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The responsiveness of spring wheat to the use of biological preparations in the gray forest soils of the Fore Kama region of the Republic of Tatarstan

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Abstract. For many years, the largest sown areas in the Republic of Tatarstan have been devoted to spring wheat. Revealing the effect of biological preparations on growth processes, plant resistance to unfavorable conditions and stresses is an important issue in the cultivation technology within the framework of biological agriculture. In studies conducted in 2018-2019 with the Ulyanovskaya 100 spring wheat variety, biological fungicides and an adaptogen were used to increase resistance to adverse conditions from the collection of the Kazan State Agrarian University. The complex use of biological fungicides in the conditions of gray forest soils made it possible to increase the yield of spring wheat by 10.6 %, and the combined use of biological fungicides and an adaptogen contributed to an increase in the yield to 15.2 %.

1 Introduction

The formation of stable yields of spring wheat depends on the use of proven technology methods in specific soil and climatic conditions. The size and quality of spring wheat grain are determined by the complex influence of difficult environmental conditions [1, 2].

To obtain ecologically safe food grains and reduce the pesticide load on agrocenosis, biological methods of plant protection are being introduced. To increase the effectiveness of the biological agents used, it is necessary to investigate and use all possible mechanisms for maintaining the stability of biological agents in time and the prevailing environmental conditions. Microorganisms of biological preparations are subject to the influence of various environmental factors that have a comprehensive impact on their growth and development.

As the researchers note, for most biological agents of bacterial nature, optimal conditions for growth and development are possible with sufficient access to oxygen (aerobes) and moderate positive temperatures [3, 4]. It is the great dependence of the effectiveness of biological protection on the influence of environmental factors that largely determine and restrains its implementation in practice [5].

Studies on various ecotypes of common wheat varieties revealed that the economic efficiency of using the well-known bio fungicide Fitosporin-M (Bacillus subtilis 26D) on spring wheat ranged from 2.6 to 143 % [6]. One of the important substances in increasing the resistance of biological agents to negative environmental factors can be adaptogens or “substances that control the compensatory-adaptive reactions of microorganisms to stress and the development of crops in non-optimal growth conditions” [7–9].

2 Research methods and techniques

The studies were carried out on gray forest soils of the experimental field of the Kazan State Agrarian University in 2018–2019. The humus content is more than 3 %, mobile phosphorus (according to Kirsanov) – 250, potassium 121–170 mg/kg of soil, the pH of the salt extract is 6.1–7.0. The object of the study was spring wheat (Triti-cum aestivum L.), cultivar Ulyanovskaya 100. Biological preparations and adaptogen from the collection of Kazan State Agrarian University were used according to the following scheme: 1. Control (seed treatment with sterile distilled water); 2. Risoplan Pseudomonas fluorescens (seed treatment 1.5 l/t) + Rizoplan, 1 l/ha (spraying plants in the tillering phase, stemming, and heading);

3.Bacillus subtilis RECB-95B (seed treatment 1 l/t) + (spraying of plants in the tillering phase of Bacillus sp. RECB-50B (1.5 l/ha), exit into the tube Pseudomonas putida RECB-14B (0.5 l/ha), heading Bacillus subtilis RECB-95B (1 l/ha));

4.Bacillus subtilis RECB-95B (seed treatment 2 l/t) + (spraying of plants in the tillering phase of Bacillus sp. RECB-50B (1.5 l/ha), exit into the tube Pseudomonas putida RECB-14B (0.5 l/ha), heading Bacillus subtilis RECB-95B (1 l/ha));

5.Bacillus subtilis RECB-95B + adaptogen (seed treatment 1 l/t) + (spraying of plants in the tillering phase of Bacillus sp. RECB-50B + adaptogen (1.5 l/ha), exit into the tube Pseudomonas putida RECB-14B +

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adaptogen (0.5 l/ha), heading Bacillus subtilis RECB-95B + adaptogen (1 l/ha));

6 Bacillus subtilis RECB-95B + adaptogen (seed treatment 2 l/t) + (spraying plants in the tillering phase of Bacillus sp. RECB-50B + adaptogen (1.5 l/ha), exit into the tube Pseudomonas putida RECB- 14B + adaptogen (0.5 l/ha), heading Bacillus subtilis RECB-95B + adaptogen (1 l/ha)).

The experiments were carried out in 4-fold repetition, the placement of the plots was sequential. The accounting area for harvesting with a combine is 25 m² each. The forerunner is winter wheat, the main cultivation of the soil consisted of stubble plowing at 6-8 cm and plowing to a depth of 22–24 cm. Statistical processing of the research data was carried out according to B. A. Dospekhov [10].

3 Results and its discussion

In 2018, the growing season of spring wheat was characterized by aridity, increased temperature conditions, and a drop of only 66 % of precipitation from the average annual values. 2019 was a more favorable year, the early arrival of spring provided warm days in May, June, and 116 % of the rainfall.

The use of biological agents for 2 years during the pre-sowing treatment of Bacillus subtilis RECB-95B seeds at a dose of 1 l/t increased the field germination by 4.9 % compared to the control (Fig. 1).

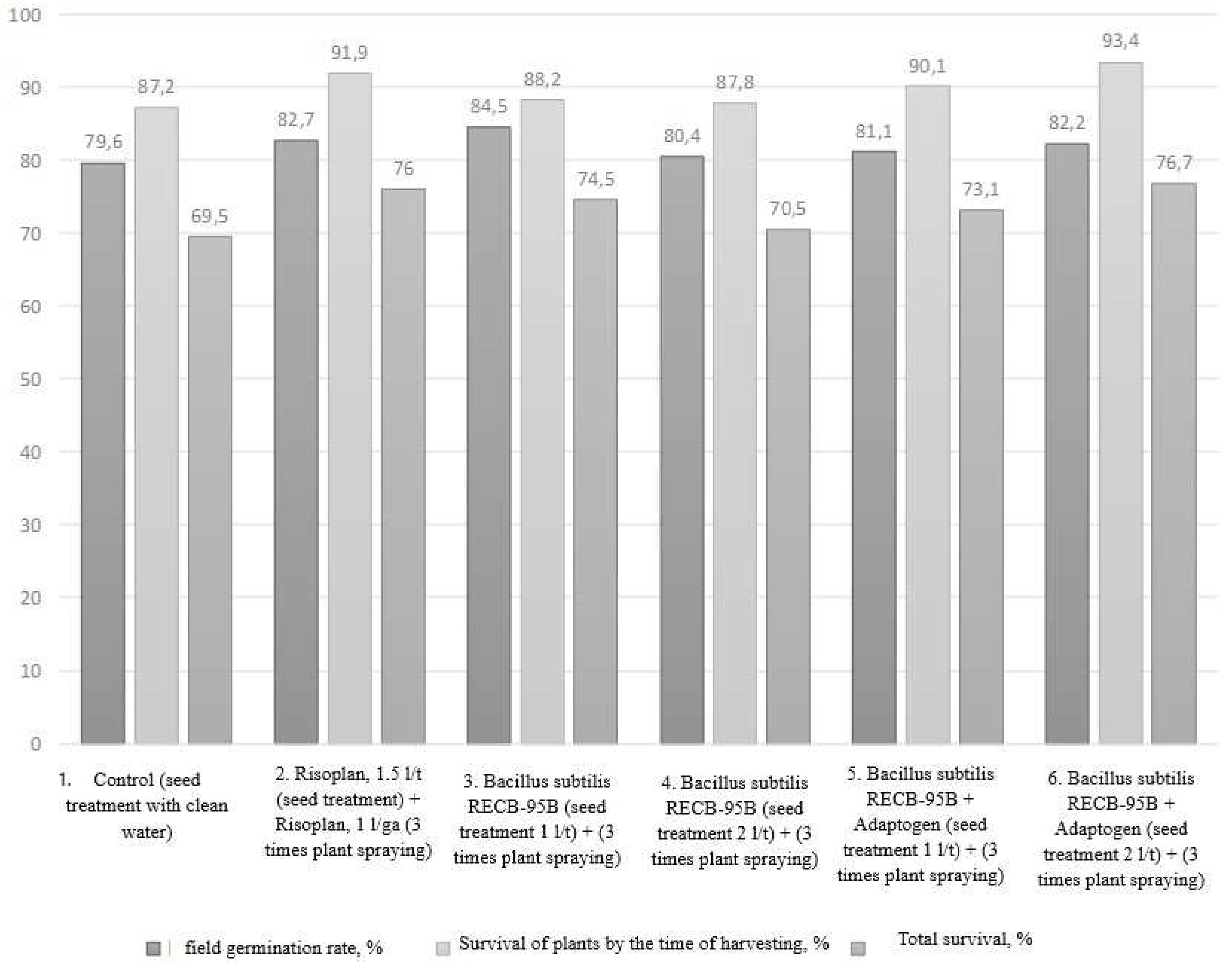

Fig. 1. Survival of spring wheat plants (%) depending on the use of biological preparations, 2018–2019

When Bacillus subtilis RECB-95B was treated with a dose of 2 l/t, field germination increased by only 0.8 %, and when combined with an adaptogen, by 2.6 %. Treatment of seeds and vegetative plants with the biological preparation Rizoplan increased not only field germination, but also the safety of plants for harvesting up to 91.1 % when in the control this indicator was 87.2 %. The complex use of biological agents for options 3 and 4 contributed to an increase in seedling safety by 0.6–1.0 %, and with the addition of adaptogen 5, 6 options by 2.9–6.2 %. Presowing treatment of Bacillus subtilis RECB-95B seeds at a dose of 1–2 l/t and spraying of crops in the tillering phase with biological agents RECB-50B at a dose of 1.5 l/t without and together with an adaptogen helped to curb the development and spread of root rot on spring wheat. The greatest increase in dry weight of roots, stem, ear of spring wheat in the phase of milk ripeness was observed in 5 and 6 variants, pre-sowing treatment of seeds with the agent RECB-95B 1–2 l/t and three-time spraying with agents RECB-50B, RECB-14B, RECB-95B together with an adaptogen (Fig. 2).

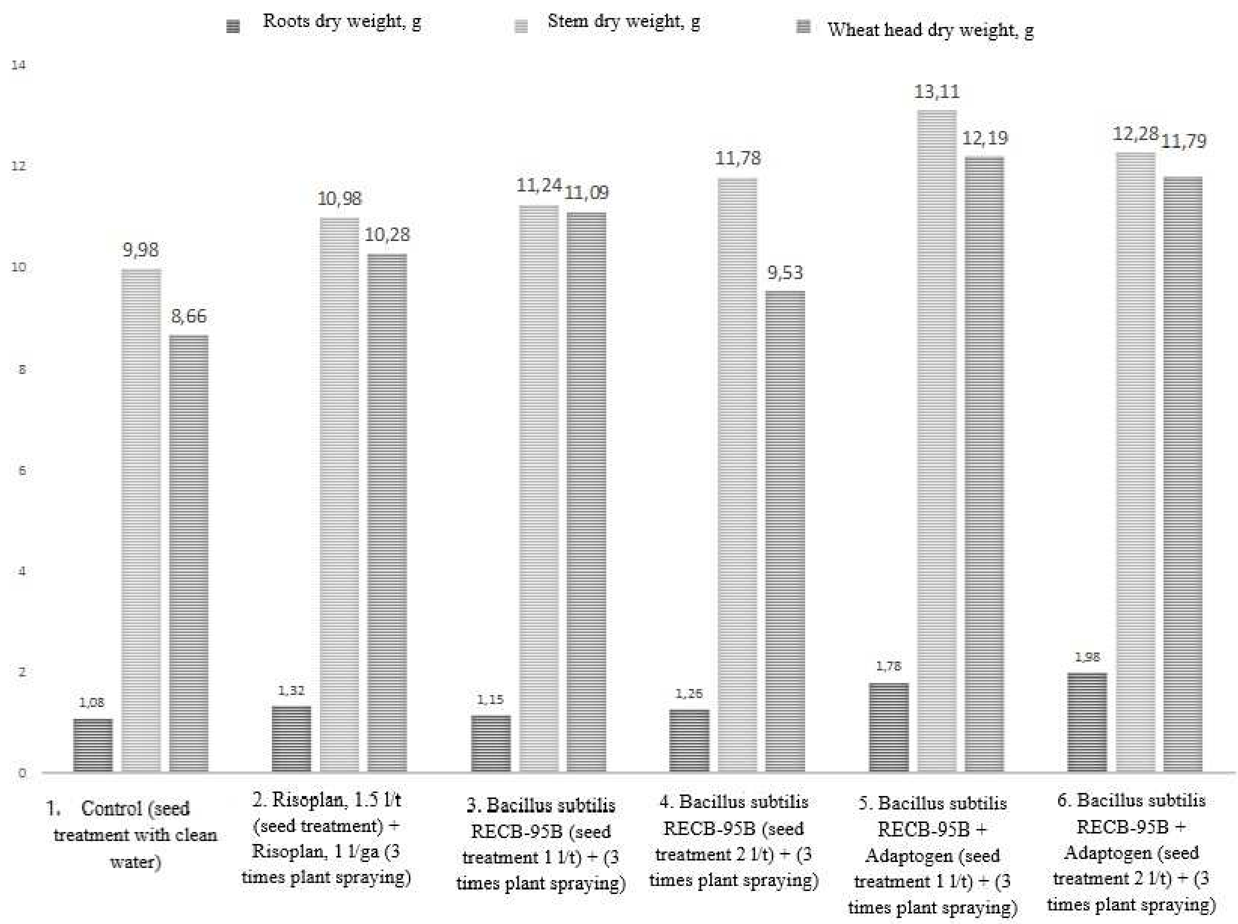

Fig. 2. Increase in dry weight of spring wheat plants in the phase of milk ripeness, depending on the use of biological preparations, 2018–2019

When biological agents without adaptogen were used, the 3rd and 4th variants, the dry weight of the roots was higher than in the control, but inferior to the 2nd variant, using the biological preparation Rizoplan.

In 2018, aridity in May and June did not allow the formation of a high yield of spring wheat (Table 1).

The highest yield in 2018 was obtained at 3.48 t/ha (option 6) when using a complex of biological agents together with an adaptogen. In 2019, the maximum yield of 5.04 t/ha (option 5) was also obtained with the combined use of a complex of biological agents and an adaptogen. The average yield for 2 years when using a complex of biological agents for spraying crops and pre-sowing seed treatment with a dose of 1.0 and 2.0 l/t was 4.07 and 4.15 t/ha, which is 10.6 and higher than the control. 12.8 %. With the combined use of the same biological agents and an adaptogen, the increase concerning the control was 12.8 and 15.2 %.

The use of biological agents in the pre-sowing treatment of seeds and when spraying crops of spring wheat did not significantly affect the quality indicators of grain (Table 2).

The protein content in wheat grain in 2018 with the use of biological preparations was higher than in the control. In 2019, an increase in the yield of spring wheat was observed with the use of biological preparations, and in the same variants, a decrease in the mass fraction of crude gluten, and the quality of gluten did not deteriorate, corresponded to the group 1.

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Table 1. Spring wheat productivity depending on the use of biological preparations, 2018–2019

Option	Grain yield, t/ha			Increase to control, %
	2018	**2019**	**Average**	
1. Control	2.53	4.82	3.68	-
2. Rizoplan, 1.5 l/t (seed treatment) + Rizoplan, 1 l/ha (3-fold spraying of plants)	2.67	5.07	3.87	5,2
3. Bacillus subtilis RECB-95B (seed treatment 1 l/t) + (3-fold spraying of plants)	3.30	5.00	4.15	12,8
4. Bacillus subtilis RECB-95B (seed treatment 2 l/t) + (3-fold spraying of plants)	3.47	4.66	4.07	10,6
5. Bacillus subtilis RECB-95B + adaptogen (seed treatment 1 l/t) + (3-fold spraying of plants)	3.26	5.04	4.15	12,8
6. Bacillus subtilis RECB-95B + adaptogen (seed treatment 2 l/t) + (3-fold spraying of plants)	3.48	5.00	4.24	15,2
LSD_{05}	0.13	0.21		

Table 2. Grain quality indicators of spring wheat depending on the use of biological preparations, 2018–2019

Option	Year	Protein content, %	Mass fraction of crude gluten, %	FDM, unit, quality group	Nature, g/cm³
1.Control (seed treatment with clean water)	2018 2019 avg.	11.5 13.5 12.5	25.1 27.6 26.4	85, II 74, I 80, II	762 791 777
2. Rizoplan, 1.5 l / t (seed treatment) + Rizoplan, 1 l / ha (3-fold spraying of plants)	2018 2019 avg.	13.4 13.4 13.4	27.2 30.4 28.8	90, II 64, I 77, II	767 788 778
3. Bacillus subtilis RECB-95B (seed treatment 1 l / t) + (3-fold spraying of plants)	2018 2019 avg.	17.0 13.7 15.4	21.1 25.3 23.2	89, II 64, I 77, II	777 793 785
4. Bacillus subtilis RECB-95B (seed treatment 2 l / t) + (3-fold spraying of plants)	2018 2019 avg.	16.0 12.8 14.4	25.1 25.1 25.1	89, II 65, I 77, II	785 781 783
5. Bacillus subtilis RECB-95B + adaptogen (seed treatment 1 l / t) + (3-fold spraying of plants)	2018 2019 avg..	12.7 14.7 13.7	24.8 22.8 23.8	87, II 53, I 70, I	780 785 783
6. Bacillus subtilis RECB-95B + adaptogen (seed treatment 2 l / t) + (3-fold spraying of plants)	2018 2019 avg.	13.1 12.7 12.9	24.6 25.3 25.0	89, II 66, I 78, II	779 784 782

4 Conclusion

Pre-sowing seed treatment with biological preparation RECB-95B and adaptogen (2 l/t), spraying of crops in the tillering phase RECB-50B together with adaptogen, in the tube emergence phase RECB-14B with adaptogen, in the heading phase RECB-95B with adaptogen on gray forest soils in 2018–2019 contributed to the formation of spring wheat yield by 15.2 % higher than the control.

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