Application of additional substances in the complex of protective measures of spring wheat

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Abstract. These studies are aimed at studying the effect of such preparations as Biogenic iron, Silicon, humic preparation Rostok applied during vegetation in the tillering phase against the background of chemical protection on plant development and yield of spring wheat in the conditions of forest-steppe of the Northern Trans-Urals. In the process of experiments phytosanitary load of seeds with the content of infectious beginning 20-30%, damage of plant roots by fusarium-helminthosporiosis infection in the soil with the spread of the disease 8%, disease development up to 3% were taken into account. The excess of biometric indices in tillering phase was observed in the variant of chemical fungicide application on seeds, where leaf development exceeded other variants by 0.8 cm. Flag leaf development with exceeding the variants by 3-4 cm was observed with application of Biogenic Iron (BioFeCo) in pure form and in mixture with humic preparation Rostok. Biometrics conducted in the phase of filling - milk ripeness determined the effect of variants with humic preparations and their mixtures with Biogenic iron (BioFeCo), silicon (SiO_2) on the increase in stem weight by 3-6 g, leaf weight by 1.0-1.7 g, ear weight by 1.0 g. Yield under the conditions of the year was 4.4-4.7 t/ha, no reliable increase in yield was not provided by any variant, but some exceeded the control in the variants biogenic iron (BioFeSo), Biogenic iron mixed with sprout (0.13 t/ha). The results of structural analysis show an increase in the values of the variants of application of Biogenic Iron (BioFeCo) in pure form and in mixture with humic preparation Rostock, so the number of spikelets 11-13.4 pcs, spike length 7.2-8.3 cm, number of grains in the spikelet 23-31 pcs, grain weight from 25 stems 27-37 g, weight of 1000 grains 34-42 g and biological yield 4.7-7.7 t/ha. Grain quality indicators did not have significant changes in the variants and the grain had a high gluten content. The studies show a positive effect on the development of spring wheat plants during the growing season with moisture deficit and excessive temperatures of the studied preparations Biogenic iron (BioFeSo), humic preparation Rostock.

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1 Introduction

The demanding nature of spring wheat to growing conditions implies constant improvement of cultivation technologies, one of the techniques is the optimization of the use of mineral and organic fertilizers, biopreparations and growth stimulants, plant protection products, which will contribute to increased yields and quality [1]. At present, scientific researchers and agricultural producers pay considerable attention to plant biostimulants and microelements in the complex of protective measures of spring wheat against negative weather conditions, diseases and pests to increase grain productivity [2]. Recently, preparations containing silicon, biogenic iron, humic substances, nanopreparations containing macro and microelements, which promote better development of wheat plants, its resistance to various negative factors, are beginning to be widely used.

Thus, the use of silicon fertilizers significantly increases plant resistance to diseases and pests, increases the bushiness of wheat plants, the weight of 1000 grains, spikelets in the ear [3-5]. Experiments of different scientific researchers have shown that the use of industrial sodium, potassium and ammonium humates in optimal doses has a stimulating effect on seed germination, facilitates plant nutrition and respiration, increases the length and weight of seedlings, improves enzymatic activity and reduces the effect of heavy metals and radionuclides on plants. Iron is an essential element for plants, it is a part of respiratory enzymes, is involved in redox processes, iron deficiency is a problem for many crops and in different regions its content in the soil is different and insufficient iron intake can lead to an imbalance of elements, which in turn affects the development of plants and quality indicators of agricultural production [7-8]. Thus, the use of biopreparations, microfertilizers and new generation growth stimulants contribute to the improvement of sowing and economic qualities of wheat grain and its yield.

The purpose of research was to determine the effect of application of trace elements silicon, Biogenic iron, in mixture with humic preparation Rostok on plant development, yield, grain quality of spring wheat.

2 Materials and methods

Laboratory and field experiments were carried out in the SRIA for NTUR – Branch of Tyumen Sci-entific Centre SB RAS, Tyumen region, Tyumen district, Moskovsky settlement, northern forest-steppe zone. The soil of the experimental plot belongs to the dark gray forest subtype, heavy loamy by granulometric composition, with favorable physical and chemical properties. Humus horizon has a low density (1.22 g/cm^3). The humus content is 4.3%. Hydrologic acidity decreases depending on the depth of the section. Nitrate nitrogen content in the research soil is low (1.36 - 2.38 mg/100 g soil), phosphorus is average (8.25 - 14.1 mg/100 g soil), potassium is above average (6.65 - 8.9 mg/100 g soil), soil solution reaction is slightly acidic (5.1-6.0). Phytoexamination of seeds was carried out by the roll method according to the following methods [9-10]. For this purpose, 2 samples of 50 grains each were taken in the control and in the variants with seed treatment. The assessment of seed infestation by various pathogens was evaluated on the 7th day. Counts and observations were carried out according to standard methodological guidelines adopted in the State Plant Production and Plant Protection Network [11]. Mathematical processing of the data was performed according to B.A. Dospekhov and using the SNEDECOR V5 application program package [12-13].

Development and prevalence of common root rot according to the method [14] were determined twice during the growing season in the tillering phase and before harvesting. Field germination of seeds, plant survival rate and structural analysis of yield were carried

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out according to generally accepted methods (Methodological Guidelines..., 1977; Experimental work in field farming, 1982).

The development of aerogenic infections (brown leaf rust, septoriosis, powdery mildew) was counted from tillering phase to milk ripeness. Ten leaves of a certain tier were sampled at ten locations, then the degree of disease coverage of leaf surface was determined using universal scales expressed in percent (Practical Recommendations..., 1988).

Yield was taken into account by the method of continuous threshing by a combine harvester Sampo 130, brought to standard moisture content and purity according to GOST 1386.5-93 and 30483-97. Determination of grain quality indicators was carried out in the center of analytical research and technological evaluation of grain according to GOST 12042-80, GOST 10840 - 64, GOST 13586.1-68.

The experiment was laid in a small-division format, the area of the accounting plot 20 m2 in 4 repetitions, spring wheat variety Grenada of the Northern Trans-Urals NIISKh selection was used in the experiment. The precursor is fallow. Sowing spring wheat with seeding rate of 6.5 million germinated grains per 1 ha, SCS - 2. Background herbicide treatment (Pomegranate, 0.020 kg/ha + Avantix Extra, 0.9 l/ha).

Scheme of the field experiment:

- Diamond Super, 1.0 L/t (seed control).
- Control, (no seed treatment).
- BioFeCo, 2 ml/ha.
- BioFeCo, 4 ml/ha.
- BioFeCo, 2 ml/ha + sprout 300 ml/ha.
- BioFeCo, 4 ml/ha + sprout 300 ml/ha.
- Sio, 2 ml/ha.
- Sio, 2 ml/ha + sprout 300 ml/ha.
- Sio, 4 ml/ha + sprout 300 ml/ha.
- Rostok, 300 ml/ha.

In terms of precipitation availability, the agricultural year 2022-2023 can be characterized as dry (precipitation availability - 66% of the long-term average, SCC - 0.74 - 57% of the long-term average), with increased heat availability - 126% of the norm. The negative influence of dryness was reduced due to precipitation in the 2nd and 3rd ten-day periods of June (296 and 123% of the multiyear average) and in the 2nd ten-day period of July (162% of the multiyear average) and decrease of mean monthly air temperature in June to mean multiyear values.

3 Results and Discussion

The phytosanitary condition of seeds is influenced by weather conditions, the presence of infectious load on plants and in the soil, according to phytoanalysis of the studied seed material had infestation of pathogenic fungi was at the level of 20-30%, of the studied preparations showed effectiveness against seed diseases only chemical fungicide used in production 93%.

During the vegetation period, plants are observed in the main phenophases, where the main treatments are carried out to regulate the phytosanitary condition and pest control. Diseases (root rots) caused by several pathogenic organisms of helminthosporiosis and fusarium etiology in the phase of crop development (tillering - tube emergence) had a distribution of 0.7-8%, on the control variant 1.65%, with the development of the disease 0.2-3%, on the control 0.41%. Full 100% protection was observed on the variants of fungicide mordant application. All other preparations had no effect on the reduction of lesions or protection from root rots.

The variation of plant density ranged from 400 to 600 plants per m^2, which was influenced by the dryness of this period, as the seeds fell into the over-dried soil layer and germinated later than the record of plants in this phase.

The main biometric indices in tillering phase were determined by the length of the upper leaf and plant length, variant No. 1 with chemical fungicide, where leaf development exceeded other variants by 0.8 cm. The plant development was at the same level and varied in this phase from 20.5-21.9 cm (Table 1).

Table 1. Plant development (leaf length / leaf width / plant length) tillering-tube phase.

Option	Leaf length, cm	Sheet width, cm	Plant length, cm
Chemical fungicide	14.05	0.83	21.7
Control	13.2	0.75	21.9

Flag leaf development, namely its length on the variants of the experiment was 19-23 cm, with its width of 0.9-1.2 cm, exceeding the control and other variants by 3-4 cm with the application of biogenic iron (BioFeSo) in all rates in pure form and with humic preparation Rostock, silicon in the rate of 2 ml mixed with sprout, humic preparation Rostock in pure form, applied in the tillering phase (Table 2).

Table 2. Flag leaf development.

Option	Number of flag leaf samples (leaf length / leaf width)										Average
	1	2	3	4	5	6	7	8	9	10	
1	22.0 /1.0	20.0 /1.0	18.0 /1.0	20.0 /1.0	20.5 /1.1	21.5 /0.9	23.0 /1.1	16.0 /1.0	19.0 /1.0	17.5 /1.0	19.75 /1.01
2	18.0 /1.2	21.0 /1.1	20.5 /1.0	21.0 /1.2	17.5 /1.1	21.0 /1.0	26.0 /1.1	20.0 /1.0	16.0 /1.0	13.5 /1.0	19.45 /1.07
3	26.0 /1.2	21.0 /0.9	23.5 /1.3	22.0 /1.2	28.0 /1.1	19.0 /1.0	22.5 /0.9	22.0 /1.1	25.0 /1.0	21.5/ 1.0.0	23.0 /1.1
4	34.0 /1.2	29.0 /1.3	21.0 /1.1	23.0 /1.4	21.0 /1.4	20.5 /1.0	19.0 /1.1	29.0 /1.3	18.0 /1.0	21.0 /1.1	23.5 /1.2
5	20.0 /1.1	23.0 /1.2	22.0 /1.3	24.0 /1.1	28.0 /1.2	26.0 /1.2	23.0 /1.1	22.0 /1.4	27.0 /1.3	23.5 /1.1	23.8 /1.2
6	25.5 /1.3	29.0 /1.4	22.0 /1.2	21.5 /1.2	32.0 /1.3	22.0 /1.3	24.0 /1.3	22.0 /1.3	18.0 /1.3	20.0 /1.4	23.6 /1.3
7	27.0 /1.0	22.5 /1.2	18.5 /1.3	18.0 /1.0	22.5 /1.0	20.5 /1.1	16.5 /1.2	22.0 /1.3	20.0 /0.9	20.0 /1.1	20.7 /1.1
8	24.5 /1.2	22.0 /1.2	23.5 /1.3	22.0 /1.2	22.0 /1.4	26.0 /1.3	27.0 /1.2	27.0 /1.3	20.0 /1.0	19.0 /1.4	23.3 /1.2
9	21.5 /1.2	21.0 /1.3	21.0 /1.3	25.5 /1.1	20.5 /1.2	22.0 /1.2	22.0 /1.2	24.0 /1.2	23.0 /1.4	23.0 /1.3	22.3 /1.1
10	26.0 /1.2	24,0 /1,2	24.0 /1.2	25.0 /1.5	20.0 /1.2	22.5 /1.3	26.0 /1.2	24.0 /1.4	26.0 /1.5	22.5 /1.4	24.0 /1.3
NSR_{05}											2.1/0.2

Biometric indicators, conducted in the phase of filling - milk ripeness insignificantly change in the variants of the experiment, so the height of plants was 70-85 cm and no clear dependence on the effect of the preparation is not observed. Stem weight 16-26 g and here its increase by 3-6 g was observed in variants with humic preparation and their mixtures with biogenic iron (BioFeCo), silicon (SiO_2). There is also an increase in leaf weight by 1.0-1.7 g and ear weight by 1.0 g in these variants (Table 3).

Table 3. Biometrics of wheat plants.

No.	Option	Plant height, cm	Mass (g)		
			stems	leaves	seeds
1	Diamond Super, 1.0 L/t (seed control)	74.5	16.72	3.19	17.74
2	Control, (no seed treatment)	72.3	18.25	3.26	18.9
3	BioFeCo, 2 ml/ha	78.0	19.7	4.14	19.9
4	BioFeCo, 4 ml/ha	80.0	24.37	4.76	20.21
5	BioFeCo, 2 ml/ha + sprout 300 ml/ha	80.7	23.75	4.97	21.75
6	BioFeCo, 4 ml/ha + sprout 300 ml/ha	76.6	26.93	6.22	22.0
7	Sio, 2 ml/ha	78.9	17.39	3.15	19.24
8	Sio, 2 ml/ha + sprout 300 ml/ha	75.0	18.96	4.15	18.21
9	Sio, 4 ml/ha + sprout 300 ml/ha	81.7	22.1	4.5	20.48
10	Rostok, 300 ml/ha	77.1	21.23	4.79	20.2

Yield of the experiment variants was high for the conditions of the year and amounted to 4.4-4.7 t/ha, on the control variant 4.7 t/ha. Significant increase in yield was not provided by any variant, but with some plus to the control there is an increase in the variants biogenic iron (BioFeSo), with a rate of 2 ml, biogenic iron in a mixture with sprout (+0.01-0.13 t/ha) applied in the tillering phase (Table 4).

Table 4. Crop yield, t/ha.

No.	Option	Average yield, t/ha		
		t/ha	+- t/ha	%
1	Diamond Super, 1.0 L/t (seed control)	4.61	-0.09	-1.91
2	Control, (no seed treatment)	4.7	-	-
3	BioFeCo, 2 ml/ha	4.73	+0.03	0.63
4	BioFeCo, 4 ml/ha	4.54	-0.16	3.40
5	BioFeCo, 2 ml/ha + sprout 300 ml/ha	4.71	+0.01	0.21
6	BioFeCo, 4 ml/ha + sprout 300 ml/ha	4.76	+0.06	1.27
7	Sio, 2 ml/ha	4.75	0.05	1.06
8	Sio, 2 ml/ha + sprout 300 ml/ha	4.49	-0.21	4.46
9	Sio, 4 ml/ha + sprout 300 ml/ha	4.63	-0.07	1.48
10	Rostok, 300 ml/ha	4.63	-0.07	1.48
	NSR $_{05}$	0.19		

According to the data of structural analysis, the number of roots was higher in the variant of chemical fungicide application 537 pcs/m^2, the number of stems increased by 80-200 pcs/m^2 in the variants of no seed pre-sowing treatment. The variation by variants the number of spikelets was 11-13.4 pcs, spike length 7.2-8.3 cm, number of grains in spikelet 23-31 pcs, weight of grain from 25 stems 27-37 g, weight of 1000 grains 34-42 g and biological yield 4.7-7.7 t/ha. The highest results were determined on variants of application of biogenic iron (BioFeCo) in pure form and in mixture with humic preparation Rostock applied in tillering phase. The average biological yield was 6.5 t/ha, the applied preparations increased the yield by 0.6-1.2 t/ha, although it was not so expressed in bunker yield. Decrease in biological yield was observed for variants of silicon application in pure form and in mixture with humic preparation up to 1.0 t/ha below the control (Table 5).

Table 5. Structural analysis.

No. Option	Plant length, cm	Number of stems, pcs.	Spikelet length, cm	Number of spikelets in an ear, pcs.	Number of grains in an ear, pcs.	Weight of grain with 25 stems, g	Weight of 1000 grains, g	Biological yield, t/ha
2	84.00	609.00	7.30	11.24	26.16	28.00	43.80	6.87
3	77.00	642.00	7.24	11.20	26.44	26.90	40.00	6.35
33	83.00	747.00	8.34	13.44	31.16	33.90	41.50	7.76
34	85.00	627.00	8.04	12.32	29.40	32.80	41.20	7.27
35	85.00	792.00	8.06	12.40	30.64	34.40	38.80	7.13
36	86.00	738.00	8.02	12.00	27.80	30.00	39.40	6.57
39	89.00	708.00	6.78	10.32	22.68	22.40	34.50	4.69
40	84.00	771.00	8.00	12.40	28.56	31.40	34.90	5.98
41	90.00	585.00	7.32	10.68	26.04	28.10	32.00	5.00
43	85.00	786.00	8.44	13.00	28.56	30.74	37.80	6.48

Gluten content in the variants of the experiment varied in the range of 32-40%, which refers them to the first and highest group, in the control without seed treatment - 37.8%, slightly lower than the control in the variants of application of the studied preparations. Gluten quality at the level of satisfactorily weak 80 - 100 units. Grain natura at the level of 738-750 g/l.

4 Conclusion

The applied preparations biogenic iron (BioFeSo) and humic preparation Rostock had a positive effect on biometric indices of spring wheat plants from tillering phase to full ripeness under moisture deficit conditions.

Biometry indicators stem weight by 3-6 g, leaves, ears by 1.0-1.7 g exceeded the control and other variants at application of humic preparation mixtures in mixture with biogenic iron.

The yield of the experiment variants was 4.4-4.7 t/ha, no variant provided a reliable increase in yield, but with some plus to the control there is an increase in the variants biogenic iron in pure form, biogenic iron in a mixture with sprout +0.01-0.13 t/ha.

Structural elements of the plant, where the change of parameters occurred within the following limits: so the number of spikelets 11-13.4 pcs, spike length 7.2-8.3 cm, number of grains in the spikelet 23-31 pcs, weight of grain from 25 stems 27-37 g, weight of 1000 grains 34-42 g, biological yield 4.7-7.7 t/ha. The highest results were determined for variants of biogenic iron application in pure form and in mixture with Rostock preparation.

Among all tested preparations, biogenic iron with cobalt, humic preparation Rostok and its mixtures with biogenic iron applied in tillering phase had a positive effect on growth and development of spring wheat plants in different phases of observations.

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