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Abstract. The results of field studies of the use of biological products and microfertilizers in the cultivation of winter wheat in the production conditions of the Krasnodar Territory are presented. Indicators of a comparative assessment of economic and new schemes for the application of fertilizers and plant protection products from the point of view of agricultural and economic efficiency are given.

1. Introduction

In the context of the projected increase in demand for wheat by half by 2050 to meet the nutritional needs of the growing world population [1], as well as increasing requirements for the quality of agricultural products [2], the role of agricultural biologization is increasing, since its cultivation using natural resources and "biologized technologies" Excludes the possibility of exceeding the maximum permissible concentration of harmful substances in agricultural products while reducing the cost of agrochemicals and breeding programs.

According to an expert assessment of the data of the Federal State Budgetary Institution "Rosselkhoztsentr" for 2019 [3], the volume of the market for biological products has more than tripled in five years due to an increase in demand from agricultural producers who have faced irreparable depletion of the soil due to prolonged use of chemicals, as well as in connection with their annual rise in price with a decrease in the cost of biological products, which occurred due to the introduction of innovative domestically produced drugs to the market, which are sometimes several times cheaper than chemical analogues with greater efficiency [4-6].

If the modern market for manufacturers of fertilizers of biological origin is quite voluminous and diverse, then the production of biological products for plant protection is formed from several research and production companies, which, as a rule, not only offer products of biological origin, but also provide support from the correct preparation of seeds to harvest. One of the leaders in this area is the Biotehagro company (Timashevsk, Krasnodar Territory) [7].

The introduction of environmentally friendly production, which will be facilitated by the use of drugs of biological origin, requires the study of their influence on the production processes of plants with their reasonable and rational use [8-10].

The purpose of the research is to assess the agrotechnical and economic efficiency of using various schemes for the introduction of biopreparations and micronutrient fertilizers of domestic production in the production technology of growing winter wheat.

2. Materials and methods

Materials for industrial research were provided by Biotehagro (Timashevsk), which acts as the developer of the "biomethod", producing drugs based on living, beneficial microorganisms and develops schemes for the effective use of these drugs in agriculture (table 1).

Table 1. Brief characteristics of the preparations.

A drug	View
BSka-3	Microbiological fertilizer of complex action with protective functions
BFTIM	Biofungicide
Helios Silicon	Liquid mineral fertilizer providing the maximum concentration of silicon in the form of silicon dioxide of a special form of processing
Helios Cropsil	Silicone generation adjuvant
Helios Super	Liquid mineral fertilizer
Helios Trio	Liquid mineral fertilizer
Humate Potassium	Complex organic fertilizer
Humate +7	Fertilizer based on humic acids (liquid concentrate)
Gumel Lux	Fertilizer based on humic acids, enriched with silicon

The research work was carried out in accordance with the methodology of field experience in economic crops of winter wheat, developed jointly with representatives of Biotehagro LLC, and taking into account their recommendations on the timing and doses of the drugs used in the experiment (table 2), as well as in compliance with certain methodological requirements (typicality, principle of single difference, etc.) according to the instructions for conducting a field experiment by B.A. Dospekhova [11].

Table 2. Experimental variants in experimental crops of winter wheat.

Processing date and plant phase	Option number 1 (control)	Option number 2 (Biotehagro)		
		2-1	2-2	2-3
10/16/19 seed	Benefit (0,8 l/t)	BSka-3 (3 l / t) + Gumel Lux (3 l / t)		
03/26/20 tillering	+ ZIM 500 (0.5 l / ha)	+ BSka-3 (2 l / ha) + Helios Silicon (1 l / ha)	Lancelot (33 g / ha) + BSka-3 (2 l / ha) + Humate + 7 (1 l / ha)	+ ZIM 500 (0.5 l / ha) + Potassium humate (0.5 l / ha)
05/03/20 phone out		+ Helios Super (1 l / ha) + Helios Cropsil (0.1 l / ha)	Urea (20 kg / ha) + BFTIM (3 l / ha) + Helios Kropsil (0.1 l / ha) + Helios Super (1 l / ha)	+ Potassium humate (0.5 l / ha)
05/15/20 earing	+ Triad (0.6 l / ha) + Urea (10 kg / ha)	+ Triad (0.6 l / ha) + Helios Trio (0.5 l / ha) + Helios Silicon (0.5 l / ha)	Эсперо (150 г/га) + Triad (0.3 l / ha) + BFTIM (2 l / ha) + Helios Trio (0.5 l / ha) + Helios Silicon (0.5 l / ha)	+ Triad (0.6 l / ha) + Carbamide (10 kg / ha) + Humate Potassium (5l / ha)

For the purity of the experiment, the experimental plots were laid on the same field according to the predecessor corn for grain, all technological operations were identical and corresponded to the generally accepted scheme of growing winter wheat in the farm.

The mid-early variety of winter soft wheat "Tanya" (State Scientific Institution Krasnodar Research Institute of Agriculture named after PP Lukyanenko) is selected from the varieties recommended for use in the North Caucasus region of the Russian Federation. The variety is semi-dwarf, highly resistant to lodging and shedding. The variety is resistant to powdery mildew and head smut. Has field resistance to brown, yellow and stem rust, moderately resistant to fusarium spike. It has an average susceptibility to septoria. Frost resistance is above average, high drought resistance. Weight of 1000 grains from 45.4 to 46.5 g, nature from 795 to 810 g/l. In terms of grain quality, it belongs to valuable wheat. The recommended seeding rate is 5 million viable seeds per hectare.

3. Results

3.1 Pre-harvest monitoring options

According to the developed methodology for a comparative assessment of the variants of the experiment, before harvesting, the crops were monitored by the variants of the experiment (table 3). For this, frames with a size of 50 × 50 cm were laid on the survey sites, within the boundaries of which all plants were dug up and a complete analysis, counting and measurement of plants were carried out (in triplicate).

Table 3. The results of the pre-harvest survey of crops.

Experience Option		Plant length, cm	Stem thickness, mm	The number of stems (ears) per 1 m^2, pcs., of which:												Ear length, cm	Number of grains per ear, pcs.
				Total	Productive		Unproductive										
					Total		with ear		Including without ear		sick						
					pcs.	%	pcs.	%	pcs.	%	pcs.	%	pcs.	%	pcs.	%	
Option number 1 (control)		55.4	3.1	900	656	72.9	244	27.1	24	2.7	216	24.0	4	0.4	6.8	22
Option no. 2 (Biote hagro)	2-1	61.3	3.5	832	620	74.5	212	25.5	24	2.9	188	22.6	-	-	7.7	25
	2-2	56.8	3.4	676	624	92.3	52	7.7	12	1.8	40	5.9	-	-	7.1	23
	2-3	59.8	3.6	904	600	66.4	304	33.6	80	8.8	224	24.8	-	-	7.9	25

As a result of a comparative assessment with the control variant, differences in the biometric parameters of plants and in the general state of crops (according to the results of analysis of sheaf material) were revealed. For option number 2 (Biotechagro):

- The length of plants (59.3 cm) is more than the length of plants in the control variant No. 1 (55.4 cm) by an average of 3.9 cm (7.0%), the greatest excess was observed in variant No. 2-1 (61.3 cm) - by 5.9 cm or 10.6%;
- The average thickness of the stem at the base of plants of variant No. 2 (3.5 mm) in comparison with the control indicator (3.1 mm) is increased by 0.4 mm or 12.9%;
- The average spike length in plants of the studied variant No. 2 (7.6 cm) differed from the control value (6.8 cm) by 0.8 cm or 11.8%;
- The smallest grain content in an ear was observed in the control variant No. 1 and amounted to 22 grains per ear, in plants of variant No. 2 on average - 24 pcs., Which is 2 grains or 9.1% more;

- The number of productive stems ranged from 66.4% to 92.3%, an average of 4.8 pp. higher than the control indicator (72.9%), the greatest excess was observed in option No. 2-2 (92.3%) - by 19.4 pp;
- The share of the number of unproductive stems (from 7.7% to 33.6%) by 4.8 percentage points on average. below the benchmark (27.1%);
- Diseased ears were not found in the sheaf material, in the control variant No. 1 their number was 0.4%.

3.2 Assessment of yield and grain quality

Evaluation of the yield for the variants of the experiment was carried out by direct combining on one day (07/01/2020) with an average grain moisture content of 12.8%. The actual yield was determined by the amount of harvested grain from the accounting plot harvested by the same combine, in accordance with ISO 8210:1989 [12]. The quality assessment of the obtained grain was carried out in a specialized certified institution. Table 4 shows the values of the main indicators of harvesting.

Table 4. The main indicators of harvesting by experience options.

Indicator name	Indicator value by experience options			
	No. 1 (control)	No. 2 (Biotehagro)		
		2-1	2-2	2-3
Productivity, c / ha	56.0	57.38	56.07	56.72
Plant height, cm	71.7	67.0	67.3	63.2
Plants lodging,%	8.0	3.4	7.6	6.8
Ratio of grain weight to straw weight above actual cutting height	1:1.1	1:1.2	1:1.2	1:1.2
Humidity,%:				
- grains	12.5	13.0	13.2	12.7
- straw	32.1	30.1	30.7	31.5
Weight of 1000 grains, g	42.3	43.4	41.7	42.1
Mass fraction of crude gluten,%	19.4	21.2	20.8	21.8
Mass fraction of protein (protein),%	12.2	13.2	12.8	13.2
Nature, g / l	821	812	817	813

According to the results of harvesting, the actual grain yield in the control option No. 1 was 56.00 c / ha, in options No. 2 (Biotechagro) - from 56.07 to 57.38 c / ha. The highest yield was obtained according to the scheme of application of preparations No. 2-1 (57.38 c / ha), which is higher than the control indicator by 1.38 c / ha or 2.5%, and improvement of the main indicators of the harvesting period is also observed:

- The weight of 1000 grains increased from 42.3 g (control variant) to 43.4 g, which is 1.1 g or 2.6% more;
- The total lodging of the grain mass decreased from 8% to 3.4% - by 4.6%.

There is an improvement in the quality of grain of the studied variants in terms of gluten and protein content compared to the control variant. Thus, the mass fraction of crude gluten on average for option No. 2 (Biotehagro) was 21.3%, which is 1.9 percentage points. more than the reference value - 19.4%. The mass fraction of protein (protein) averaged 13.1%, which is 0.9 pp. more - 12.2%.

In accordance with the technical requirements of ISO 7970 [13], grain from four variants of experience in terms of quality indicators belongs to the 4th class of soft wheat.

3.3 Economic evaluation of technology options

The cost of winter wheat for technology option No. 1 (control) was 5332.7 rubles / ton. For three treatment options with Biotehagro LLC preparations, the cost of winter wheat was obtained from 5280.0 rubles / ton (option No. 2-3) to 5509.1 rubles / ton (option No. 2-2).

Let us analyze the indicators of economic efficiency (table 5) of the introduction of preparations by OOO Biotehagro (option No. 2) in comparison with option No. 1 (control).

In all three variants No. 2 (Biotehagro), the yield of winter wheat was higher by 0.007 - 0.138 t / ha. At the same time, the profit per hectare only in two variants was obtained higher: by 216 rubles / ha or by 0.8% (option No. 2-1) and by 635 rubles / ha or by 2.4% (option No. 2 -3).

Table 5. Indicators of the economic efficiency of technology options.

Indicator name	Indicator value by variants			
	No. 1 (control)	No. 2 (Biotehagro)		
		2-1	2-2	2-3
Productivity, t / ha	5.600	5.738	5.607	5.672
Cost of products sold, thousand rubles	56000.00	57380.00	56070.00	56720.00
Working capital (total), thousand rubles, including:	21031.95	21195.95	22058.05	21116.95
- fuel	2074.01	2074.01	2074.01	2074.01
- seeds	4090.00	4090.00	4090.00	4090.00
- fertilizers	12640.00	14372.00	14025.00	13045.00
- plant protection products	2227.94	1659.94	1869.04	1907.94
Cost of production, thousand rubles	29863.12	31027.12	30889.21	29948.12
Profit, thousand rubles	26136.88	26352.88	25180.78	26771.88
Profitability of culture,%	87.52	84.93	81.52	89.39
Profit, rubles / ha	26136.88	26352.88	25180.78	26771.88
Profit, rubles / t	4667.30	4592.70	4490.96	4720.01
Labor costs, man-h / t	0.74	0.72	0.74	0.73
Additional costs for drugs in comparison with economic application, rubles / ha	-	1164.00	1026.09	85.00
In addition, the profit received due to the introduction of drugs in comparison with the economic application, rubles / ha	-	216.00	-956.10	635.00

However, only in option No. 2-3 (Biotechagro) there is an excess of the amount of additional profit (635 rubles / ha) obtained through the use of drugs over the amount of additional costs for the purchase of drugs (85 rubles / ha). In option No. 2-1, the amount of additional profit (216 rubles / ha) is significantly lower than the amount of additional costs (1164 rubles / ha). In option No. 2-2 (Biotehagro), the profit was received lower by 956 rubles / ha or by 3.7% compared to option No. 1 (control).

4. Discussion

Analyzing the results obtained from the use of preparations produced by Biotehagro LLC (option No. 2) in the production technology of winter wheat cultivation, there is a positive trend in improving such indicators as the length and grain size of an ear, as well as the quantitative share of productive stems in the total stem. An increase in their values contributed to an increase in yield on average for the options by 0.7 centners / ha or by 1.3%. Improvement in quality indicators of grain did not lead to an increase in the class of wheat.

The analysis of the results of the economic assessment made it possible to determine the most effective option out of the three schemes - No. 2-3, in which the profit increases by 1.3% in comparison with the economic application, and the additional profit obtained from the increase in yield due to the use of drugs is much higher and amounts to 635 rubles / ha, which is 7.5 times higher than the additional costs for drugs.

5. Conclusion

Based on the results of experimental studies of various schemes for the use of biological preparations and micronutrient fertilizers from LLC Biotehagro in the production technology of growing winter

wheat of the zoned variety "Tanya" (according to the predecessor of corn for grain) at the KubNIITiM validation ground (central zone of the eastern subzone of Krasnodar Territory), it was established:

- The use of drugs provides an increase in yield from 0.1 to 2.5%, improves the quality indicators of grain stand (by an excess of the number of productive stems by 4.8 pp and the absence of diseased ears, in the presence of 0.4% in the control variant) and grain (an increase in the mass fraction of crude gluten by 1.9 pp and protein (protein) - by 0.9 pp);
- The most effective option is No. 2-3, which differs from the control one by replacing a chemical seed dressing with a biological one and adding an organic mineral fertilizer "Potassium Humat" (0.5 l / ha each) to subsequent crops, the amount of additional profit was 635 rubles / ha, which is 7.5 times higher than the additional costs.

Thus, the results of the analysis provide prerequisites for the inclusion of schemes for the introduction of biological preparations and micronutrient fertilizers of domestic production into the technology of cultivation of winter wheat and recommendations for agricultural producers of the Krasnodar Territory in order to improve and reduce the cost of production.

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