Additional growth substances on spring wheat under conditions of moisture deficiency

Vyacheslav Nikolaevich Timofeev[1*]

[1]Scientific Research Institute of Agriculture for Northern Trans-Ural Region - Branch of Federal State Institutions Federal Research Centre Tyumen Scientific Centre of Siberian Branch of the Russian Academy of Sciences, 2, Burlaki street, Moskowskiy, Tyumen district, Tyumen region, 625501, Russian Federation

Abstract. The research was carried out in the conditions of the Northern forest-steppe of the Tyumen region, with weather indicators in 2023, characterized by elevated temperatures and lack of moisture. The tested products: biogenic FeCo, humic preparation, nanopreparation containing potassium, biogor, bacterial preparation, chemical fungicide had different effects on the morphological parameters of the plant. The development of embryonic organs such as root mass exceeded other options by 0.7 - 1.8 g when using a chemical disinfectant and Biogor Zh. High germination rate of 96% was observed when processing Biogor Zh seeds in a mixture with a bacterial consortium, which is higher than other options by 2-4%. Reduction in sprout length by 1.0 cm relative to absolute control for most options. The options used had no effect on seed diseases and root rot, with the exception of a fungicidal disinfectant with an effectiveness of 93-100%. The growth of the top leaf in the tillering phase - the tubes exceeded by 3-4 cm according to the Biogor-Zh option when treating seeds and plants in the tillering phase. The development of the flag leaf also exceeded when Biogor Zh was used in combination with bacteria, biogenic iron in its pure form and with a humic preparation applied in the tillering phase. Plant biometric indicators such as the weight of stems by 3-6 g, leaves, ears by 1.0-1.7 g exceeded the control and other options when using humic preparations and their mixtures with biogenic iron.

1 Introduction

We included among additional substances drugs that have growth-regulating properties, use as microfertilizers, biofungicides; some drugs have been tested for several years, while others can be tried in the field after positive laboratory tests. The drugs have different nano-sized forms, and small application rates; the use of these drugs can have positive and negative properties, which requires, if the answer is positive, to work out certain regulations for use.

* Corresponding author: timofeev_vn2010@mail.ru

The positive effect of pre-sowing seed treatment with molybdenum on the photosynthetic activity of wheat plants and donor-acceptor relationships has been established; it increases the protective-adaptive resistance of wheat to water deficiency [1].

Treatment of seeds with silicon under model arid conditions contributed to the development of biometric indicators of wheat sprouts and had no effect under favorable growth conditions [2].

Studying the mechanisms of interaction of Bacillus spp. with wheat plants under different stress conditions can be used to create targeted biological products [3- 5]. The use of biological preparations had a positive effect on the yield of spring wheat [6-7].

Exposure of soil and plants to Fe-containing biological products changes the activity of enzymes that affect nutrients and redox processes in the soil, which changes the conditions of soil fertility and the level of crop productivity in different directions [8-9].

Our previous studies have shown that the influence of nanoforms of micro and macroelements is ambiguous; they have regulating negative and positive properties on germination, development and growth of plants, productivity and efficiency of other elements, and require clear regulations for use according to the norms and phases of crop development [10].

The use of various methods and elements of nutrition and plant protection largely depends on the correct combination, complexity of application, for example, in studies on winter wheat, microelements complexes provided an increase in yield by 8-12%, the combination of microelements with growth regulators by 18-23%, and the combined use microfertilizers, plant growth regulators and mineral fertilizers contributed to improving the quality of the crop [10-11].

The purpose of the study is to determine the economic efficiency of using additional nutritional substances, growth-regulating, and fungicidal effects.

2 Materials and methods

Phytoexamination of seeds using the roll method with assessment of the infestation of seed material by various pathogens on the 7th day [13]. Structural analysis of the crop, phenological and biometric observations, yield by the method of continuous threshing, led to standard moisture and purity in accordance with GOST 1386.5-93 and 30483-97 [14-15]. Determination of grain quality indicators was carried out according to GOST 12042-80, GOST 10840 - 64, GOST 13586.1-68.

Field experience design:

- Diamond super, 1.0 l/t (seed phase).
- Control (without treating seeds and plants with fungicides).
- Biogor-Zh series KM, 2.0 l/t (seed phase); 2 l/ha (tillering phase); 2 l/ha (milk ripeness phase).
- Biogor-Z series KM, 2.0 l/t (seed phase) + consortium Bacillus simplex / B. Megaterium, titer 108 CFU/ml 5.0 l/ha (tillering phase) + 5.0 l/ha (phase flag sheet).
- Potassium 150 ml/ha (tillering phase).
- Potassium 250 ml/ha (tillering phase).
- Biogenic FeCo 2 ml/ha (tillering phase).
- Biogenic FeCo 4 ml/ha (tillering phase).
- Biogenic FeCo 2 ml/ha + humate 0.3 l/ha (tillering phase).
- Biogenic FeCo 4 ml/ha + humate 0.3 l/ha (tillering phase).
- Biogenic FeCo 2 ml/ha + humate 0.3 l/ha (flag leaf phase).

Technological features: Predecessor of steam; Harrowing April, May; pre-sowing cultivation to a depth of 8 cm; seed dressing, sowing of spring wheat with a seeding rate of

6.5 million germinating grains per 1 ha on the 3rd decade of May; herbicide treatment with background (Pomegranate, 0.020 kg/ha + Avantix Extra, 0.8 l/ha) 2nd ten days of June; fungicidal treatment 1st decade of July.

These indicators indicate that in terms of precipitation, this year, both for the year as a whole and for the growing season, was insufficiently provided, with short-term good precipitation in the 2nd and 3rd ten days of June and the 2nd ten days of July.

The provision of heat during the growing season was increased. The average daily temperature in May is 139%, in June – 98%, in July – 119%, in August – 110%, and the average for May-August was 17.50C – 114% in relation to the long-term average. The sum of effective temperatures above 50C for the period May-August was 16120C – 126% of the norm. Therefore, the growing season can be characterized as having an increased supply of heat.

The Selyaninov hydrothermal coefficient (HTC), which most fully reflects the weather conditions for the provision of agricultural crops with precipitation, taking into account the average daily temperatures for the period May-August, indicates that the growing season was dry, the HTC during this period amounted to 0.74 - 57% of the long-term average norm.

At the same time, during the 2nd and 3rd ten days of June its value was 4.11 and 1.94, in the 2nd ten days of July – 2.39, in the 3rd ten days of August – 1.27, which characterized them as periods with favorable moisture conditions.

3 Results and Discussion

In laboratory conditions, studies were carried out on seed treatment for germination and development of embryonic organs for 7 days (root, coleoptile, sprout). These indicators determine the effect of a particular drug on the initial development of the plant, possible retardant properties, overestimation of the norm and the effectiveness of reducing the infectious load.

The population of pathogenic fungi was observed at a level of 30%, and seed treatment reduces the pathogenic load by 50–100%, depending on the effectiveness of the active substance of the fungicidal drug, all of which does not have a determining influence on less effectiveness, since seeds during germination are also exposed to soil infection.

Indicators of the influence of preparative forms may be the development of the plant both in the first phases of ontogenesis and on the continuation of all stages of the growing season. The determining parameters of development that show the effect are the length of the root, which varied according to the variants from 12-14 cm, with the root length in the control being 14.6 cm, a decrease was observed in most variants.

The root weight was 0.7-0.9 g higher than the control and other options by 1.8 g when using the classic fungicide option 1 and the biological preparation Biogor-Zh. The use of chemical seed protectants contributes to the most complete reduction in the amount of pathogenic fungal and bacterial microflora, provides protection in the soil layer and stronger development of above-ground and underground vegetative mass due to inhibition and regulation of growth. Biological preparations based on positive strains of bacteria do not have contrasting effects and are very dependent on the conditions and methods of application; the influence of these preparations on the plant is manifested through the activation of biological processes, competition against harmful microflora due to faster distribution and absorption of nutritional resources, increased mobilization nutrients and their absorption by plants.

The germination and energy of seeds varied by 90-96%, naturally the energy was 2-3% lower than germination. High germination was noted for the option of using the biopreparation Biogor Zh in a mixture with the Bacillus consortium - 96%; the combination

of a biological fertilizer and a bacterial preparation with fungicidal properties and growth-stimulating properties increased germination by 4-6%, due to the activation of growth processes and the stimulating effect on the seed.

The development of coleoptile in most variants was at the control level for this variety 4.5-5.0 cm, the tested preparations were neutral to this organ, only when treated with a fertilizer-bacterial mixture of preparations there was some effect on growth, which in turn can have a negative influence during growth in the natural environment (diseases, growth, resistance to lodging). The use of a classic chemical disinfectant reduced the length of the coleoptile by 1.2 cm, which is a common phenomenon for this type of preparation and is taken into account when sowing depth, and subsequently the young plants look greener and stronger, there is some growth restriction throughout the growing season and accelerated ripening.

When growing on the 7th day, the above-ground organ sprout developed in length up to 10-11.5 cm, in the absolute control it was 11.5 cm, in all variants there was a decrease in the sprout by 1.0-1.5 cm relative to the absolute control. These preparative forms had a limiting effect and slightly reduced the length of the sprout. The weight of the sprout was 6.4–7.6 g and in most cases did not differ significantly from the control.

Most of the experimental preparations affected by limiting the growth of the root and young stem, but with compensation by mass, which means thickening and strengthening of plant organs with some stimulating effect on coleoptile growth, which can also affect the plant's architectonics and mechanical stability (Table 1).

Table 1. Morphology of plants on day 7.

Option	Root length, cm	Root weight, g	Sprout length, cm	Sprout mass, g	Length of coleoptile, cm	Germination rate, %
1	13.37	5.24	10.08	6.42	3.57	90
2	14.66	4.47	11.47	7.54	4.81	92
3	14.35	5.45	10.5	7.63	5.07	92
4	12.72	3.70	10.06	7.02	5.22	96

– Weight indicators are recalculated per 100 plants

Root diseases in the tillering phase of the crop had a prevalence of 0.7-8%, complete 100% protection was observed when using a fungicidal protectant, the tested drugs had no effect on reducing damage or protecting against root rot. This indicator has a significant impact on the development and productivity of plants under favorable conditions for the spread of the disease, which usually occurs with direct sowing, a large amount of crop residues with persistence of infection, the absence of protective measures, and prevailing weather conditions.

Indicators of plant development in the tillering phase were determined by the length of the upper leaf and the length of the plant; in this phase, a greater effect was observed when a mixture of Biogor Z preparations and the Bacillus consortium was applied to the seeds; a stimulating effect on wheat plants was present, although some moisture deficiency was already evident and, as it were, limit of the impact of seed treatments to stimulate growth, in dry conditions the effectiveness may not be evident.

To reduce stress, caused by various factors, to continue to influence the regulation of growth and development of wheat plants, additional substances are used together with herbicides, fungicides or separately, the effect of which can be manifested by an increase in yield, or the possible leveling of unfavorable conditions.

In the flag leaf phase - the beginning of heading, biometric measurements were taken of the formed flag leaf as the main remaining organ responsible for photosynthesis until the plant fully matures.

The length of the flag leaf in the experimental variants was 19-23 cm, exceeding the control by 3-4 cm when using the biological fertilizer Biogor Zh in combination with bacteria, biogenic FeCo in its pure form and with a humic preparation, leaf width 0.9-1.2 cm with an excess of 0.13 – 0.23 cm in variants with biogenic iron.

The full manifestation of the effect of the preparations on the parameters of the flag leaf was demonstrated when using (Biogenic FeCo – 4 ml/ha, Biogenic FeCo – 2 ml/ha + humate – 0.3 l/ha, Biogenic FeCo – 4 ml/ha + humate – 0.3 l/ha (tillering phase). The preparation Biogenic FeCo had an effect on the complex development of the flag leaf, at low application rates it has some effect on the biology of the plant and growth stimulation (Table 2).

Table 2. Flag Leaf Biometrics.

Option	Sheet length, cm	+–	Sheet width, cm	+–
1	19.75	+0.3	1.01	–0.06
2	19.45	–	1.07	–
3	20.1	+0.65	1.1	+0.03
4	23.5	+4.05	1.0	–0.07
5	18.3	–1.15	1.0	–0.07
6	21.1	+1.65	1.0	–0.07
7	23.0	+3.55	1.1	+0.03
8	23.5	+4.05	1.2	+0.13
9	23.8	+4.35	1.2	+0.13
10	23.6	+4.15	1.3	+0.23
11	19.5	+0.05	1.0	–0.07
NSR05	1.4	–	0.04	–

Testing of means influencing the development of plants involves the growth and formation of the entire plant and separately according to the main morphometric indicators (root, stem, leaf, ear). Morphometry indicators depend on many influences, but when additional substances are used, they can be an indicator of their positive or negative influence due to the overall use of funds, a combination of the relationship between condition and drug factors. Our studies show the influence of some drugs on the growth of plant organs and their excess over the control, and in a pattern across drugs, but with different application rates.

In conditions of lack of moisture, influence the formation of the main organs of the plant and have a slight increase in indicators in the filling phase - milky ripeness, but at the same time, in the future, at the final accounting of the harvest, there will be no increase. If there is a lack of moisture, the plant begins to regulate its productive potential and the intervention of additional substances from the outside can have the opposite effect.

The biometric indicators carried out in the filling-milky ripeness phase change slightly according to the experimental variants, the plant height was 70-83 cm, with maximum indicators according to the variants Potassium, 150-250 ml/ha, Biogenic FeCo, 4 ml/ha, Biogenic FeCo 2 ml/ha + humate, where the excess of the control was 8-11 cm. The stem weight is 16-26 g and here an increase of 3-6 g is noted according to the variants with biogenic FeCo mixed with humate, Biogor Zh.

An increase in leaf weight by 1.0-1.7 g in variants with biogenic FeCo mixed with humate, and in ear weight by 1.0 g with biogenic FeCo mixed with humate, Biogor Zh. The

preparation biogenic FeCo mixed with humate showed a positive effect on the formation and development of all the main above-ground organs of spring wheat (Table 3).

Table 3. Wheat plant biometrics.

Option	Plant height, cm	Weight from 10 plants		
		Stems, g	Leaf, g	Kolos, g
1	74.5	16.72	3.19	17.74
2	72.3	18.25	3.26	18.9
3	73	21.56	3.82	21.65
4	73.6	18.35	3.57	19.69
5	83	19.08	3.74	19.95
6	82	19.64	3.59	19.71
7	78	19.7	4.14	19.9
8	80	24.37	4.76	20.21
9	80.7	23.75	4.97	21.75
10	76.6	26.93	6.22	22
11	78.4	17.58	3.13	18.32
NSR05	3.2	2.2	1.3	0.9

The yield according to the experimental variants was high for the conditions of the year and amounted to 4.4-4.73 t/ha, in the control variant it was 4.7 t/ha. Not a single option provided a significant increase in yield; at the control level and with some excess when using biogenic iron with humate and a biological preparation, preparations containing potassium reduced the yield.

According to the structural analysis, the increase in the indicators was observed for the variants of using biogenic FeCo in pure form and in a mixture with humate, so the number of spikelets was 11-13.4 pcs., exceeding the control by 0.8-1.2 pieces, the length of the spike was 7.2-8.3 cm, exceeding the control by 0.7-1.1 cm, the number of grains in the spike was 24-31 pcs., exceeding the control by 1.3-4.7 pieces. The indicators of the structural elements of the spike had an excess of the control and other variants by numbers No. 7-10.

The visible influence and effect of the preparation on the ear elements, and taking into account the yield, the excess of control is insignificant, dry weather conditions leveled the influence of preparations on obtaining yield, namely the options with the use of biogenic FeCo in the tillering phase.

The 1000-grain weight indicator is 38-42 g, the increase in the indicator was facilitated by the use of chemical treatment at 3.8 g, the biological preparation Biogor Zh with a bacterial consortium at 3.0 g and biogenic FeCo in the tillering phase at 1.2-1.5 g. The formation and filling of grain occurs better with long-term work of the flag leaf and ear, the use of seed treatment with dressing and biopreparations during vegetation had a certain effect on the purity of green parts of plants from diseases and other physiological factors, as well as a possible factor of the speed of filling and ripening. The later phase of application of the preparations had no effect on the potential of the plants, since dry weather and moisture deficit accelerated the process of ripening and formation of the yield. Grain quality indicators under conditions of high temperatures and good agricultural background had a high gluten content of 32-40%, the applied preparations had no effect on improving the quality (Table 4).

Table 4. Structural analysis of the ear.

Option	Spike length, cm	Number of spikelets, pieces	Number of grains, pieces	Weight of 1000 grains, g
1	7.30	11.24	26.16	43.80
2	7.24	11.20	26.44	40.00
3	7.20	10.92	25.60	39.40
4	7.60	11.24	26.16	43.00
5	7.24	10.92	24.48	40.60
6	7.42	11.83	25.92	39.80
7	8.34	13.44	31.16	41.50
8	8.04	12.32	29.40	41.20
9	8.06	12.40	30.64	38.80
10	8.02	12.00	27.80	39.40
11	7.56	11.80	26.40	38.50
NSR05	0.6	0.49	1.2	

4 Conclusion

The tested products had a certain positive effect on the root mass, exceeding other options by 0.7 - 1.8 g when using a chemical disinfectant and Biogor Zh; germination rate of 96% was noted when treating Biogor Zh seeds in a mixture with bacteria.

Morphometry of plants in the tillering phase determined an excess of 3-4 cm in the length of the top leaf in the Biogor-Zh variant; the flag leaf also had greater development when Biogor Zh was used in combination with bacteria, biogenic FeCo iron in its pure form and with a humic preparation.

The structural elements of the ear had a certain increase under the influence of biogenic FeCo, and to a lesser extent, biological preparations, but the conditions of lack of moisture did not allow increasing the productivity potential of the crop due to the means used. Certain positive results in different phases of crop growth were noted when using Biogor Zh, a bacterial preparation, biogenic FeCo in pure form and in a mixture with humates.

Additional preparations of various targeted effects are most conveniently used in the main 3 phases of spring wheat development, without significant biological effects, a certain universal effect with the inclusion in one preparation of some functional properties of fungicidal, stimulating, nutritional effects that increase stress resistance. With a high agricultural background and optimal conditions, minor stimulation and protection from harmful factors are necessary; the biogenic iron preparation has a certain positive effect on crop productivity.

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