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Productivity of spring spiked crops when using biological products based on *Bacillus subtilis* in the conditions of the Republic of Tatarstan

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Abstract. The effectiveness of the use of an experimental strain of Bacillus subtilis RECB-95B in the treatment of seeds of barley and spring wheat against diseases was studied. The growing season during the years of research was favorable for the growth and development of the tested crops. Barley and spring wheat seeds were treated with various doses of the experimental preparation. The scheme of the experiment included: control without seed fertilizing; the industrial biological product Rhizoplane was used as the standard. The smallest development of striped and brown spots on plants was noted on the variant, the seeds of which were treated with the biological product Rhizoplane. Plant damage by net blotch and root rot was minimal in the variant with Bacillus Subtilis RECB-95B 2.0l/t seed treatment. The highest yield of barley and spring wheat in the experiment was achieved with the treatment of seeds with Bacillus Subtilis RECB-95B 2 l/t (3.23 t/ha and 3.47 t/ha).

1 Introduction

Spring wheat is the main grain fodder crop of the Republic of Tatarstan. Among the most important agroecological features of barley is its higher potential for genotypic adaptation compared to spring wheat [7]. The yield and sowing qualities of spring wheat and barley seeds are determined by many factors, among which the correct high agricultural technology, meteorological conditions, the use of various groups of biological products and the adapted variety mainly play a determinant role. In modern zonal farming systems, the quality of seeds is of paramount importance, because without the full provision of farms with conditioned seeds of the best varieties, the efficiency of all other parts of the agrotechnical complex decreases [2, 3]. The formation of the crop of spring wheat and barley is determined under the influence of a complex set of conditions, each of which affects its quantity and quality [5, 6]. One of the important aspects of the influence of the environment surrounding the mother plant is the change in the viability of seeds as a result of infection with fungi, bacteria and viruses that cause various diseases of germinating seeds, seedlings and adult plants [1]. Resource saving in the field of crop production involves the widespread use of the achievements of modern biotechnology, including the use of various groups of biological products in the technology of growing crops [4].

2 Materials and Methods

Microfield experiments were performed on the experimental field of Kazan State Agrarian University in 2018. The soil of the experimental plot was gray forest. The content of humus was 4.1%, the pH of the salt extract was 5.5, easily hydrolysable nitrogen was 98–112, mobile phosphorus (according to Kirsanov) was 206-232, exchangeable potassium (according to Kirsanov) was 89-93 mg/kg of soil. The plot area was 1.0 m^2. The experiments were performed six times. The predecessor was winter rye. Fall plowing was carried out in August with preliminary stubble peeling. Fertilizers were applied under pre-sowing cultivation. The fallow harrowing was carried out on April 30, pre-sowing cultivation, respectively, on May 6. Sowing was carried out with a SN-16 seeder and an MTZ-82 tractor. The sowing rate for wheat was 5, and for spring wheat 6 million germinating seeds per 1 ha.

The object of the study was spring wheat and barley of Raushan and Ulyanovskaya 100 varieties.

The scheme of the experiment included the study of the following options:

1. No treatment (control);
2. *Chemical fungicide Armor* (seed treatment, standard KS 1.5 l/t);
3. *Pseudomonas fluorescens* Rhizoplane (seed treatment) + Rhizoplane, 1 l/ha (plant spraying);
4. *Bacillus subtilis* RECB – 95 B (1.0 l/t) (seed treatment) + RECB-95 B, 1.0 l/t (plant spraying);
5. *Bacillus subtilis* RECB – 95 B (2.0 l/t) (seed treatment) + RECB-95 B, 2.0 l/t (plant spraying);
6. *Trichoderma viride* RECB − 74 V (2.0 l/t) (seed treatment) + RECB-74 V, 2.0 l/t (plant spraying).

In 2019, the research was continued with spring wheat on the experimental field of Kazan State Agrarian University in the Laishensky district and in three state

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variety plots of the Republic of Tatarstan (Chistopolsky, Zainsky and Buinsky).

Table 1 shows the grain yield of spring wheat depending on presowing seed treatment and spraying (microfield experience) in 2018. In this experiment, biological agents were used, but the agent *Bacillus subtilis* RECB – 95 B (2.0 l/t) gave the highest increase to the control.

3 Results and Discussion

Seed treatment and the use of spraying in the experiments in 2018 contributed to the formation of higher yields of both wheat and spring wheat (Figure 1).

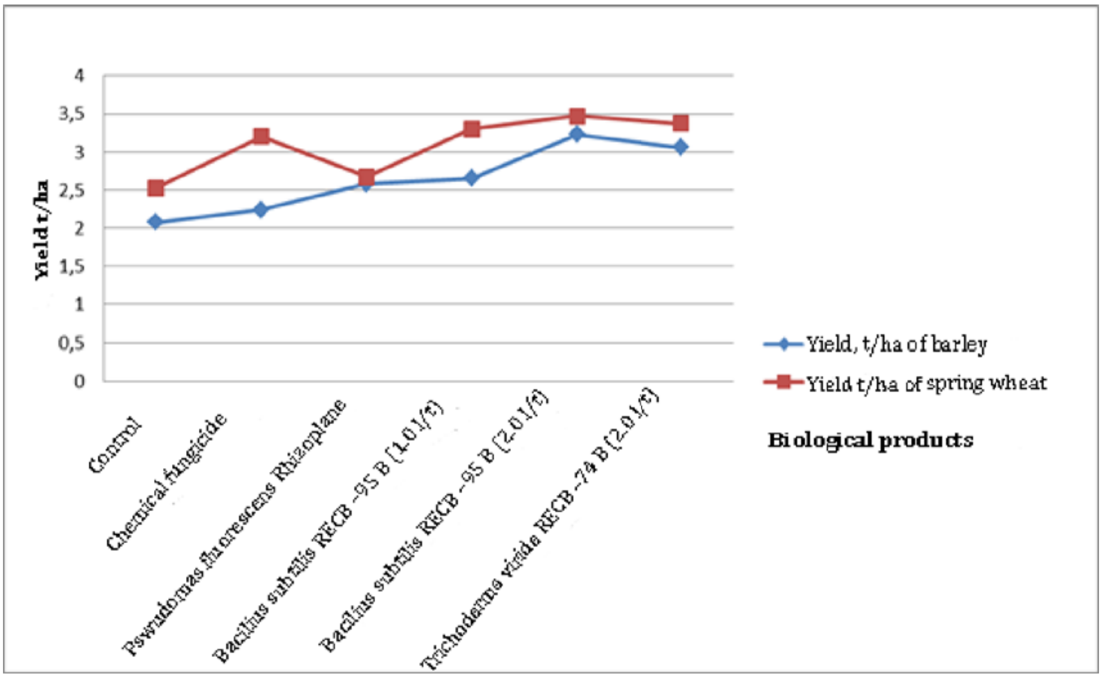

Fig. 1. Grain yield (t/ha) of spring wheat and barley depending on pre-sowing seed treatment and spraying (microfield experience), 2018.

The largest increase in grain yield of spring wheat - 0.94 t/ha and barley – 1.15 t/ha were obtained using *Bacillus subtilis* RECB – 95 B (2.0 l/t). The use of *Trichoderma viride* RECB – 74 V (2.0 l/t) also provided a significant increase of 0.84 t/ha and 0.98 t/ha in grain yield. The great importance of increasing the protein content in grain is generally recognized. Protein content is a quantitative trait with polygenic inheritance and high sensitivity to environmental conditions. In order to obtain high quality grain, nutrients and products that contribute to their better use are of great importance. The maximum protein content in the grain of spring wheat and wheat was 13.7–16.7% and nature 703–784 g/l was in the variant with drug treatment *Bacillus subtilis* RECB – 95 B (2.0 l/t) (Table 1).

Table 1. Grain quality indicators of wheat and spring wheat depending on presowing seed treatment and spraying (microfield experience), 2018.

Variant	Grain nature, g/l		Protein content, %	
	Barley	Spring wheat	Barley	Spring wheat
Control	672	763	12.5	10.8
Chemical fungicide	679	783	12.9	10.0
Pseudomonas fluorescens Rhizoplane	684	774	13.2	13.0
Bacillus subtilis RECB – 95 B (1.0 l/t)	677	778	13.3	14.9
Bacillus subtilis RECB – 95 B (2.0 l/t)	703	784	13.7	16.7
Trichoderma viride RECB – 74 V (2.0 l/t)	671	778	12.6	13.5

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In 2019, in field experiments in the conditions of the Laishevsky district (the Pre-Kama) on gray forest soils, a significant increase in the yield of spring wheat was obtained using *Trichoderma viride* RECB – 74 V (2.0 l/t) and *Pseudomonas fluorescens Rhizoplane* 0.26 and 0.25 t/ha, respectively (Figure 2).

In field experiments conducted in the same year according to the same scheme, but in the conditions of the Western the Pre-Kama (Chistopol state variety testing plots) on leached chernozems, the maximum spring wheat yield of 4.53 and 4.50 t/ha was obtained using *Bacillus subtilis* RECB – 95 B (1.0 l/t) and *Trichoderma viride* RECB – 74 V (2.0 l/t) (Fig. 3).

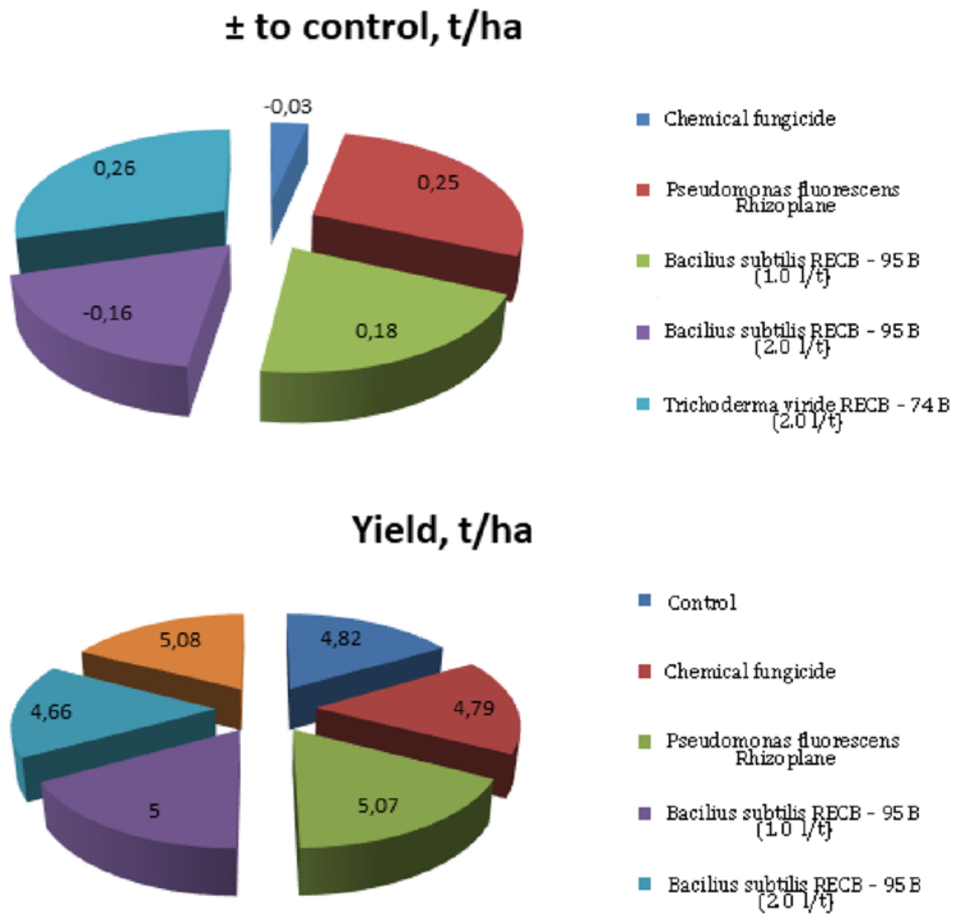
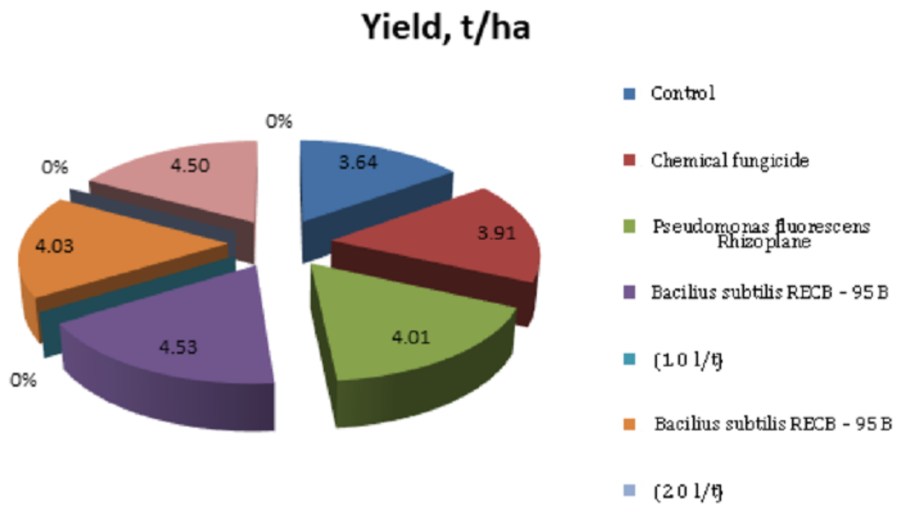


Fig. 2. Grain yield (t/ha) of spring wheat on gray forest soils of the Pre-Kama (Laishevsky district) depending on presowing seed treatment and spraying (field experience), 2019.

The results of studies in the conditions of the Eastern Trans-Kama region (Zainsky state variety testing plots) are shown (Fig. 4) A significant increase in the yield of spring wheat was obtained using *Bacillus subtilis* RECB – 95 B (1.0 l/t) and (2.0 l/t) – 0.50 and 0.35 t/ha. The use of *Trichoderma viride* RECB – 74 V (2.0 l/t) provided the increase in spring wheat grain yield of 0.37 t/ha compared to the control one.



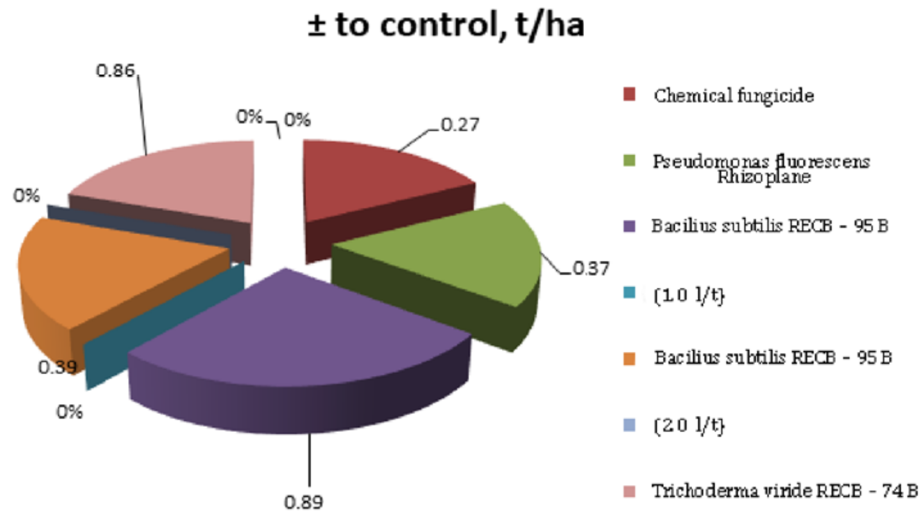
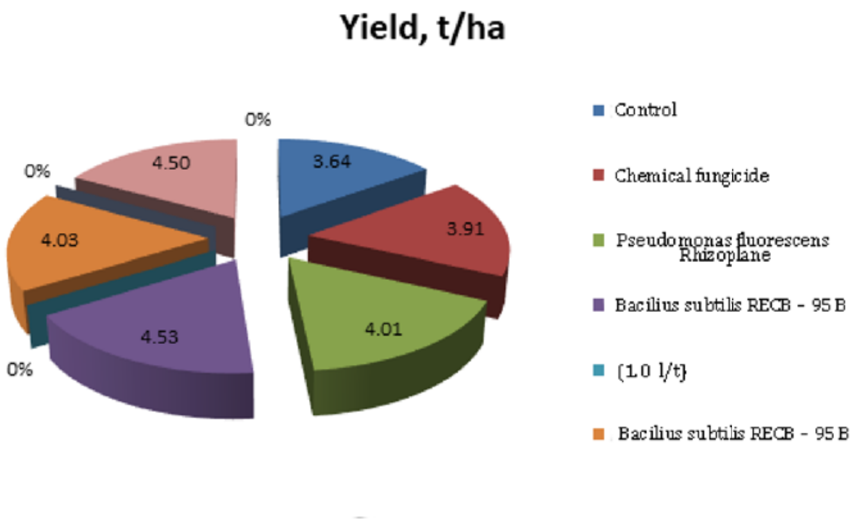


Figure 3. Grain yield (t/ha) of spring wheat on the chernozems of the Western Trans – Kama region, depending on pre-sowing seed treatment and spraying (field experience), 2019.



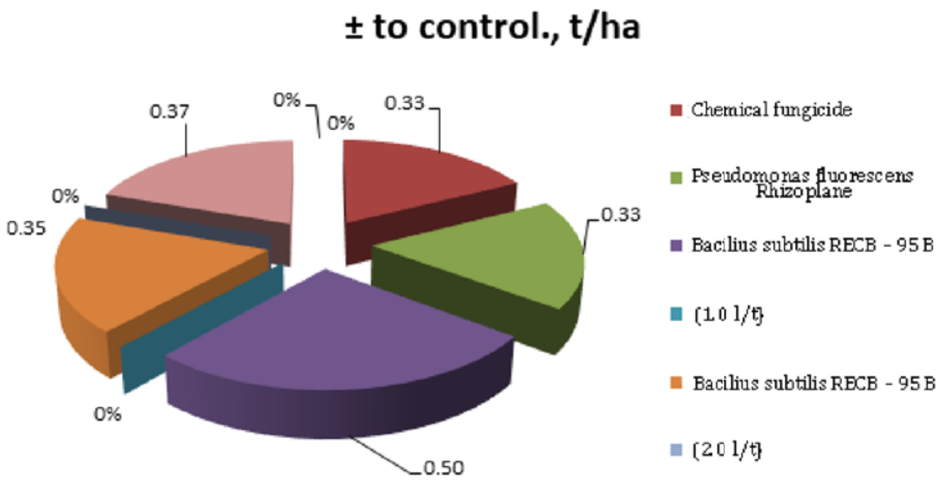


Fig. 4. Grain yield (t/ha) of spring wheat on chernozems of the Eastern Trans-Kama, depending on the pre-sowing treatment of seeds and spraying (field experience), 2019.

4 Conclusion

In the conditions of the Pre-Kama region of the Republic of Tatarstan on gray forest soils in 2018, the highest yield of barley and spring wheat was obtained when using *Bacillus subtilis* RECB – 95 B (2.0 l/t) and *Trichoderma viride* RECB – 74 B (2.0 l/t), and in 2019, only *Trichoderma viride* RECB – 74 V (2.0 l/t) gave a significant increase.

In the conditions of the Trans-Kama region of the Republic of Tatarstan on leached chernozems, the highest yield of spring wheat was obtained using *Bacillus subtilis* RECB – 95 B (1.0 l/t) and *Trichoderma viride* RECB – 74 B (2.0 l/t).

In order to increase the protein content in barley grain and to stabilize high yields of the main grain fodder crop in the Republic of Tatarstan, it is advisable to use the biological product *Bacillus subtilis* RECB – 95 B for seed treatment before sowing and spraying plants during the growing season.

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