poltava State Agrarian Academy. 2:14–18. https://www.pdau.edu.ua/sites/default/files/visnyk/2011/02/14.pdf

Shpak V (compiled) (2023) Creative approaches in modern scientific and practical activities. GS Publishing Services 15137 Magnolia Blvd, # D, Sherman Oaks, CA 91403, USA. DOI: 10.51587/9798-9866-95990-2023-013

Sokolovska I, Maschenko Yu (2023a) Biotechnological methods of growing sunflower in different fertilizer systems. Helia 46(79):233–243. DOI: 10.1515/helia-2023-0011

Sokolovska IM, Mashchenko YuV (2023b) Productivity of short-rotation crop rotations with different soybean saturation depending on the fertilization system. Taurida Scientific Herald, 134:123–134. DOI: 10.32782/2226-0099.2023.134.18

Weiss EA (1983) Oilseed Crops. London, UK: Longman; 1983:660.

https://www.cambridge.org/core/journals/experimental-agriculture/article/abs/oilseed-crops-by-e-a-weiss-london-longman-1983-pp-660-35/1A7D0B128F6A43EC5A07856F29F52FFF

УРОЖАЙНІСТЬ ТА ЕКОНОМІЧНА ЕФЕКТИВНІСТЬ ВИРОЩУВАННЯ СОЇ В РІЗНИХ МОДЕЛЯХ КОРОТКОРОТАЦІЙНИХ СІВОЗМІН

Ю. В. Мащенко, І. М. Соколовська, О. М. Звєздун
Інститут сільського господарства Степу НААН,
Херсонський державний аграрно-економічний університет
Центральноукраїнський національний технічний університет

В статті висвітлені актуальні питання виробництва сої як важливої олійної культури, представлені шляхи оптимізації агротехнології її вирощування в класичних та біологізованих сівозмінах з коротким періодом ротації, наведений аналіз економічних показників та надані рекомендації виробництву. Встановлено, що найбільший врожай сої отримали в біологізованій сівозміні з насичення культурою до 20% (1,72 т/га). Істотної різниці між рівнем врожайності в сівозмінах з насиченням культурою 60% та 100% встановлено не було, що дає можливість зробити рекомендацію виробництву в соєвих сівозмінах використовувати моделі з максимальним насиченням соєю або беззмінне вирощування. Економічну ефективність вирощування сої можливо підвищувати при використанні біопрепаратів в комбінації Мікофренд 1,5 л/т + Різолайн 2 л/т + Різосейв 1 л/т та безвитратного елемента технології – сівозмінного фактору. Найвища економічна ефективність вирощування сої встановлена в біологізованій сівозміні з насиченням соєю до 20%, при цьому, вартість валової продукції становила 30503 грн/га, умовно-чистий прибуток – 14299 грн/га за рентабельності 88,6%.

Ключові слова: соя, моделі сівозмін, біологізовані сівозміни, урожайність сої, економіна ефективність вирощування олійної культури