PRODUCTIVITY AND GRAIN QUALITY OF SOYBEAN DEPENDING ON TILLAGE, FERTILIZERS AND BIOLOGICAL PREPARATIONS APPLICATION IN NORTHERN STEPPE OF UKRAINE

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The paper presents the results of microbial preparation Rhizohumin effects both individually and in combination with the plant growth regulators Biolan and Biosil on productivity of soybeans of Medeya variety under different fertilization background and soil tillage. Higher level of productivity and high economic efficiency indices were obtained on the natural background with plowing and seeds inoculation with Rhizohumin and Biolan with subsequent crops treatment with Biosil.

Keywords: soybean, inoculation, Rhizohumin, Biolan, Biosil, plowing, disking, mineral fertilizers.

The successful cultivation of any crop includes not only aspects of its economic efficiency but the production methods as well as rational utilization of tools required for creating of optimal growing conditions in agrocenosis. Thus, the growing technology should include a set of consecutive operations aimed on high yields based on the biological characteristics of the plant development stages. Recently, in many countries, despite the wide possibilities of application of agrochemicals in crops cultivation, the priority is given to the use of microbial preparations.

Lack of plant protein, agriculture focusing on sustainability and environmentally reasonable production, high cost of mineral and organic fertilizers determine the increasing interest in leguminous plants [1]. Legumes are an inexhaustible source of soil enrichment with nitrogen compounds via the nitrogen fixing symbiosis of nodule bacteria with plants and, therefore, are of great agronomic importance. Cultivation of leguminous crops reduces the agricultural production costs due to fixation of atmospheric nitrogen, improvement of phytosanitary conditions of crops and significant increase of arable soil productivity [2].

Soybeans hold a leading position among the cultivated legume plants. Since its cultivation areas in Ukraine are continuously growing, they include new fields where it had never been cultivated. Under these circumstances, it is necessary to ensure the presence of active strains of rhizobia in the soil by pre-sowing inoculation of soybean seeds. For this purpose the biological preparation Rhizohumin, created on the basis of selected strains of rhizobia and physiologically active substances of biological origin, is widely used nowadays [3].

Effective and efficient use of fertilizers, optimization soybeans nutrition due to the application of advanced biological preparations is one of the priority measures that can provide a guaranteed and competitive production of soybeans. Therefore, studying the effectiveness of pre-sowing seeds inoculation combined with the stimulation of plant growth and development when grown under different fertilization

and tillage systems on soybean productivity has an important practical significance and relevance.

Materials and methods. The study of complex biological effects of pre-sowing seed treatment and spraying of crops grown on different mineral fertilization backgrounds and at various tillage methods used on productivity of soybean in unstable moistening conditions of Northern Steppe of Ukraine were carried out in field experiments on three-factor scheme (Table 1).

Two main tillage ways of – plowing (depth 25–27 cm) and disking (depth 12–14 cm) were used. The fertilization scheme used was as following: 1 – no fertilizer, 2 – $N_{20}P_{20}K_{20}$; 3 – $N_{40}P_{40}K_{40}$. Each system had variants with and without pre-sowing seeds treatment with biological preparation Rhizohuminom at a dose of 200 grams per hectare of seed rate, both separately and in combination with growth regulator Biolan, 20 ml/t. Crops spraying with growth regulators Biolan and Biosil (20 ml/ha) was performed during the budding development stage of soybeans. Soybean variety – Medeya.

Predecessor crop for soybean was spring barley. Cultivation technology, except for the studied factors, was common for the area. Experiments setup, observation and recording, as well as sampling was carried out in accordance to the field experiments methods by B. A. Dospehov [4].

Seed inoculation was performed on the day of sowing by conventional method using bacterial preparations and manufacturer's recommendations [5].

Experimental fields of Kirovograd State Agricultural Experimental Station of the Institute of Agriculture of the Steppe Zone of NAAS of Ukraine are located in chernozem zone of Northern Steppe subzone of Right-bank territories of Ukraine in subzone of ordinary and deep chernozems.

Experiments were performed on ordinary chernozem medium-humic heavily loamy with high humus content – 4.69 %, low levels of hydrolyzed nitrogen – 13.7 mg/100 g, medium levels of mobile phosphorus and high levels of exchangeable potassium – 10.0 and 15.1 mg/100 g soil, respectively. Acidity level is close to neutral ($pH_{salt} = 5.9$).

Weather conditions had varied both in moisture and temperature conditions during the studies (Fig. 1).

The growing season in 2012 was significantly warmer than 2011 and mean levels, insufficient rainfall and had resulted in a lower yield. In 2011 during the maximum demand of soybean plants for moisture its levels in meter and arable soil layers was sufficient (according to the scale of assessment of levels of productive moisture needs of crops). In July, the rainfall deficit was 24 mm (33%), in August – 33 mm (69%), in September – 29 mm (76%) compared to the long-term mean performance.

During the 2012 growing season the 181.9 mm of rain had fell, while long-term mean value was 233 mm. The summer-like hot weather had prevailed in May. The average daily temperature for the month had exceed the long-term mean values by 5.1 °C with rainfall deficit was 20.5 mm or 97.2 %. In June, 31.7 mm of rain had fell, which is only 48.0% of the norm. It should be noted, that during the flowering stage there were almost no moisture in a meter soil layer. In July, there was a 45.7% of normal precipitation fell in a single day as hail, causing significant damage to

soybean plants and influencing the crop productivity. Hydrothermal coefficient during the vegetation season was 0.49 at long-term mean level of 1.00.

FIGURE 1. Agrometeorological conditions, 2011–2012.

Results and discussion. Productivity is the main criteria that allows effectiveness evaluation of various techniques aimed on improvement of crops growing conditions. As it was shown in our studies, application of Rhizohumin for seeds inoculation in the technologies of soybeans cultivation, both separately and in combination with plant growth regulators, on different backgrounds of mineral nutrition and under the different soil tillage systems had provided better conditions for nitrogen fixation, relatively high seed production and high quality output if compared to the control variants without treatment.

In 2011 in variants with plowing, used for soil preparation, the higher yield of soybean was received both in variants without fertilizers and on $N_{20}P_{20}K_{20}$ background at pre-sowing seeds treatment with complex microbial preparation Rhizohumin followed by crops spraying with plant growth regulator Biosil and at combined use of Rhizohumin + Biolan (20 ml/t) + Biosil (20 ml/ha) – 3.26 & 3.32 t/ha and 3.33 & 3.33 t/ha, respectively, which is on 0,55 t/ha (20.3 %), 0.61 t/ha (22.5 %) and 0.62 t/ha (22.9 t/ha) higher if compared to absolute control (without fertilizers and inoculation) (Table 1).

The significant increase in yield was obtained at $N_{40}P_{40}K_{40}$ background with Rhizohumin use in composition with Biosil – 3.30 t/ha, which is 0,37 t/ha higher if compared to this experimental block control and 0.59 t/ha – to the absolute control.

Disking on backgrounds without fertilizers and at $N_{20}P_{20}K_{20}$ application the higher soybean yields were obtained in variants with pre-sowing seeds inoculation with Rhizohumin followed by crops spraying with plant growth regulator Biolan – 3.07 and 3.11 t/ha, respectively, which is 0,49 t/ha or 19.0 % and 0.53 t/ha or 23.4 % higher if compared to absolute control.

TABLE 1. Soybeans yield influenced by biological preparations under different fertilization and tillage systems

Soil tillage (factor A)	Fertilization background (factor B)	Biological preparations (factor C)	Years of study		
			2011	2012	Mean
1	2	3	4	5	6
Plowing	Without fertilizers – control	Without treatment	2,71	1,08	1,90
		Rhizohumin	3,18	1,10	2,14
		Rhizohumin + Biolan	3,23	1,22	2,23
		Rhizohumin + Biosil	3,26	1,08	2,17
		Rhizohumin + Biolan + Biosil	3,32	1,18	2,25
	<i>Mean by fertilization background</i>		<i>3,14</i>	<i>1,13</i>	<i>2,14</i>
	N ₂₀ P ₂₀ K ₂₀	Without treatment	3,00	1,10	2,05
		Rhizohumin	3,23	1,14	2,19
		Rhizohumin + Biolan	3,25	1,17	2,21
		Rhizohumin + Biosil	3,33	1,12	2,23
		Rhizohumin + Biolan + Biosil	3,33	1,09	2,21
	<i>Mean by fertilization background</i>		<i>3,23</i>	<i>1,12</i>	<i>2,18</i>
	N ₄₀ P ₄₀ K ₄₀	Without treatment	2,93	1,13	2,03
		Rhizohumin	3,20	1,15	2,18
		Rhizohumin + Biolan	3,00	1,19	2,10
		Rhizohumin + Biosil	3,30	1,27	2,29
		Rhizohumin + Biolan + Biosil	3,16	1,28	2,22
	<i>Mean by fertilization background</i>		<i>3,12</i>	<i>1,20</i>	<i>2,16</i>
	<i>Mean by tillage system</i>		<i>3,16</i>	<i>1,15</i>	<i>2,16</i>

TABLE CONTINUED 1.

1	2	3	4	5	6
Disking	Without fertilizers – control	Without treatment	2,58	1,08	1,83
		Rhizohumin	2,96	1,13	2,05
		Rhizohumin + Biolan	3,07	1,23	2,15
		Rhizohumin + Biosil	2,72	0,96	1,84
		Rhizohumin + Biolan + Biosil	2,94	1,04	1,99
	<i>Mean by fertilization background</i>		2,85	1,09	1,97
	N ₂₀ P ₂₀ K ₂₀	Without treatment	2,52	1,05	1,79
		Rhizohumin	3,08	1,12	2,10
		Rhizohumin + Biolan	3,11	1,11	2,11
		Rhizohumin + Biosil	2,78	1,15	1,97
		Rhizohumin + Biolan + Biosil	2,96	1,27	2,12
	<i>Mean by fertilization background</i>		2,89	1,14	2,02
	N ₄₀ P ₄₀ K ₄₀	Without treatment	2,89	1,13	2,01
		Rhizohumin	3,10	1,11	2,11
		Rhizohumin + Biolan	2,93	1,24	2,09
		Rhizohumin + Biosil	2,82	1,15	1,99
		Rhizohumin + Biolan + Biosil	3,01	1,25	2,13
	<i>Mean by fertilization background</i>		2,95	1,18	2,07
	<i>Mean by tillage system</i>		2,90	1,14	2,02
	LCD ₀₅ factor A		0,01	0,02	
	LCD ₀₅ factor B		0,02	0,03	
	LCD ₀₅ factor C		0,02	0,03	
	HIP ₀₅ ABC		0,05	0,08	

In 2012, at plowing to a depth of 25-27 cm (primary tillage method), a higher yield of soybean on background without fertilizers and N₂₀P₂₀K₂₀ application was

received in variants with combined application of Rhizohumin and Biolan – 1.22 and 1.17 t/ha, that was significantly higher if compared to the control – on 0.14 and 0.09 t/ha, respectively. In variants with $N_{40}P_{40}K_{40}$ fertilizers application the best yields were obtained at combined use of Rhizohumin + Biosil and Rhizohumin in combination with Biolan + Biosil – 1.27 and 1.28 t/ha, or 17.6 and 18.5 % higher than in the reference variants (without fertilizer and pre-sowing seeds inoculation), respectively.

Disking to a depth of 12–14 cm a higher soybean yield was obtained on the background without fertilizers in variants with pre-sowing seeds inoculation with Rhizohumin followed by crops spraying with growth regulator Biolan – 1.23 t/ha, if compared to 1.08 t/ha in control. Fall application of $N_{20}P_{20}K_{20}$ and $N_{40}P_{40}K_{40}$ at main tillage had significantly increased the yield obtained in variants with combined application of Rhizohumin and growth regulators Biolan (20 ml/m) + Biosil (20 ml/ha) – 1.27 and 1.25 t/ha, correspondingly to backgrounds. Increment to the absolute control (without application of biological preparations or chemical fertilizers) was 0.20 t/ha or 18.7 % and 0.18 t/ha or 16.8 %, respectively (Fig. 2).

FIGURE 2. Productivity indices influenced by various technological factors, the average for 2011–2012.

Based on the data obtained during both experimental years and two-year mean values, it was established that deep tillage had promoted significant increase of soybean yield: in 2011 – from 2.90 t/ha in variants with disking to 3.16 t/ha in variants with plowing. Correspondingly, in 2012 those values had ranged from 1.14 to 1.15 t/ha and mean for two years had ranged from 2.02 to 2.16 t/ha.

It was established that on average increment of soybean yield during 2011 – 2012 in variants with biological preparations was 0.20–0.39 t/ha or 10.5–20.5 % on plowed soils and 0.14–0.32 t/ha or 7.7–17.5 % – on the ones that were disked.

The highest protein content in soybeans in variants with plowing tillage system on both natural background and application of 40 kg/ha of fertilizer was received for plants inoculated with Rhizohumin in combination with growth regulator Biolan – 41.57 and 42.47 %, respectively, at 40.69 % parameter value in absolute control. At disking the maximum values were obtained on the background without fertilizer at use of the same biological preparations – 42.00 %, which was 3.47 % higher if compared to the control (Fig. 3).

FIGURE 3. Protein content in soybeans seeds, the average for 2011–2012.

The calculations of economic efficiency of biological preparations in the technologies of soybeans cultivation had shown that it is economically viable and feasible. However, due to the high fertilizers price the higher indices both in variants with plowing and disking tillage systems were obtained on the backgrounds without fertilization. Depending on application variants of biological preparations the best values for net operating profit were obtained for plowing tillage system – 6 131–6 553 UAH/ha with profitability level 215–226 %. Cost of 1 ton of soybean output at the same time had decreased on 8.7–12.0 %. Use of disking instead of plowing had resulted in decrease of these parameters to 4 908–5 766 UAH / ha, or 174–215 % of level profitability and cost of 1 ton 5.1–11.8 %, respectively.

Thus, it was shown that pre-sowing seed inoculation is a mandatory agricultural technology, which provides a substantial yield increase and improvement of quality parameters of soybeans in combination with plant growth regulators. In order to obtain the best results at soybeans cultivation in dry conditions of the Northern Steppe region of Ukraine it is recommended to use complex microbial

preparation Rhizohumin in combination with growth regulators Biolan + Biosil with plowing on natural fertilization background that in average during 2011–2012 had ensured gaining of additional 0.35 tons/ha or 18.4 % of output. At soybeans growing with disking used for soil preparation the application of biological preparation Rhizohumin, 200 grams per hectare of seed rate + Biolan (20 ml/ha), was shown to be the most effective. The soybean yield at this was 2.15 t/ha, which is 0.32 t/ha or 17.5 % higher if compared to the control without treatment.