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Economic evaluation of winter rye cultivation technology

Evaluación económica de la tecnología para el cultivo de centeno invernal

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Contents

ABSTRACT:
As a consequence of the conducted study, it was revealed that the grain yield of winter rye as affected by mineral fertilizers had increased by 23.1-34.6%. When applying low doses of nitrogen fertilizers, higher effectiveness of biopreparations was noted. It was proved that applying mineral fertilizers at a dose of $N_{90}P_{70}K_{80}$ resulted in the highest net operating profit, while increasing the dose of nitrogen fertilizers led to its decrease. The use of biopreparations in the cultivation of winter rye was economically viable. When treating crops with these preparations, net operating profit increased by 4.1-6.3%, compared to the control. The largest income per one ruble of expenditures for biopreparations was obtained when using Albite and Azotovit. As affected by mineral fertilizers and biopreparations, the number of wintered plants in the first case significantly increased by 2.6-4.3% compared to the control, while in the second case the increase was by 1.5-2.8%. The application of complete fertilizer (NPK-compound) and treatment of crops with biopreparations had a positive effect on the plants' preservation for harvesting. As affected by complete mineral fertilizer, preservation degree significantly increased by 3.9-7.9% compared to the control, while the treatment of crops with biopreparations contributed to its increase by 1.4-2.0%.
Keywords: economic evaluation, net operating profit,

RESUMEN:
Como consecuencia del estudio realizado, se reveló que el rendimiento de grano del centeno de invierno afectado por los fertilizantes minerales había aumentado entre un 23,1 y un 34,6%. Al aplicar dosis bajas de fertilizantes nitrogenados, se observó una mayor efectividad de las biopreparaciones. Se demostró que la aplicación de fertilizantes minerales a una dosis de $N_{90}P_{70}K_{80}$ resultó en la ganancia operativa neta más alta, mientras que el aumento de la dosis de fertilizantes nitrogenados llevó a su disminución. El uso de biopreparaciones en el cultivo de centeno de invierno fue económicamente viable. Al tratar los cultivos con estas preparaciones, la ganancia operativa neta aumentó en un 4.1-6.3%, en comparación con el control. El mayor ingreso por rublo de gastos para biopreparaciones se obtuvo al usar Albite y Azotovit. Como afectados por los fertilizantes minerales y las biopreparaciones, el número de plantas invernadas en el primer caso aumentó significativamente en un 2,6-4,3% en comparación con el control, mientras que en el segundo caso el aumento fue de un 1,5-2,8%. La aplicación de fertilizante completo (compuesto NPK) y el tratamiento de cultivos con biopreparaciones tuvieron un efecto positivo en la preservación de las plantas para la cosecha. Como se vio afectado por el fertilizante mineral completo, el grado de conservación aumentó significativamente en un 3.9-

winter rye, leached chernozem, mineral fertilizers, biopreparations, preservation of plants for harvesting

7.9% en comparación con el control, mientras que el tratamiento de cultivos con biopreparaciones contribuyó a su aumento en un 1.4-2.0%.
Palabras clave: evaluación económica, beneficio neto de explotación, centeno de invierno, chernozem lixiviado, fertilizantes minerales, biopreparaciones, preservación de plantas para la cosecha.

1. Introduction

Grain farming is a multipurpose, multifunctional, and system forming industry in the agribusiness of the country (Altukhov, 2005; Kargin, et al., 2016; Tireuov, et al., 2018).

The dynamics of bulk yields are subject to great variability. Crop productivity and chemical composition of grain are determined by soil quality, cultivation technology, variety, and weather conditions (Eryashev, et al., 2015; Kargin and Zaharkina, 2016; Kargin and Nemtsev, 2014; Nemtsev and Sharipova, 2012; Potapova, et al., 2013).

It is necessary to take into account the ecological state of each field, while the doses of fertilizers should be established taking into account the characteristics of each variety, test plot, and meteorological conditions. The use of fertilizers requires large financial expenditures taking into account the regional characteristics of edaphoclimatic conditions. The relevance of economic assessment of doses of fertilizers and biopreparations in the winter rye cultivation technology increases with the introduction of the new varieties.

In order to improve the efficiency of land use, optimize grain farming, and ensure food security, it is necessary to organize the territories of agricultural land use along with the preparation of intra-farm land management projects, their implementation and development (Geraskin, et al., 2014; Polushkina and Sedova, 2014; Polushkina, et al., 2015; Yerseitova, et al. 2018; Faridi, Sulphey, 2019).

The purpose of the present research is to assess the economic efficiency of mineral fertilizers and biopreparations when cultivating winter rye.

2. Materials and methods

The time horizon from 2009 to 2012 was the study period. The conducted field trials were analyzed at the Mordovian grade-testing station, while soil and plant samples were studied through laboratory tests.

The research objects included Relay of Tatarstan variety of winter rye, fertilizers, and biopreparations.

Field two-factor trial was incorporated in three-fold repetition. The size of the first order plots was 75 m^2 (5 x 15 m), while of the second order ones – 15 m^2 (5 x 3 m). The location of the plots was systematic. The study of the effectiveness of mineral fertilizer doses in combination with biopreparations when cultivating winter rye was carried out according to the following trial arrangement.

Factor A (mineral fertilizers): 1 – without fertilizers (control); 2 – $N_{30}P_{70}K_{80}$ (at pre-sowing treatment); 3 – $N_{60}P_{70}K_{80}$ (at pre-sowing treatment); 4 – $N_{60}P_{70}K_{80}$ (at pre-sowing treatment) + N30 (in early spring at side-dressing); 5 – $N_{60}P_{70}K_{80}$ (at pre-sowing treatment) + N64 (in early spring at side-dressing).

Factor B (biopreparations): 1 – without biopreparations (control); applying the following biopreparations: 2 – Planriz – 1 l/ha; 3 – Azotovit – 0.4 l/ha; 4 – Agrovit-kor – 2 l/ha; 5 – Albite – 0.04 l/ha.

The doses of mineral fertilizers were determined to take into account the regulatory balance of nutrients. In the second variant, nitrogen yield was compensated by 20%, in the third variant – by 40%, in the fourth – by 60%, and in the fifth – by 80%. Phosphorus yield was compensated by 100%, while the yield of potassium – by 60%.

Crops were treated with biopreparations at the tillering phase in autumn and spring during the resumption of vegetation.

The soil of the test plot was medium-heavy loamy leached chernozem. The humus content in the arable layer of the test plot was 7.22-7.72%; the pHsalt – 4.9-5.2; the number of absorbed bases – 21.6-22.6; hydrolytic acidity – 5.7-6.2 mmol /100 g of soil; the content of P2O5 – 153-160 mg/kg of soil; and of K2O – 150-152 mg/kg of soil.

Economic assessment of winter rye cultivation technology was performed based on the flow process charts using standards and pricing adapted to the production conditions at the Mordovian grade-testing station.

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3. Results

The research outcomes obtained on average during three years showed that the highest net operating profit was received when applying mineral fertilizers at a dose of $N_{90}P_{70}K_{80}$ that made up 11.3% compared to the control (Table 1). However, the high cost of mineral fertilizers, the increase in the cost of their application, the further increase in doses of nitrogen fertilizers have led to a decrease in the net operating profit. When applying biopreparations, net operating profit increased by 3.0-7.6%. The largest income per one ruble of expenditures for biopreparations was obtained when using Albite and Azotovit.

Meteorological conditions have affected the efficiency of fertilizers and biopreparations. In the favorable year of 2011, grain yield amounted to 4.33 t/ha, while in the extremely arid year of 2010 it amounted to 2.34 t/ha (Table 2). The application of mineral fertilizers had affected crop productivity, which had increased by 16-35%. The greatest increment of crop productivity was obtained when applying the trichloroethanoic acid in the dose of $N_{60-90}P_{70}K_{80}$. Under the impact of biopreparations, crop productivity had increased by 4-6%. The greatest effect of biopreparations was noted when applying low doses of nitrogen fertilizers. While the crop productivity of the control under their effect had increased by 0.20-0.27 t/ha, at the application of nitrogen in the amount exceeding 90 kg per one ha, it increased only by 0.08-0.20 t/ha. The highest increment was obtained in the variant where the crops were treated by Albite and Azotovit.

Table 1
Effect of mineral fertilizers and biopreparations on the net operating profit (thousand rubles/ha), 3-year average

Fertilizer dozes (Factor A)	**Biopreparations (Factor B)**					**Average for factor A**
	Without treatment	**Planriz**	**Aztovit**	**Agrovit-Kor**	**Albite**	
Without fertilizers	10 .8	11 .6	11 .7	11 .7	12 .2	11 .6
$N_{30}P_{70}K_{80}$	11 .9	12 .6	12 .7	12 .6	13 .0	12 .5
$N_{60}P_{70}K_{80}$	12 .2	12 .8	12 .9	12 .9	13 .0	12 .7
$N_{90}P_{70}K_{80}$	13 .1	12 .7	12 .9	12 .7	13 .3	12 .9
N124P70K80	10 .6	10 .6	10 .7	10 .6	10 .8	10 .6
Average for factor B	11 .7	12 .1	12 .2	12 .1	12 .6	

Table 2
Effect of mineral fertilizers and biopreparations on the yield of winter rye (t/ha), 3-year average

Fertilizer dozes (Factor A)	Biopreparations (Factor B)					Average for factor A (LSD05 = 0.21)
	Without treatment	Planriz	Aztovit	Agrovit-Kor	Albite	
Without fertilizers	2 .42	2 .62	2 .62	2 .65	2 .69	2 .60
$N_{30}P_{70}K_{80}$	2 .86	3 .04	3 .05	3 .06	3 .09	3 .02
$N_{60}P_{70}K_{80}$	3 .20	3 .37	3 .38	3 .40	3 .40	3 .35
$N_{90}P_{70}K_{80}$	3 .46	3 .49	3 .51	3 .50	3 .56	3 .50
N124P70K80	3 .36	3 .44	3 .45	3 .46	3 .46	3 .43
Average for factor B (LSD05 =0.19)	3 .06	3 .19	3 .20	3 .21	3 .24	

LSD05 of partial differences = 0 .30

Besides, an increase in protein content, which amounted to 0.6-1.9% (Table 3) and resulted from the impact of mineral fertilizers, was noted as well. When applying 30 kg of nitrogen before sowing, protein content increased by 0.6%, while with an increase in the dose to 60 kg/ha – by 0.9%. Additional spring side-dressing with nitrogen fertilizers at a dose of 30 kg/ha increased the protein content by 1.4%. When increasing the dose of fertilizer due to the early spring feeding (rate application equal to 64 kg/ha), this figure increased by 1.9% compared to the control. A significant increase in protein accumulation was also observed when treating crops with biopreparations. It ranged from 0.2 to 0.4%.

The ability to neutralize the adverse conditions of the autumn-winter-spring period reflected the effectiveness of fertilizers and biopreparations.

It was revealed that on average during three years, the number of wintered plants under the impact of mineral fertilizers increased by 6-14 pcs/m^2, while the number of plants preserved by spring increased by 2.3-5.5%. The greatest number of wintered plants was noted when applying $N_{90}P_{70}K_{80}$. A significant increase in the number of wintered plants was noted when treating crops with biopreparations.

The effect of mineral fertilizers and biopreparations was reflected by the preservation of plants by harvesting. In the study, it was determined mainly by meteorological conditions. On average in 2010-2012, the number of preserved plants when applying mineral fertilizers increased by 7.1-15.7%. The greatest plants' preservation rate was noted in the options where $N_{90}P_{70}K_{80}$ was used. Treatment of crops with biopreparations also significantly increased this figure. Under the influence of biopreparations, the number of preserved plants increased by 18-24 pcs/m^2. Greatest preservation of winter rye was noticed on crops treated with the Albite.

Table 3

Effect of mineral fertilizers and biopreparations on protein content in winter rye grain (%), 3-year average

Fertilizer dozes	Biopreparations (Factor B)					Average for factor A

(Factor A)	Without treatment	Planriz	Aztovit	Agrovit-Kor	Albite	(LSD05 = 0.15)
Without fertilizers	9 .4	9 .6	9 .7	9 .7	9 .6	9 .6
$N_{30}P_{70}K_{80}$	10 .0	10 .1	10 .3	10 .3	10 .2	10 .2
$N_{60}P_{70}K_{80}$	10 .3	10 .4	10 .6	10 .7	10 .6	10 .5
$N_{90}P_{70}K_{80}$	10 .7	10 .9	11 .1	11 .1	11 .1	11 .0
N124P70K80	11 .2	11 .3	11 .6	11 .7	11 .6	11 .5
Average for factor B (LSD05 =0 .14)	10 .3	10 .5	10 .7	10 .7	10 .6	

LSD05 of partial differences = 0 .33

4. Discussion

In the Republic of Mordovia, when cultivating Relay of Tatarstan winter rye variety on well-cultivated heavy loamy leached chernozems with high content of mobile phosphorus and potassium, it is recommended to apply mineral fertilizers in a dose of $N_{90}P_{70}K_{80}$. Biological treatment of crops should be carried out when applying mineral fertilizers in the dose of $N_{60}P_{70}K_{80}$, or when using Albite (0.04 l/ha) and Azotovit (0.4 l/ha) biopreparations in autumn at the phase of tillering and in the spring during the resumption of the vegetation.

Obtaining higher yields of winter rye grain with better quality can be achieved through the application of mineral fertilizers and biological preparations. Due to the application of mineral fertilizers, crop yield had increased by 23.1-34.6%.

Application of 60 kg of nitrogen in autumn on the background of phosphorus-potassium fertilizers, and 30 kg of nitrogen in the feed in the spring gives the greatest increment. Higher effectiveness of biopreparations is noted at the application of low doses of nitrogen fertilizers. In the variants, where the crops were treated with Azotovit and Albite biopreparations, the greatest yield increase was reported. When applying mineral fertilizers in a dose of $N_{90}P_{70}K_{80}$, the obtained net operating profit was the highest, while increasing further the doses of nitrogen fertilizer led to decline of the profit. The use of biopreparations in the cultivation of winter rye was economically sound. The largest income per one ruble of expenditures for biopreparations was obtained when using Albite and Azotovit. Net operating profit when treating crops with these biopreparations had increased by 4.1-6.3% compared to the control.

Under the impact of mineral fertilizers and biopreparations, the adaptive properties of plants in the autumn-winter period significantly improved. In the first case, the number of wintered plants significantly increased by 2.6-4.3% compared to the control, while in the second case the increase was 1.5-2.8%.

Application of complete fertilizer and treatment of crops with biopreparations had a positive effect on the preservation of plants for harvesting. Under the impact of complete mineral fertilizer, preservation rate significantly increased by 3.9-7.9% compared to the control, while the treatment of crops with biopreparations contributed to its growth by 1.4-2.0%. The Albite proved to be the most effective among all biopreparations used in the trials.

5. Conclusion

When cultivating Relay of Tatarstan variety of winter rye on heavy loamy leached chernozem, the following measures are considered to be economically and agronomically beneficial:

1. Applying mineral fertilizers in the dose of $N_{90}P_{70}K_{80}$;

2. Applying mineral fertilizers in the dose of $N_{60}P_{70}K_{80}$ in combination with the treatment of crops with Albite (0.04 l/ha) or Azotovit (0.4 l/ha) in the autumn at the tillering phase and in the spring during the resumption of plant vegetation.

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