Effect of Combined Dressing Agents on Phytosanitary Situation in Winter Wheat Ecosystems

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Abstract. The Middle Volga forest-steppe was subject to a comparative assessment to evaluate the effectiveness of combined insect-fungicidal pesticides as regulators of a phytosanitary state of farming ecosystems and yields of winter wheat. Insect-fungicidal pesticides used for pre-sowing treatment do not guarantee unconditional success, but they help to significantly reduce pest-induced losses and obtain safer grain produce. Regulated seeding rates showed that, once applied, combined dressing agents become slightly less biologically effective with overcrowding or thinning of crops. Dividend Supreme effectively reduced damage to shoots by Swedish flies, slightly worse than Celest Top. Celest Top and Dividend Supreme ensured stable suppression of root rot during the years of research. The winter wheat increasingly lodged when Celest Top and Dividend Supreme were used for seed dressing compared to the control (without dressing). Insect-fungicidal dressing agents increased the yield of winter wheat compared to the control and, at the same time, the risk of lodging. This effect was especially noticeable when Celest Top was used. It is recommended to use the combined Dividend Supreme and Celest Top pesticides for ensuring a stable phytosanitary situation and obtaining a high-quality harvest with a seeding rate of the target crop of 2-3 million seeds per 1 ha.

1 Introduction

Wheat is a worldwide staple food. It feeds millions of people all over the planet and provides food for animals. Wheat is grown on an area making up about 230 million hectares in the world. For Russian people, wheat has been the most valuable and productive crop for centuries [1, 2].

Driven by global warming and climate change over the last decades of the 20th century and the turn of the new century, winter wheat gradually began to be introduced into production, replacing winter rye. Winter wheat was mainly grown in the south of the region in steppe areas, where crop failures were less common due to the absence of severe frosts (38-40 °C), rotting and damping-off, since a poor snow cover provides no conditions for the latter to occur. In recent years, winter wheat has become one of the staple foods in the Samara region. Wheat-sown areas have increased and occupy more than 400 thousand hectares [2, 3].

Among many factors that reduce the efficiency of grain production, overlooking an arsenal of phytophages and phytopathogens developing, which significantly hampers yield growth, subject to specific natural and climatic conditions and closely related crop production processes, is fatal. A more flexible approach in framing the strategy, feasibility and agenda of measures to protect crops will not only increase the yield of winter wheat, but also reduce the environmental risks associated with an unwarranted use of pesticides [3–6].

Insect-fungicidal dressings used for pre-sowing seed treatment do not guarantee unconditional success, but help to significantly reduce pest-induced harmful effects and obtain safe grain produce [3, 7, 8].

2 Material and methods

2.1 Object of study

The objects of study were released varieties of spring wheat – Kinelskaya Niva, Kinelskaya Otrada, Kinelskaya Yubileinaya, and dressing agents – Maxim, Vitaros, plant growth regulators – succinic acid, Epin Extra, Immunocytophyte, Zircon, HB 101 and an arsenal of phytopathogens and phytophages developed in winter wheat ecosystems.

The paper aims to find out the effectiveness of the preparations used for pre-sowing treatment of winter wheat seeds, as well as to study their effect on the yield of the target crop.

The objectives are to identify the effect of dressing agents and seeding rates on defeat and damage of winter wheat ecosystems, as well as on the yield of winter wheat, depending on an experimental design in the forest-steppe conditions of the Samara region.

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2.2 Methods of research

A microfield test was laid out in 2016 at the Samara Research Institute of Agriculture named after V.I. Tulaykov. A spacing of wheat was systematic, each experiment was 4-time replicated. The area of a selection plot was 100 m^2. The experiment designs were: 1. control (without pre-sowing seed treatment) + seeding rate of 5 million germinating seeds; 2. seed treatment with Ranazol Ultra, FS (0.2 l/t) + seeding rate of 5 million germinating seeds; 3. seed treatment with Celest Top, FS (1.5 l/t) + seeding rate of 5 million germinating seeds; 4. seed treatment with Celest Top, FS (1.5 l/t) + seeding rate of 4 million germinating seeds; 5. seed treatment with Celest Top, FS (1.5 l/t) + seeding rate of 3 million germinating seeds; 6. seed treatment with Celest Top, FS (1.5 l/t) + seeding rate of 2 million germinating seeds; 7.seed treatment with Celest Top, FS (1.5 l/t) + seeding rate of 1 million germinating seeds.

The same studies were carried out in 2018-19, at Pobeda-Agro LLC, Stavropol district, Samara region, with winter wheat. The seeding rate was 4 million viable seeds/ha. A spacing of wheat was systematic, each experiment was 3-time replicated. The area of a selection plot was 0.95 hectares. The experimental designs were: 1. control – without pre-sowing seed treatment; 2. seed treatment with Celest Top, FS (1.5 l/t); 3. Dividend Supreme, FS (2.5 l/t); 4. Dividend Extreme, FS (0.75 l/t); 5. Magnat Total, FS + Agent, WG (1l/t + 0.07kg/t).

A winter wheat variety promising for breeding in the Samara region – Svetoch – was taken for tests. Laboratory trials and field surveys were carried out according to generally accepted methods.

3 Results

Once applied, a Celest Top combined dressing agent helped to reduce damage to winter wheat crops from the Swedish fly, both in autumn and spring (Table 1). Celest Top has a smaller insecticidal effect on overgrown crops. The best ecosystems turned out to be those pre-treated with Celest Top and seeding rates of 2-3 million seeds per hectare.

Table 1. Infestation of spring wheat ecosystems with root rot, depending on experimental designs, %

Experimental designs	Crop damage, %	
	21/09/2015	27/05/2016
Control – 5 million seeds/ha	0.9	12.2
Ranazol Ultra, FS – 5 million seeds/ha	0.9	13.1
Celest Top, FS – 5 million seeds/ha	0.6	4.6
Celest Top, FS – 4 million seeds/ha	0.4	3.1
Celest Top, FS – 3 million seeds/ha	0.3	2.7
Celest Top, FS – 2 million seeds/ha	0.3	1.9
Celest Top, FS – 1 million seeds/ha	0.4	3.4

Once the crops were overcrowded or thinned out by the seeding rates adjusted, the effectiveness of the combined dressing agent slightly decreased. Damage to crops when using a Ranazol Ultra fungicidal dressing agent was at the control level, due to the absence of an insecticidal component.

Both studied dressing agents reduced the infestation of winter wheat crops with root rot by 2-3 times, depending on the experimental design (Fig. 1). But probably, the shoots of the studied crop infested by Swedish fly larvae were less resistant to infestation by root rot when the seeds were treated with Ranazol Ultra, which caused damage to the ecosystem in this variant at the level of 10.2%. Treating seeds with Celest Top, with the same seeding rate of 5 million seeds per 1 ha, more effectively reduced the infestation of crops with root rot as contrary to Ranazol Ultra.

Regarding the experimental designs with Celest Top seed treatment and different seeding rates, the crops with a seeding rate of 3 million seeds per 1 ha were least damaged. Overcrowding or thinning of winter wheat crops, as in the case of Swedish flies, reduced the effect of dressing agents and increased the incidence of root rot compared with ecosystems with a seeding rate of 3 million seeds per hectare.

The preparations applied for pre-sowing seed treatment also contributed to the weight per bushel and mass of 100 grains (Table 2). The weight per bushel increased significantly when processing seeds with Celest Top and slightly when using the Ranazol Ultra one-component dressing agent.

The weight also fluctuated at different seeding rates with a tendency to increase with thinning crops, which is most likely due mainly to an increase in the feeding area of winter wheat plants.

Table 2. Effect of dressing agents and seeding rates on the weight per bushel and mass of 1000 grains of winter wheat

Experimental designs	Weight per bushel, g/l	Mass of 1000 grains, g
Control – 5 million seeds/ha	686	31.8
Ranazol Ultra, FS – 5 million seeds/ha	698	32.7
Celest Top, FS – 5 million seeds/ha	703	32.6
Celest Top, FS – 4 million seeds/ha	704	32.5
Celest Top, FS – 3 million seeds/ha	707	32.9
Celest Top, FS – 2 million seeds/ha	712	34.6
Celest Top, FS – 1 million seeds/ha	713	35.1

Subject to a definite experimental design, the mass of 1000 grains changed similarly to those patterns listed above for the weight per bushel of winter wheat.

The Celest Top insect-fungicidal dressing agent under insufficient moisture in autumn and spring-summer at a relatively late sowing period in abnormal conditions activated growth and protected well against diseases and pests, which resulted in a high yield of winter wheat of 24.5-26.9 c/ha and provided a significant yield gain of 13.4-24.5%, compared to the control (Table 3).

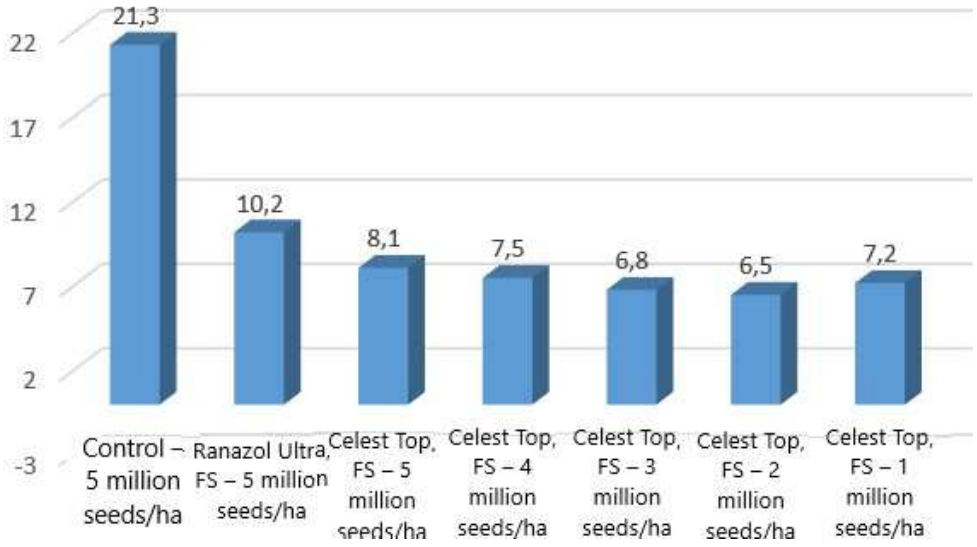

Fig. 1. Effect of dressing agents and seeding rates on infestation (%) of winter wheat crops with root rot, 09/21/2015

Table 3. Effect of dressing agents and seeding rates on winter wheat yields

Experimental designs	Yield, c/ha	Yield gain	
		c/ha	%
Control – 5 million seeds/ha	21.6	_	_
Ranazol Ultra, FS – 5 million seeds/ha	23.6	2.0	9.3
Celest Top, FS – 5 million seeds/ha	24.5	2.9	13.4
Celest Top, FS – 4 million seeds/ha	26.3	4.7	21.8
Celest Top, FS – 3 million seeds/ha	26.9	5.3	24.5
Celest Top, FS – 2 million seeds/ha	26.6	5.0	23.1
Celest Top, FS – 1 million seeds/ha	26.2	4.6	21.3

GAP = 0.74 c/ha

Ranazole Ultra provided a smaller increase in winter wheat yield compared to Celest Top. The seeding rates of the studied culture also affected the effectiveness of the combined dressing agent. A high seeding rate of 5 million seeds per 1 hectare, giving overcrowded crops, almost halved yield gains caused by a dressing agent applied.

The highest harvest was yielded with a seeding rate of 2.0-3.0 million seeds per hectare – 26.6-26.9 c/ha. The maximum difference in yield with a fungicidal dressing agent was 5.3 c/ha at a seeding rate of 3 million seeds per hectare.

There was a slightly different damage to winter wheat crops by Swedish fly larvae in the target years (Table 4). The greatest damage was caused in the growing season of 2019, which is most likely due to weather conditions favorable for the pest in a hibernation-like stage and a corresponding outbreak of the studied phytophage in the first generation.

There was also a sharply decreased infestation of wheat shoots in ecosystems treated with dressing agents in both years of research.

The Dividend Supreme was more effective in combating the infestation of shoots by the Swedish fly larvae, slightly worse than Celest Top. An intermediate level of crop damage was provided by the Dividend Extreme.

A tank mixture of Magnat Total fungicide and Agent insecticide reduced the infestation of wheat shoots by flies, though worse than combined insect-fungicidal dressings, possibly due to incomplete chemical compatibility.

Table 4. Effect of preparations for pre-sowing seed treatment on damage to winter wheat crops by Swedish flies, 2018-19

Experimental designs	Damage, %			Biological effectiveness, %
	25/05/2018	19/05/2019	Average	
Control	9.7	15.4	12.6	-
Celest Top, FS	2.1	3.7	2.9	77.0
Dividend Supreme, FS	1.9	2.6	2.3	82.1
Dividend Extreme, FS	3.1	4.4	3.8	70.2
Magnat Total, FS + Agent, WG	4.2	5.2	4.7	62.7

On average, for two studies, Dividend Supreme turned out to be the best dressing agent that almost 5 times reduced damage to winter wheat crops during the years of research. The Celest Top disinfectant showed a slightly higher infestation of shoots of the studied culture with Swedish flies – 2.9%.

A Magnat Total+Agent mixture was just as effective in reducing damage to the ecosystem (4.7%), despite lower rates compared to other dressing agents.

The studied preparations applied for pre-sowing seed treatment had a suppressive effect on pathogens as well

(Table 5), although less pronounced compared to phytophages.

In both years of research, the best option towards root rot was the Celest Top pre-sowing treatment. The Dividend Extreme disinfectant reduced the infestation of winter wheat ecosystems with root rot somewhat worse among the studied preparations.

Table 5. Effect of seed pretreatment preparations on infestation of winter wheat crops with root rot, 2018-19

Experimental designs	Damage, %			Biological effectiveness, %
	25/05/2018	19/05/2019	Average	
Control	12.3	21.7	17.0	-
Celest Top, FS	4.3	8.2	6.3	63.2
Dividend Supreme, FS	4.7	7.8	6.3	63.2
Dividend Extreme, FS	5.2	12.8	9.0	47.1
Magnat Total, FS + Agent, WG	7.8	12.9	10.4	39.1

On average, over two years, the studied dressing agents reduced the infestation of crops by root rot by 2 or more times. Celest Top and Dividend Supreme ensured stable suppression of the studied phytopathogens during the years of research. Dividend Extreme showed a stable good decrease in the incidence of crops, but slightly less than other preparations in the experiment.

The Magnat Total+Agent mixture showed an ambiguous decrease in the infection of wheat plants with rot, most likely due to the moisture conditions and soil temperature in the first year of research that allowed the fungicidal component of the mixture to effectively reduce a number of propagules of root rot pathogens compared to the next year.

As observed, the target pre-treatment preparations in no way affected the grain moisture during harvesting (Table 6).

Table 6. Effect of seed pretreatment preparations on winter wheat moisture and lodging, on average 2018-19

Experimental designs	Moisture during harvesting, %	Lodging, %
Control	11.8	9.5
Celest Top, FS	11.8	65.5
Dividend Supreme, FS	11.8	52.4
Dividend Extreme, FS	11.8	1.5
Magnat Total, FS + Agent, WG	11.8	0.5

However, it is necessary to pay attention to a sharp increase in lodging of winter wheat when using Celest Top (65.5%) and Dividend Supreme (52.4%) for seed dressing compared to control (9.5%). In ecosystems where Extreme Dividend and the Magnat Total+Agent mixture were used, grain lodging was present in trace amounts. This is most likely caused by inhibited growth of winter wheat due to some suppression by pests and diseases, an increase in ear mass associated with a need to obtain better conditions for plant development, as well as some retardant effect of chemical constituents of the preparations.

According to the studies, the insect-fungicidal dressing agents increased the yield of the studied crop. Over the entire period, the option with the Dividend Supreme as a dressing agent was consistently the best (Table 7). A slightly lower yield was produced following Celest Top pre-sowing treatment. The Magnat Total+Agent mixture was slightly inferior to ready-made insect-fungicidal disinfectants, both in phytosanitary indicators and winter wheat yields.

The changing yields of the studied crop are reflected by the economic efficiency that shows that the tank mixture of insecticides and fungicides in the proposed version as a seed disinfectant is ineffective. It is more expedient to use ready-made industrial mixtures of dressing agents.

Table 7. Effect of seed pretreatment preparations on winter wheat yield, 2018-19

Experimental designs	Yield, c/ha			Economic efficiency, %
	2018 г.	2019 г.	в среднем	
Control	30.4	21.1	25.8	-
Celest Top, FS	34.2	25.8	30.0	16.3
Dividend Supreme, FS	35.1	26.7	30.9	19.8
Dividend Extreme, FS	33.3	24.6	29.0	12.2
Magnat Total, FS + Agent, WG	30.9	21.6	26.3	1.7

GAP = 0.59 c/ha (2018);
GAP = 0.56 c/ha (2019).

In general, the use of insect-fungicidal dressings increased the yield of the crop compared to the control, but increased the risk of lodging, which is especially noticeable when using Celest Top (65.5% lodging), causing losses and shortages of crops, because a culm cannot always withstand such a mass of ears. To avoid this, it is necessary to use growth regulators that affect the development of a thicker culm with short internodes.

4 Discussion

The use of the Celest Top combined dressing agent reduced the damage to winter wheat crops by the Swedish fly, both in autumn and spring. Celest Top has a smaller insecticidal effect on overgrown crops. The best ecosystems turned out to be those pre-treated with Celest Top and seeding rates of 2-3 million seeds per hectare.

The Celest Top insect-fungicidal dressing agent under insufficient moisture in autumn and spring-summer in a relatively late sowing period in abnormal conditions activated growth and protected well against diseases and pests, which resulted in a high yield of winter wheat of 24.5-26.9 c/ha and provided a significant yield gain of 13.4-24.5%, compared to the control.

On average, for two studies, Dividend Supreme turned out to be the best dressing agent that almost 5 times reduced damage to winter wheat crops during the years of research. The Celest Top disinfectant showed a slightly higher infestation of shoots of the studied culture with Swedish flies – 2.9%.

Based on the studies, insect-fungicidal dressing agents increased the yield of the studied crop. Over the entire period, the use of Supreme Dividend as a dressing was consistently the best. Celest Top pre-treated crops provided a slightly lower yield. The Magnat Total+Agent mixture was slightly inferior to ready-made insect-fungicidal disinfectants, both in phytosanitary indicators and winter wheat yields.

The most profitable was the pre-sowing treatment of seeds with Dividend Extreme – 99.4%, a slightly lower profitability – with the treatment with Dividend Supreme – 71.4%, less economic effect was produced by Celest Top – 4.7%. Seed processing with Dividend Extreme was unprofitable at all.

5 Conclusion

Plant protection chemicals used for pre-sowing seed treatment reduces a pesticide load on the beneficial inhabitants of ecosystems and helps obtain safe grain produce. Growth regulators and fungicides used for pre-sowing seed treatment do not guarantee unconditional success, but help to significantly reduce pest-induced harmful effects and obtain safe grain produce.

In the forest-steppe conditions of the Samara region, in order to improve the phytosanitary state of winter wheat ecosystems and obtain a high-quality harvest, it is more expedient to use the insect-fungicidal Dividend Supreme and Celest Top disinfectants with seeding rates of the target crop of 2-3 million seeds per hectare.

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