Effectiveness of foliar treatment of intensive varieties of spring barleycorn under the conditions of Middle Volga region

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Abstract. Experimental studies were conducted in 2015-2017 on Agat and Povolzhsky 22 barleycorn varieties in order to identify the effectiveness of foliar treatments with modern drugs. The treatments increased the yield of varieties to 28%. Grain quality indicators did not change. An individual reaction of barleycorn varieties to yield and grain quality was revealed. During the use of the Biostim Grain drug, Souffler + Intermag complexes of Profi Grain and Mival-Agro + Lignogumat + Zelenit N, the net income reached 3561 rubles / ha, and the profitability was 221%.

1 Introduction

In order to increase the yield of grain crops and stabilize it over the years, it is necessary to use highly productive varieties with good adaptation to specific weather and climate conditions, to observe the cultivation technology, including the introduction of recommended doses of fertilizers [1–4].

The use of mineral fertilizers increases the yield and improves its quality. At the same time, soil moisture is consumed more economically. The effect of stress decreases, increasing the resistance of plants to drought [5, 6].

In Samara region, more than 80% of soils are classified as medium and low-income in terms of humus content. There is a deficiency of the basic elements of plant nutrition and a lack of active forms of microelements and sulfur [7, 8].

In addition, in the continental climate, there is a decrease in the effectiveness of fertilizers applied to soil [9]. At the same time, fertilizers, as in most regions, are insufficiently introduced, mainly due to their high cost [1, 4, 9]. It is possible to improve plant nutrition using foliar treatments with modern fertilizers.

The varieties adapted to the action of biotic and abiotic stressors of the region with high potential productivity were created at P.N. Konstantinov Volga Research Institute of Selection and Seed Production [10, 11].

The studies show that the use of new generation fertilizers on modern varieties of barleycorns allows getting stable grain yields by year [12, 13]. The use of drugs or their complexes, which include organic and mineral substances, macro- and microelements, is of considerable interest.

In this regard, the purpose of the research is to study the individual reaction of intensive Agat and Povolzhsky 22 barleycorn varieties when using foliar treatments with modern drugs, their effect on yield and grain quality, agronomic and economic evaluation of their use under the conditions of the Middle Volga.

2 Materials and methods

Experimental studies were conducted during 2015-2017 in the fields of the first selective crop rotation of P.N. Konstantinov Volga Research Institute of Selection and Seed Production.

The studies tested the varieties of intensive barleycorn of Agat and Povolzhsky 22 types zoned in the seventh region of the Russian Federation.

The predecessor of the studied varieties of barleycorn was spring wheat. The seeding rate was 4.5 million germinating grains per 1 ha.

For foliar treatments, the following agents were used: complex mineral fertilizers with microelements (Megamix, Intermag Profi Grain, Zelenite N, Zelenite RK); fertilizers based on humic acids (Lignohumate, Prompter); organic fertilizers (Biostim Growth, Biostim Grain, Bioplant Flora); stimulator Mival-Agro. All the agents are included in the list of the State catalog of pesticides and agrochemicals approved for use in the Russian Federation.

Study variants: 1. Control; 2) Prompter (0.3 l / ha) + Intermag of Profi Grain (1 l / ha); 3) Biostim Growth (1 l / ha) + Intermag Profi Grain (1 l / ha); 4) Grain biostim (1 l / ha); 5) Mival-Agro (10 g / ha) + Megamix (0.3 l / ha); 6) Mival-Agro (10 g / ha) + Lignohumate (30 g / ha)

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+ Green N (0.1 l / ha); 7) Bioplant Flora (1 l / ha) + Zelenite N (0.05 l / ha) + Zelenite PK (0.05 l / ha).

The allocation of plots is systematic, the repetition is threefold. The accounting area is 9.5-10 m^2.

Foliar treatment was carried out in variants 2 and 4 once in the tillering period, in variants 3, 5, 6 and 7 twice in tillering and tubing periods.

The soil of the experimental plot is typical low-humus, low-power, light clay black soil. The humus content is 4.3%, P_2O_5 - 60.5 mg / kg, K_2O - 91 mg / kg.

The experiments were carried out according to generally accepted methods. Statistical data processing was carried out by the method of two-way analysis of variance [14, 15].

3 Results

The hydrothermal conditions of barleycorn vegetation periods developed differently during the years of the experiment: 2015 can be described as dry (hydrothermal index = 0.7), 2016 as extremely dry (hydrothermal index = 0.5), and 2017 as subhumid (hydrothermal index = 1.4), which objectively allows evaluating the studied factors.

At the same time, a dry period was observed in all years of research, which, to varying degrees, influenced the realization of the potential of crop yield. Thus, in 2015, the drought occurred during the third decade of May - June, that is, from the tillering to the formation period of a grain.

The hydrothermal index of these four weeks was 0.17. In 2016, arid stress was noted from the second decade of June to the second decade of July, during the period of active development of the assimilation apparatus and generative organs of barleycorns.

The hydrothermal index of these three weeks was 0.18. In 2017, drought occurred in the second half of the growing season, from the second decade of July and August. The hydrothermal coefficient of this period was 0.05.

Barleycorn yields largely depended on June weather conditions. The correlation analysis showed that barley productivity was associated with the meteorological indicators of this month: with average air temperature (r = - 0.822-1.000) and with moderate and strong degree of precipitation (r = 0.490-1.000), as well as with a hydrothermal index in June (Table 1).

At the same time, the conjugation of characters in most variants of the Povolzhsky 22 variety turned out to be stronger than that of the Agat variety.

Table 1. Main meteorological indicators of June and their relation to the yield of barleycorn grains

Calendar period	Meteorological indicator	Years			Correlation index of yield and weather	
		2015	2016	2017	Agat	Povolzhsky 22
June	Temperature, °C	23.3	19.9	16.5	– 0.822-1.000	– 0.894-1.000
	Weather elements, mm	0.5	12.8	129.8	0.504-0.993	0.863-1.000
	Hydrothermal index	0.01	0.21	2.62	0.490-0. 991	0.855-1.000

Taking into account the meteorological indicators of June, the least favorable year was 2015, as evidenced by the lowest barleycorn yield in three years - 2.16-2.62 t / ha. Year of 2016 was less stressful when 2.52-3.30 tons of barley grains from 1 ha were obtained.

The most favorable year was 2017 with the productivity of barley varieties of 2.95-3.64 t / ha (Table 2).

On average, for three years, the Povolzhsky 22 variety proved to be more productive in control and variants 4, 5 and 6, exceeding the Agat variety in this indicator by 0.07-0.17 t / ha. The Agat showed the highest yield in comparison with the Povolzhsky 22 in variants 2 and 3.

A significant increase in grain yield was 0.18 t / ha and 0.12 t / ha, respectively. In variant 7, the average productivity of these varieties was at the same level.

The use of modern drugs in the form of foliar treatments contributed to the increase in crop yield by 0.11-0.72 t / ha or 5-28% and depended on the treatment variant and the reaction of the variety.

The increase of the yield of the Agat variety during foliar treatments was 0.26-0.52 t / ha or 11-20%, which was higher than in the Povolzhsky 22 variety by 0.26-0.39 t / ha or 10-15%.

The highest yield increase of the Agat variety compared to the control was in variants 2, 3 and 7 (0.52 t / ha, 0.47 t / ha and 0.43 t / ha, respectively), and in the Povolzhsky 22 variety - in variants 4, 6 and 7 (0.39 t / ha, 0.37 t / ha and 0.37 t / ha, respectively).

During the use of foliar treatments, it is important to maintain grain quality. The protein content of grain was differentiated by year, varieties and sorts. It is known that under the conditions of drought, more protein accumulates in the grain [6, 11].

The studies showed that in the dry year (2015) this indicator was 14.2-15.4%, and in the more favorable 2017, it was in the range of 10.8-12.3%.

The Agat variety in the control and most variants in terms of the amount of protein in grain was 0.3-0.7% on average for three years higher than the Volga 22 variety.

The increase in barleycorn yield kept the protein content of grain at the control level, which indicates an adequate and balanced nutrition of plants during foliar treatments.

The use of barleycorn grain for feed purposes involves accounting for protein collection per unit area. On average, over three years the value of this indicator was 327.6-390.2 kg / ha. In the control and in variants 4, 5 and 7, protein collection was at the same level.

Table 2. Yield and grain quality of spring barley varieties depending on the use of complex fertilizers

Variant	Yield, t/ha				Fiber content, %	Fiber collection, kg/ha
	2015	2016	2017	Average		
Agat						
1	2.16	2.58	2.95	2.56	13.3	336.8
2	2.51	3.10	3.64	3.08	12.5	376.2
3	2.41	3.24	3.43	3.03	12.9	383.5
4	2.48	2.97	3.12	2.86	12.9	363.8
5	2.57	2.70	3.20	2.82	13.1	367.4
6	2.27	3.05	3.22	2.85	12.6	349.9
7	2.45	3.30	3.23	2.99	13.2	390.2
Povolzhsky 22						
1	2.30	2.52	3.09	2.64	12.6	327.6
2	2.62	2.67	3.41	2.90	12.4	357.2
3	2.36	2.96	3.39	2.90	12.6	359.8
4	2.47	2.89	3.72	3.03	12.5	369.9
5	2.51	2.75	3.60	2.95	12.6	367.9
6	2.62	2.82	3.60	3.01	12.4	369.2
7	2.74	3.00	3.29	3.01	12.6	374.7
LSD_{05} general	0.12	0.16	0.16	0.19	0.65	45.2
LSD_{05} variant	0.09	0.11	0.11	0.13	0.46	32.0
LSD_{05} sort	0.04	0.05	0.05	0.06	0.22	17.1

The difference between the varieties for this indicator by 19.0-23.7 kg / ha was noted in variants 2 and 3 with an excess of the Agat variety, and in variant 6 the Volga 22 variety turned out to be higher.

The technological quality of grain of intensive varieties of barleycorn depended on weather conditions during the growing season and varietal characteristics. The Agat variety formed a larger grain with a mass of 1000 seeds of 48.7-50.4 g than the Povolzhsky 22 (47.4-48.5 g).

By the full weight of the grain, the Povolzhsky 22 variety exceeded the Agat variety by 29-34 g / l. Significant changes in the weight of 1000 seeds and the nature of the grain in the variants relative to the control was not observed when exposed to the studied drugs.

The agronomic effectiveness of the complexes of preparations varied by year, variant and variety, ranging from 15 to 1821 kg of barley grain per 1 kg of spent preparations. The lowest agronomic effectiveness of the preparations turned out to be in variant 3. On average, it was 118 kg for the Agat variety and 22 65 kg of grain for the Povolzhsky variety per 1 kg of preparations with yield gains of 0.47 and 0.26 t/ha. Payment for one kilogram of the active substance of 168-200 kg/kg was noted in the Agat variety in the 7th variant and in the Povolzhsky 22 variety – in the variants 2 and 7. 300-500 kg of grain per 1 kg of the active substance was obtained in variants 4 and 5 in two varieties and in the Agat variety in variant 2.

Table 3. Indicators of economic efficiency when using complex fertilizers on varieties of spring barleycorn

Variant	2		3	4		5	6		7
Yield increase, t/ha	0.15	0.69	0.66	0.17	0.39	0.51	0.11	0.47	0.72
Additional income, rubles/ha	1125	5175	4950	1275	2925	3825	825	3525	5400
Total cost of the agents, rubles/ha	279		1410	471		434	270		584
Additional costs, rubles/ha	536	1335	1291	566	891	1069	477	1010	1694
Total additional costs, rubles/ha	815	1614	2701	1037	1362	1503	747	1280	2278
Share of the agents in total additional costs, %	34	17	52	45	35	29	36	21	26
Conditional net income, rubles/ha	310	3561	2249	238	1563	2322	78	2245	3122
Economic return of additional costs, rubles/ha	1.38	3.21	1.83	1.23	2.15	2.55	1.1	2.75	2.37
Profitability, %	38	221	83	23	115	155	10	175	137

The largest payment for one kilogram of active substance was during the use of the complex in variant 5: on average, 1036 and 1321 kg of grain were obtained with the increase in grain yield of 0.29 and 0.37 t / ha.

The economic analysis of the use of complex fertilizers showed the feasibility of using drugs in foliar treatments. The variants 2, 4 and 6 turned out to be the most economically profitable, in which the additional costs associated with the use of fertilizers were repaid annually due to crop yields of 0.15-0.63 t / ha and the low cost of agents of 270-471 rubles / ha (table 3).

The share of agents in these variants did not exceed 45% of the total amount of additional costs. Net income in this case amounted to 3561 rubles / ha, and profitability reached 221%.

4 Conclusion

The studies showed the effectiveness of foliar treatments with the new generation of studied agents on Agat and Povolzhsky 22 varieties. The yield increase from the use of these agents amounted to 0.26-0.52 t / ha or 10-20%, while the grain quality indicators were preserved. The yield increase depended on the individual reaction of the variety and varied by variant and year.

The use of the Bioplant Flora + Zelenit N and RK complex was the most effective on Agat and Volga 22 varieties with crop yields of 0.43 and 0.37 t / ha.

The use of Souffler + Intermag Profi Grain and Biostim Rost + Intermag Profi Grain complexes increased the productivity of Agat by 0.52 and 0.47 t / ha.

The treatments with the Mival-Agro + Lignogumat + Zelenit N complex and Biostim Grain agent increased the yield of the Volga 22 variety by 0.37 and 0.39 t / ha.

The most cost-effective was the use of the Biostim Grain, Souffler + Intermag Profi Grain and Mival-Agro + Lignohumat + Zelenite N complexes: net income amounted to 3561 rubles / ha, and profitability reached 221%.

Thus, the foliar use of most of the studied agents on the Agat and Povolzhsky 22 intensive barley varieties is economically feasible. It allows one to increase grain yield and stabilize its production in the arid zone of the Middle Volga.

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