

PRODUCTIVITY OF SOYBEAN DEPENDING ON AGROTECHNICAL METHODS OF ITS GROWING IN CONDITIONS OF THE NORTHERN STEPPE OF UKRAINE

Shown are results of studies on the use of complex microbial preparation Ryzohumin both separately and in combination with regulators plant growth Biolan and Biosil in the technology of soybean variety Medeya growing by different systems of fertilization and basic soil tillage. A higher level of grain productivity and high indexes of economic efficiency were proved to be gained by ploughing against the background without mineral fertilizers application when Ryzohumin used for inoculation followed with further spraying of crops with Biolan.

Keywords: soybean, biopreparations, inoculation, Ryzohumin, Biolan, Biosil, ploughing, disking, mineral fertilizers, productivity

Introduction. One of the important tasks of agroindustrial complex of Ukraine is to stabilize the production of high-quality products of plant-growing. In a solution of this problem an important meaning has the improvement of agrotechnological process of growing of main crops. It is known that the intensive technologies of cultivation are based on the extensive use of mineral fertilizers and pesticides, but their uncontrolled use is economically unjustified and environmentally dangerous.

An overcoming of the negative effects of intensification of agricultural production is the creation of new non-standard technologies, taking into account the experience gained generations, particularly those aimed at the realization of the natural potential of ecosystems and are based on the effective use of their biological possibilities, optimizing the interaction between microorganisms and plants in agrophytocenosis [1]. The plant, which is provided with a sound complex of microorganisms is able to get a full-blooded nutrition and realizes its potential as to the productivity. One of the measures directed at increasing the number and activity of microorganisms which are agronomically valuable in a root zone of plants is the use of microbial preparations in the technologies of growing of plants [2].

A deficiency of vegetable protein, orientation of agriculture to environmentally friendly production and high prices of mineral and organic fertilizers led to a growing of interest to leguminous crops [3].

Soybean is the main source of vegetable protein and oil. Its seeds are widely used in the production of agricultural products and industrial products. Thanks to the fixing of nitrogen by the nodule bacteria of the Rhizobium genus these plants play an important role in improving of soil fertility, so the treatment of seed with these microorganisms is effective and necessary technique that affects the development of plants throughout ontogeny [4]. Growing of the leguminous crops and particularly soybean, allows to reduce the cost of crop production by including a production of the atmospheric nitrogen in the process of agricultural production and improve the phytosanitary state of crops, to increase significantly a productivity of arable soil. [5]

The main condition for the realization of a high potential of crop is the development and introduction into production of modern innovative technology of growing. Today a long-term in this direction is the introduction into production of growth regulating substances which can increase the potential of biological productivity of plants in the normal range of reaction of genotype and intensify their adaptive capacity to environmental stressors if they are used in low doses.

Taking into account the above, the aim of our researches was to determine the effectiveness of biologics in productivity of soybean at different levels of mineral nutrition and ways of a basic soil tillage.

Materials and methods. Investigations of the impact of biologics on the productivity and qualitative parameters of soybean grain in inoculation of seed combined with spraying of crops

under different fertilization and tillage was performed by the method of setting a three-factorial field experiment in the laboratory of agriculture of the Kirovograd State Agricultural Experimental Station at the section of a crop rotation spring barley-soybean-corn for grain during 2011-2013.

The soil of a crop rotation is a normal heavy loam black earth with a high content of humus – 4.69%, low content of hydrolyzed nitrogen (by Kornfeld) – 13.7 mg/100 g, the average content of a mobile phosphorus and a high content of exchangeable potassium (by Chirikov) – respectively 10.0 and 15.1 mg/100 g of soil. The content of mobile forms of manganese, zinc, boron and sulfur – respectively 20.0, 0.41, 1.2 and 9.8 mg per kilogram of soil, a degree of an acidity is close to neutral (Ph_{sol} is 5.9).

The experiments were carried out by two methods of basic tillage – ploughing to a depth of 25-27 cm and disking to a depth of 12-14 cm. There were used the fertilization systems: 1 – without fertilizers; 2 – $\text{N}_{20}\text{P}_{20}\text{K}_{20}$; 3 – $\text{N}_{40}\text{P}_{40}\text{K}_{40}$. Each system foresaw the variants without use of biologics and with the inoculation of seed with Ryzohumin with the calculation of 200 grams per a hectare seed rate both separately and in combination with growth regulator Biolan, 20 ml/t. A spraying with growth regulators Biolan and Biosil was performed in the phase of budding of soybean with the rate of 20 ml per a hectare. It was the variety of soybean Medeya.

The laying of experiments, their management, accounting of harvest was carried out in accordance with existing requirements [6, 7]. The agrotechnics was recommended in the area of the research, with the exception of the variants that were investigated [8].

Agrometeorological conditions for a period of a scientific experiment were contrast and differed significantly from average long-term indicators that gave the opportunity to investigate the response of soybean plants to the action of hydrothermal factors in use of the application of microbial preparations in the technology of growing of crop in different systems of fertilization and tillage.

In particular, the period of vegetation in 2012 was significantly warmer than in 2011 and 2013 and long-term level and was remarkable for a lack of rainfall, which resulted a formation of lower yield. In 2011, during the period of maximum need for moisture of soybean the damping of arable and meter soil layers was sufficient according to the scale of the conformity assessment of stocks of productive moisture needs of crops. In July, the deficit of rainfall was 24 mm (33%), in August – 33 mm (69%), in September – 29 mm (76%) compared to the average long-term indicators. During the period of vegetation the HTC of Selyaninova was 0.75, i.e. the damping was insufficient and unstable. In 2012 fell 181.9 mm of rainfall when the average long-term value was 233 mm during the period of vegetation of soybean. In May prevailed a hot weather, as in summer. The average daily temperature for the month exceeded the rate on 5.1 °C, a deficit of rainfall was 20.5 mm or 97.2 %. In June fell 48.0% of rainfall to normal. At the time of flowering of soybean the moisture was practically absent in the meter soil layer. In July, during the day fell 45.7 % of rainfall to normal in the form of hail that brought a significant damage to soybean plants and affected negatively the indicators of productivity of crop. The hydrothermal coefficient during the period of vegetation was 0.49 when the average long-term value was 1.00. In 2013 the HTC in April was 0.5 at a rate of 1.35. In May and June the HTC value was close to the average long-term indicator. July and August were characterized by a higher on 2.8 and 3.3 °C average daily air temperature compared to the average long-term indicators and lack of effective rainfall. The HTC in this period was respectively 0.4 and 0.3 at the average long-term value 1.16 and 0.80. The optimum soil moisture during the critical period of development of soybean contributed to the formation of grain productivity on a relatively high level.

Results and discussion. The received results showed a positive effect of biopreparations on the productivity of soybean. In the conditions of 2011 for the plowing on the background without fertilizers the higher grain productivity was obtained by a combined use for a pre-sowing inoculation the microbial preparation Ryzohumin with the growth regulator Biolan 20 ml/t and a subsequent spraying of crops with Biosil 20 ml/ha – 3.32 t/ha, that was larger at 0.61 t/ha (22.5 %) compared to absolute control without fertilizers and inoculation (Table 1).

Table 1

Productivity of corn depending on the use of biopreparations by different systems of fertilizing and soil tillage, t/ha

Soil tillage (factor A)	Background of nutrition (factor B)	Biopreparations (factor C)	Years				Increase to the control	
			2011	2012	2013	average	t/ha	%
Ploughing	without fertilizers (control)	Without treatment	2,71	1,08	2,84	2,21	-	-
		Ryzohumin	3,18	1,10	2,98	2,42	0,21	9,5
		Ryzohumin + Biolan	3,23	1,22	3,06	2,50	0,29	13,1
		Ryzohumin + Biosil	3,26	1,08	2,94	2,43	0,22	10,0
		Ryzohumin + Biolan + Biosil	3,32	1,18	3,02	2,51	0,30	13,6
	average on a background of nutrition		3,14	1,13	2,97	2,41	x	x
	N ₂₀ P ₂₀ K ₂₀	Without treatment	3,00	1,10	2,94	2,35	0,14	6,3
		Ryzohumin	3,23	1,14	3,03	2,47	0,26	11,8
		Ryzohumin + Biolan	3,25	1,17	3,06	2,49	0,28	12,7
		Ryzohumin + Biosil	3,33	1,12	3,14	2,53	0,32	14,5
		Ryzohumin + Biolan + Biosil	3,33	1,09	3,05	2,49	0,28	12,7
	average on a background of nutrition		3,23	1,12	3,04	2,47	x	x
	N ₄₀ P ₄₀ K ₄₀	Without treatment	2,93	1,13	2,97	2,34	0,13	5,9
		Ryzohumin	3,20	1,15	3,05	2,47	0,26	11,8
		Ryzohumin + Biolan	3,00	1,19	3,00	2,40	0,19	8,6
		Ryzohumin + Biosil	3,30	1,27	3,20	2,59	0,38	17,2
		Ryzohumin + Biolan + Biosil	3,16	1,28	3,13	2,52	0,31	14,0
	average on a background of nutrition		3,12	1,20	3,07	2,46	x	x
average on a treatment		3,16	1,15	3,03	2,45	x	x	
Disking	without fertilizers (control)	Without treatment	2,58	1,08	2,09	1,92	-	-
		Ryzohumin	2,96	1,13	2,20	2,10	0,18	9,4
		Ryzohumin + Biolan	3,07	1,23	2,36	2,22	0,30	15,6
		Ryzohumin + Biosil	2,72	0,96	2,09	1,92	-	-
		Ryzohumin + Biolan + Biosil	2,94	1,04	2,21	2,06	0,14	7,3
	average on a background of nutrition		2,85	1,09	2,19	2,04	x	x
	N ₂₀ P ₂₀ K ₂₀	Without treatment	2,52	1,05	2,09	1,89	-0,03	-
		Ryzohumin	3,08	1,12	2,14	2,11	0,19	9,9
		Ryzohumin + Biolan	3,11	1,11	2,37	2,20	0,28	14,6
		Ryzohumin + Biosil	2,78	1,15	2,33	2,09	0,17	8,9
		Ryzohumin + Biolan + Biosil	2,96	1,27	2,28	2,17	0,25	13,0
	average on a background of nutrition		2,89	1,14	2,24	2,09	x	x
	N ₄₀ P ₄₀ K ₄₀	Without treatment	2,89	1,13	2,40	2,14	0,22	11,5
		Ryzohumin	3,10	1,11	2,50	2,24	0,32	16,7
		Ryzohumin + Biolan	2,93	1,24	2,48	2,22	0,30	15,6
		Ryzohumin + Biosil	2,82	1,15	2,45	2,14	0,22	11,5
		Ryzohumin + Biolan + Biosil	3,01	1,25	2,51	2,26	0,34	17,7
	average on a background of nutrition		2,95	1,18	2,47	2,20	x	x
average on a treatment		2,90	1,14	2,30	2,11	x	x	
<i>LSD₀₅ of a factor A</i>			0,01	0,02				
<i>LSD₀₅ of a factor B</i>			0,02	0,03				
<i>LSD₀₅ of a factor C</i>			0,02	0,03				
<i>LSD₀₅ ABC</i>			0,05	0,08				

On the richest soil (N40P40K40) the essential increase of productivity was obtained in the variant with use of Ryzohumin in a composition with Biosil – 3.30 t/ha which was larger on 0.37 t/ha compared to the control in this block of researches and larger on 0.59 t/ha to absolute control. When disking both on the background without fertilizers and with N20P20K20 the soybean formed a higher productivity by the pre-sowing inoculation with Ryzohumin and a subsequent spraying of crops with the growth regulator of plants Biolan – respectively 3.07 and 3.11 t/ha which was larger on 0/49 t/ha (19.0 %) and 0.53 t/ha (23.4 %) compared to the control without fertilizers and the inoculation.

In 2012 when it was used a ploughing as a basic soil tillage a higher productivity of soybean was obtained on a natural background by a combined use of preparations Ryzohumin + Biolan – 1.22 t/ha, which gave an opportunity to obtain an additional 0.14 t/ha of grain. By the insertion of N40P40K40 better was a combined use of preparations Ryzohumin + Biosil, where the increase of yield from mineral fertilizers was 0.19 t/ha, and from the biopreparations – 0.14 t/ha. By disking on the background without fertilization the productivity of soybean was greater in the variant of seed inoculation with Ryzohumin with the further spraying of plants with Biolan – 1.23 t/ha with 1.08 t/ha in the control. With the increase of the background of mineral nutrition up to N20P20K20 and N40P40K40 the significantly higher yield was obtained by a combined use of Ryzohumin with Biolan, 20 ml/t in combination with Biosil, 20 ml/ha – according to the backgrounds of nutrition 1.27 and 1.25 t/ha. The overstepping to the control without use of biopreparations and insertion of mineral fertilizers was 0.20 t/ha or 18.7 % and 0.18 t/ha or 16.8 % respectively.

The higher productivity of soybean in the conditions of 2013 was received in the variant of complex use of biopreparations application Ryzohumin + Biolan on the background without fertilizers both by deep and shallow tillages. By a ploughing this indicator was 3.06 t/ha and for a disking – 2.36 t/ha, which is respectively higher of the control on 0.22 t/ha (7.7 %) and on 0.27 t/ha (12.9%).

By the application of N₂₀P₂₀K₂₀ with both methods of the basic soil tillage the best was the complex use of Rizohumin and Biosil where it was obtained 3.14 t/ha when it was ploughing and 2.33 t/ha when it was disking. The increase to the control was respectively 10.6 and 11.5 %. The maximum productivity of soybean in the conditions of the year was obtained by the complex use of preparations Rizohumin in combination with Biolan, 20 ml/t + Biosil, 20 ml/ha on the background of N₄₀P₄₀K₄₀ – 3.20 t/ha when it was ploughing and 2.51 t/ha when it was disking, that gave the opportunity to get additionally 0/36 and 0.42 t/ha compared to absolute control.

By the results of the researches it was established that on average in 2011-2013 the increase of the grain productivity of soybean was 0.18-0.29 t/ha or 7.7-13.1 % from the use of biopreparations when it was ploughing and 0.12-0.31 t/ha or 5.6-16.4 % when it was disking; from mineral fertilizers respectively 0.13-0.14 t/ha (5.8-6.3 %) and 0.12 t/ha or 5.6 %. As for years of researches so on average for three years the deep soil tillage essentially increased the productivity of grain of soybean: in 2011 from 2.90 t/ha when it was disking to 3.16 t/ha when it was ploughing; in 2012 – from 1.14 to 1.15 t/ha, in 2013 from 2.30 to 3.03 t/ha, on average for three years – from 2.11 to 2.45 t/ha.

It is known that the chemical composition of straw and grain are genetically caused signs. But the qualitative indicators of products can be improved by the method of application of certain agrotechnical measures. At the same time the albumin content in grain is an indicator which also depends from the peculiarities of weather conditions which take place during the formation of grain.

The researches which were conducted in 2011-2013 established that the content of albumin in the soybean grain depended on the technological factors. When it was ploughing on a natural background and by an application of N₄₀P₄₀K₄₀ this indicator was higher in a variant of a complex application of biopreparations and exactly Ryzohumin + Biolan, 20 ml/ha – respectively 39.97 and 40.13 %, which was higher on 1.39 or 1.55 % compared to the absolute control. When it was conducted a disking on a background without fertilizers a content of protein increased in all variants of application of biopreparations from 38.07 % in a control variant to 39.71% in a variant with application of Ryzohumin + Biolan. An overstepping to the control was 1.64 % (Fig. 1).

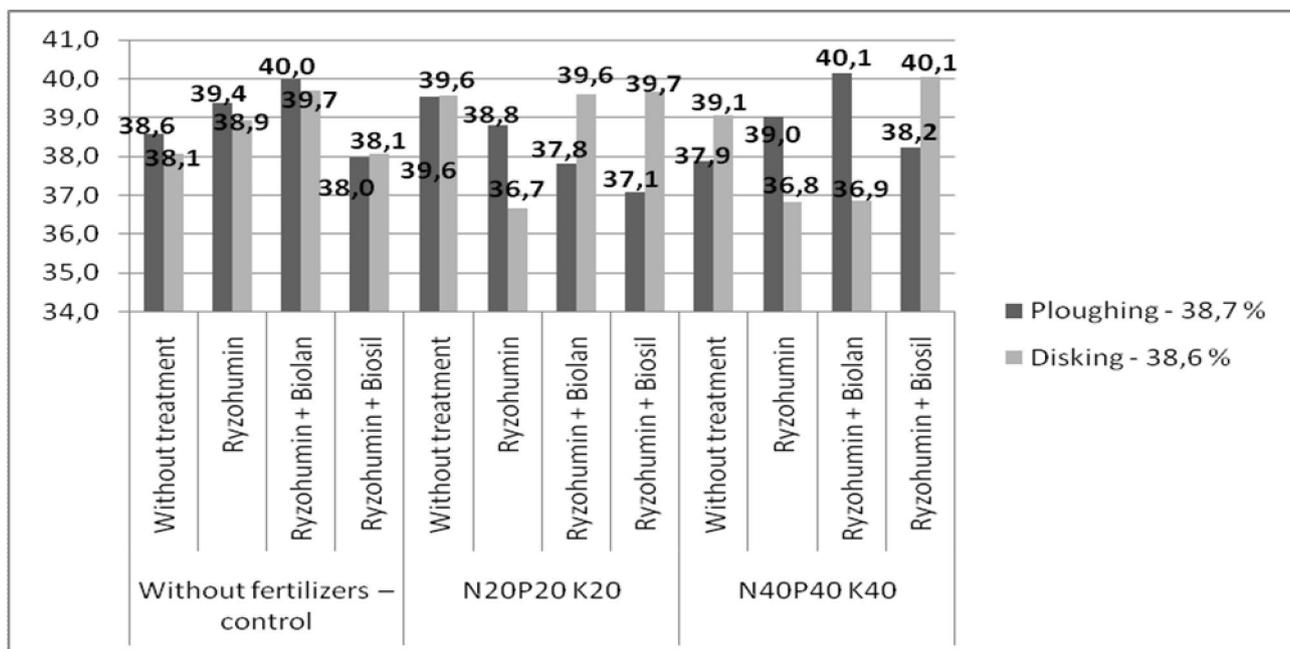


Fig. 1. The protein content in soybean grain of the variety Medeya depending on technological factors, average for 2011-2013, %

By the results of the biochemical analysis it was established that on average in the experiment the fat content was higher on 0.20 % compared to ploughing when it was done shallow soil tillage (Fig. 2).

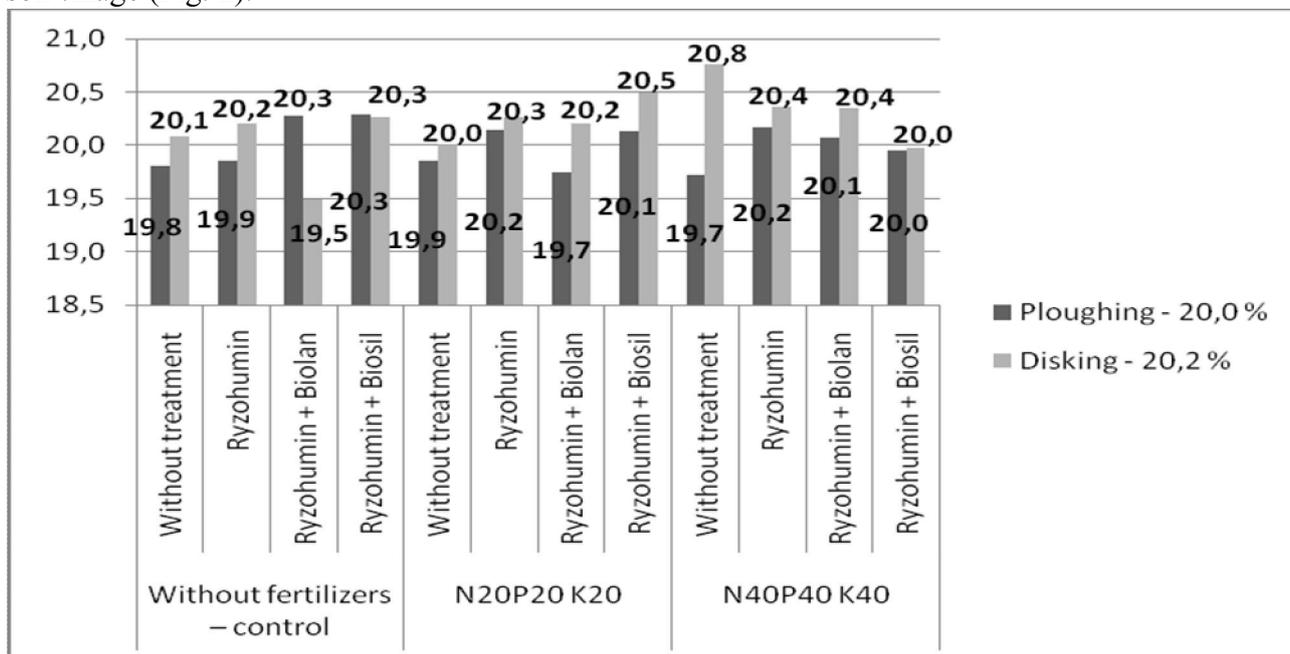


Fig. 2. Fat content in soybean grain of the variety Medeya depending on technological factors, average for 2011-2013, %

By plowing the higher fat content on the natural and N₂₀P₂₀K₂₀ backgrounds was in the variant of complex use of preparations Ryzohumin + Biolan, 20 ml/t + Biosil, 20 ml/ha – respectively 20.60 and 20.39 %, which is higher compared to absolute control on 0.80, and 0.59 %. In the block of researches with disking the maximum fat content in soybean grain on the natural and moderate soil was obtained when used the biopreparations Ryzohumin + Biosil – respectively 20.27 and 20.50 %, which was higher compared to absolute control on 0.19 and 0.42 %.

The calculations of the economic efficiency of use of biopreparations in growing of soybean show that this agromeasure is economically profitable and appropriate for both soil tillages. The use

of mineral fertilizers provided the growth of yield on 0.14-0.38 t/ha by ploughing, on 0.03-0.34 t/ha by disking. However, due to the high prices of mineral fertilizers the higher indicators of economic efficiency were obtained by growing of a crop on natural soil fertility. Depending on the use of biopreparations better values of conditionally net profit were achieved by ploughing – 7129-7399 UAH/ha at the level of profitability of 252-260 %. The application of disking in the technological process led to a decrease of these parameters according to the level of 5212-6417 UAH/ha or 196-239 %. The return of additional costs for a bacterization in growing of soybean by a ploughing was 7.48-17.72 UAH/UAH, by a disking – 3.13-15.40 UAH/UAH. With the increasing of doses of mineral nutrition to 20 kg/ha of a. s. this indicator decreases, while with the application of mineral fertilizers of 40 kg/ha of a. s. it is negative.

Conclusions. In the conditions of low moisture in the northern Steppe of Ukraine the pre-sowing inoculation of seed is the obligatory agrotechnical agromeasure, which allows to get a substantial increase of yield, has a positive effect on improving the qualitative indicators of soybean grain, and contributes a significant increase of economic efficiency of production in combination with plant growth regulators. When growing of a crop for both methods of basic soil tillage on a natural soil fertility for a better effect, it is economically appropriate to use the microbial preparation of a complex action Ryzohumin, 200 g per a hectare seed rate with the growth regulator Biolan, 20 ml/ha when spraying of crops, that made it possible to obtain additional 0.29 t/ha or 13.1 % by a ploughing and 0.30 t/ha or 15.6 % by a disking on average in 2011-2013.

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Анотація

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Продуктивність сої залежно від агротехнічних заходів її вирощування в умовах північного Степу України

Досліджено ефективність застосування мікробного препарату комплексної дії Ризогумін як окремо, так і у комбінації з регуляторами росту рослин Біолан та Біосил, у технології вирощування сої сорту Медея за різних систем удобрення та основного обробітку ґрунту. Встановлено, що найвищий рівень урожайності зерна та показники економічної ефективності виробництва цієї культури, забезпечуються за оранки на фоні без

застосування мінеральних добрив при використанні для інокуляції насіння Ризогуміну з наступним обприскуванням посівів Біоланом.

Ключові слова: соя, біопрепарати, інокуляція, Ризогумін, Біолан, Біосил, оранка, дискування, мінеральні добрива, урожайність

Аннотація

Григорьева Е.Н.

Продуктивность сои в зависимости от агротехнических приемов её выращивания в условиях северной Степи Украины

Исследовано эффективность применения микробного препарата комплексного действия Ризогумин как отдельно, так и в комбинации с регуляторами роста растений Биолан и Биосил, в технологии выращивания сои сорта Медея при разных системах удобрения и обработки почвы. Установлено, что наивысший уровень урожайности зерна и показатели экономической эффективности производства этой культуры, обеспечиваются при вспашке на фоне без применения минеральных удобрений и использовании для инокуляции семян Ризогумина с последующим опрыскиванием посевов Биоланом.

Ключевые слова: соя, биопрепараты, инокуляция, Ризогумин, Биолан, Биосил, вспашка, дискование, минеральные удобрения, урожайность