Bulgarian Journal of Agricultural Science, 26 (No 5) 2020, 958–965

Efficiency of using stimulating preparations in pre-treatment of spring barley seeds

Sergey V. Mitrofanov* and Nikolay N. Novikov

Federal State Budgetary Scientific Institution "Federal Scientific Agroengineering Center VIM", 109428 Moscow, Russia
**Corresponding author:* f-mitrofanoff2015@yandex.ru

Abstract

Mitrofanov, S. V. & Novikov, N. N. (2020). Efficiency of using stimulating preparations in pre-treatment of spring barley seeds. *Bulg. J. Agric. Sci., 26 (5)*, 958–965

Laboratory studies, field and laboratory tests and field tests have been conducted on gray forest soils in Ryazan oblast to study the effectiveness of humic and bacterial preparations and complex liquid micronutrients when treating spring barley seeds. The investigations results showed that all the studied preparations have some stimulating effect on the sowing qualities of seeds and production processes, especially in the early stages of organogenesis. Field germination, plant safety, general and productive tillering, accumulation of vegetative mass in tillering and earing phases are increased. Subsequently, the stimulating effect decreased and was very weakly manifested in the final phases of ontogenesis. The enhancement of the stimulating effect of mixtures of preparations on the production processes at the beginning of the growing season led to vegetative proliferation of crops and excessive reduction of generative metameres. The effectiveness of the best preparations increased when higher availability of mineral nutrition.

Keywords: complex microfertilizers; gray forest soils; humic and bacterial preparations; spring barley

Introduction

Increasing the yield of field crops is the main task of agricultural producers. Paying tribute to traditional methods of increasing the productivity of the crop industry (crop rotations, organic and mineral fertilizers, means of plant protection from extreme growing conditions, weeds and pests), it should be remembered that modern science, based on the energy efficiency of production, creates, tests and offers the industry some innovative technologies and individual elements of these technologies that increase yields, reduce labor and material costs and chemical stress on the environment (Abbott et al., 2018; Mohd Taufik et al., 2011; Mvila et al., 2016).

Currently, one of the effective factors of managing the production process and obtaining environmentally friendly products of agricultural crops in the crop industry is the use of exogenous biological substances possessing immunomodulatory properties and stimulating activity. These include microfertilizers and humic preparations (Aguiar et al., 2016; Canellas et al., 2015; Naujokienė et al., 2018).

Agrochemical and physiological role of trace elements is multifaceted. They improve the metabolism in plants, remove functional impairment and contribute to the normal course of physiological and biochemical processes. Trace elements are a part of physiologically active substances and are involved in the synthesis of proteins, carbohydrates, vitamins and fats. Trace elements improve the processes of photosynthesis and assimilate transport. Due to them, the process of fixing atmospheric nitrogen and the reduction of nitrates in plants happen. They have some positive effect on seeds development and their sowing properties (El-Ramady et al., 2018; Hussain et al., 2018; Tavakoli et al., 2014). At the same time, modern technologies of farming intensification increase the need for trace elements. This is associated with an increase in crop yield and an increase in the removal of trace elements. The need for microfertilizers is also growing due to the growing use of concentrated mineral fertilizers, better purified, and containing small quantities of trace elements. This does not provide for the replenishment of trace elements consumption (Noreen et al., 2018; Tripathi et al., 2015).

Humic substances are systems of organic molecules of high molecular weight, which are formed, transformed and decomposed at the intermediate stages of the process of mineralization of organic matter of dying organisms. The range of reactions that humic substances can enter is very wide, especially for their most reactive part, humic acids. They are capable of forming both water-soluble and water-insoluble complexes with metal ions and hydroxides, as well as interacting with minerals and a wide variety of organic compounds, including alkanes, fatty acids, dialkyl phthalates, pesticides, and others (Seyedbagheri et al., 2012). Humic acids are involved in the structure formation of the soil, the accumulation of nutrients and trace elements in a plant-accessible form, and the regulation of the geochemical fluxes of metals in aquatic and soil ecosystems (Idrees et al., 2018). Along with binding activity, they have pronounced surface-active properties, which allow them to be used as agents that increase the solubility of hydrophobic organic substances, including oil products. This allows the use of humates to remove aromatic petroleum hydrocarbons from polluted aquifers (Nikitina et al., 2016; Prakash et al., 2018). Finally, the high biological activity of humic acids determines the possibility of their use as plant growth stimulants (Delfine et al., 2005; Olk et al., 2018).

The aim of the research is to study the effectiveness of the use of biological preparations in the pre-seeding treatment of spring barley seeds**.**

Materials and Methods

Field experiments in 2014–2016 held on the gray forest soils of the collective farm (APC) named after Lenin in Starozhilovsky district of Ryazan oblast with the following crop rotation – complete fallow, winter wheat, corn for silage, barley.

The soils of the experimental plots were medium loamy and well cultivated due to the development of crop rotation and the systematic introduction of organic and mineral fertilizers.

The experimental plots were located on fields with smooth relief (slope 1, southern exposure), which were harvested at the end of August – early September. Autumn tillage consisted of disking and fall tillage to the depth of 20–22 cm.

The agrochemical characteristics of the experimental plots indicate a rather low content of humus, which was at the level of 1.0–2.0%. The levels of available phosphorus (256–269 mg/kg of soil) and exchangeable potassium (81–120 mg/kg of soil) were high. The reaction of the soil environment was medium acid (2014, 2016) and slightly acid (2015).

Weather conditions for the years of investigations were contrasting. In May 2014, the rainfall (31 mm) and temperature (16.4°C) were close to the long-term average annual. In June, the average monthly air temperature was close to the long-term average annual, precipitations fell at the end of the month (139.0 mm at a rate of 64.0 mm). In July and August, the average monthly temperatures were slightly higher than the long-term average annual, but there was a shortage of precipitation. So in July, only 14.0 mm of rain fell, but heavy rainfall at the end of June ensured sufficient soil moisture. In August, 20.0 mm fell, which was 35% of the norm.

In 2015, May and June were close in temperature to the long-term average annual parameters. Precipitation was 45.8 mm and 81.2 mm, which exceeded the long-term average annual figures by 34.7% and 26.9 %. Such weather conditions affected the germination, growth and development of plants rather favorably. In July and August, the mean monthly temperatures were slightly higher than the long-term average annual and there was a deficit of precipitation – 71.4 and 84.4% of the norm.

May 2016 was extremely rainy and the amount of precipitation was twice as much as the long-term average annual value. In this regard, the sowing of barley in the experiment was made only in early June. August was also rainy, due to which the barley was harvested in September.

The length of the experimental plots was 100 m, the width was 3.6 m and the distance between the variants was 0.45 m. The experiment was repeated three times. The scheme of the experiment in 2014 is presented in Tables 1– 4.

Barley seeds were treated with solutions of preparations at the rate of 10 liters of the treatment solution / ton of seeds by a semi-dry method in a tank mixture with Vial Trust complex fungicidal disinfectant. Fertilizers (ammonium nitrate phosphate) in the third variant were treated with humate Ecorost (10 l of the treatment solution/ton) and those in other variants were treated with clean water, in order to ensure equal flowability.

In 2015–2016 the scheme of the experiment was modernized: the absolute control was introduced (without fertilizers), the variant with Rizoagrin seed treatment was eliminated, and variants with seed treatment with Raykat

Start and the complex of Raykat Start and humate Ecorost were introduced. The experiments had three backgrounds: 1) without the use of mineral fertilizers; 2) $N_{30}P_{30}K_{30}$; 3) $N_{30}R_{30}K_{30}$ + humate Ecorost. Fertilizers used on the second background were also damped to provide the same flowability. Eight variants with seed treatments are arranged across the backgrounds (Tables 5–8). The forecrop, the parameters of the plots and the replication were similar to 2014. The agro technology in the experiment corresponded to the regional recommendations.

Results and Discussion

The studied preparations had a significant effect on the phenology of development of spring barley during the 2014 field experiment. In all variants, the seedlings appeared 1-3 days earlier than those in the control. Humate Ecorost and complexes with it contributed to the earlier vegetation phases. Rizoagrin in its pure form and in combination with other preparations slowed down the development, making it close to control (Table 1).

The analysis of biometric parameters made it possible to establish that, in the tillering phase the variants with the treatment of seeds with Micromac; mixtures of Ecorost and Nutri – Fight PK, Ecorost and Rizoagrin were best as for leafy mass. The excess over the control was 56.8, 44.8 and 46.1%, respectively. The same variants had a more developed root system.

The stimulating effect was quite strong in the earing phase too and all the studied variants exceeded the control (Table 2).

The best results were in cases when seeds were treated with Micromac or a complex of Ecorost and Micromac. The excess over the control was 54.3 and 42.6%, respectively.

The results of the crop are presented in Table 3. They indicate a significant positive effect of preparations. The increase in grain yield on the best variants reached 9-17.4%. However, the variant with Rizoagrin had a negative result and the yield was lower than the control one by 14.85%.

The analysis of the elements of productivity (Table 4) shows that the most significant parameter is the productive density. The excess of the variants with the treatment with Micromac and humate Ecorost over the control was respec-

Table 1. The effect of methods of seed treatment and fertilizer on the air-dry mass of shoots and roots in the tillering phase (2014)

Variant			Shoots mass, g	Roots mass, g	Difference with control, %	
#	Seed treatment	Fertilizer			Shoots mass	Roots mass
1	No seed treatment	$N_{30}P_{30}K_{30}$	23.2	7.2	–	–
2	Humate Ecorost	$N_{30}P_{30}K_{30}$	31.7	9.4	36.6	30.6
3	Humate Ecorost	$N_{30}P_{30}K_{30}$ + humate Ecorost	26.4	7.5	13.8	4.2
4	Humate Ecorost + Micromac	$N_{30}P_{30}K_{30}$	29.0	8.0	25.0	11.1
5	Micromac	$N_{30}P_{30}K_{30}$	36.4	10.6	56.9	47.2
6	Humate Ecorost + Rizoagrin	$N_{30}P_{30}K_{30}$	33.9	9.8	46.1	36.1
7	Humate Ecorost + Micromac + Rizoagrin	$N_{30}P_{30}K_{30}$	28.3	9.8	22.0	36.1
8	Humate Ecorost + Nutri – Fight PK	$N_{30}P_{30}K_{30}$	33.6	10.4	44.8	44.4
9	Rizoagrin	$N_{30}P_{30}K_{30}$	23.1	6.7	- 0.43	- 7.0

Table 2. The effect of methods of seed treatment and fertilizer on the air-dry mass in the earing phase (2014)

Variant		Shoots mass, g	Difference with control, %
Seed treatment	Fertilizer		
No seed treatment	$N_{30}P_{30}K_{30}$	129	-
Humate Ecorost	$N_{30}P_{30}K_{30}$	161	24.8
Humate Ecorost	$N_{30}P_{30}K_{30}$ + humate Ecorost	164	27.1
Humate Ecorost + Micromac	$N_{30}P_{30}K_{30}$	184	42.6
Micromac	$N_{30}P_{30}K_{30}$	199	54.3
Humate Ecorost + Rizoagrin	$N_{30}P_{30}K_{30}$	133	3.1
Humate Ecorost + Micromac + Rizoagrin	$N_{30}P_{30}K_{30}$	170	31.8
Humate Ecorost + Nutri – Fight PK	$N_{30}P_{30}K_{30}$	169	31.0
Rizoagrin	$N_{30}P_{30}K_{30}$	140	8.5

Table 3. Effect of humic and bacterial preparations, complex microfertilizers on barley yield (2014)

Variant		Real yield, t/ha	Difference with control, %
Seed treatment	Fertilizer		
No seed treatment	$N_{30}P_{30}K_{30}$	3.27	–
Humate Ecorost	$N_{30}P_{30}K_{30}$	3.64	+ 11.5
Humate Ecorost	$N_{30}P_{30}K_{30}$ + humate Ecorost	3.84	+ 17.4
Humate Ecorost + Micromac	$N_{30}P_{30}K_{30}$	3.25	- 0.58
Micromac	$N_{30}P_{30}K_{30}$	3.81	+ 16.7
Humate Ecorost + Rizoagrin	$N_{30}P_{30}K_{30}$	3.32	- 1.47
Humate Ecorost + Micromac + Rizoagrin	$N_{30}P_{30}K_{30}$	3.60	+ 10.2
Humate Ecorost + Nutri – Fight PK	$N_{30}P_{30}K_{30}$	3.56	+ 9.0
Rizoagrin	$N_{30}P_{30}K_{30}$	2.78	- 14.85
Least significant difference at 5% significance level (LSD_{05}) = 0.31 t / ha			

Table 4. Structure of spring barley harvest depending on seed treatment (2014)

Variant		Number of plants, pcs.	Number of yielding ears, pcs./m^2	Number of grains in ear, pcs./m^2	Mass of 1000 seeds, g	Mass of ear, g	Biological yield, t/ha
Seed treatment	Fertilizer						
No seed treatment	$N_{30}P_{30}K_{30}$	235	389	18	53.00	0.87	3.38
Humate Ecorost	$N_{30}P_{30}K_{30}$	212	441	17	49.40	0.89	3.93
Humate Ecorost	$N_{30}P_{30}K_{30}$ + Ecorost	246	459	18	50.20	0.91	4.18
Humate Ecorost + Micromac	$N_{30}P_{30}K_{30}$	210	435	21	50.30	1.04	4.52
Micromac	$N_{30}P_{30}K_{30}$	234	464	18	55.90	1.00	4.60
Humate Ecorost + Rizoagrin	$N_{30}P_{30}K_{30}$	190	439	18	49.30	0.91	4.00
Humate Ecorost + Micromac +Rizoagrin	$N_{30}P_{30}K_{30}$	194	402	17	49.30	0.86	3.46
Humate Ecorost + Nutri – Fight PK	$N_{30}P_{30}K_{30}$	214	432	20	50.50	1.01	4.36
Rizoagrin	$N_{30}P_{30}K_{30}$	214	429	19	49.20	0.94	4.03

tively 19.3 and 16.4%. The ear on the Ecorost + Micromac variant was the most grained one, and the largest grain was on the Micromac variant.

The data of the analysis of the fractional composition of the grain (descent from sieves of 2.0 and 2.5 mm) showed that the variants differed slightly in terms of this parameter. The proportion of the larger fraction was in the variant with seeds treatment with a mixture of Ecorost and Micromac. The parameters of two variants, Ecorost treatment and Micromac treatment, were lower than that of the control and they were 406.8 and 409.7 g versus 423.4 g in the control. The other variants were at the level of the control. Differences in the fractional composition can be explained by the degree of productive tillering. Variants with higher productive tillering (and these are the control, humate Ecorost and Micromac) had the increased proportion of fine fractions.

The data obtained during the experiments of 2015-2016 are in many respects similar to those of 2014. The seedlings appeared 1-3 days earlier than those of the control in all the variants when pre-seeding treatment with the preparations under study. Seeds treatment with the Ecorost + Raykat Start complex had the strongest influence on the acceleration of phenological phase's rate.

Accounting for the number of plants in the tillering stage showed some positive effect of the preparations under study. Seed treatments on all backgrounds of fertility increased plant density. The best results were on the variant with Ecorost, where the excess over the control was 81 plants (21.8%).

The highest values of the density of planting were on the background of $(NPK)_{30}$ with their treating with Ecorost. At the same time, variants with seed treatment with Micromac, Raykat Start and complexes with them were outstanding.

The determination of the air-dry mass of plants in the tillering stage showed that seed treatments on all backgrounds of fertility contributed to its more intensive formation as compared to the control.

On the background without fertilizers, Ecorost + Raykat Start, Ecorost + Micromac and Nutri – Fight PK were the best

Table 5. The effect of seed treatment methods and fertilizers on the air-dry mass of plants in the earing phase (2015–2016), g/m²

Variant \ Background	Without fertilizers	$N_{30}P_{30}K_{30}$	$N_{30}P_{30}K_{30}$ + Ecorost	Difference with absolute control in background, %		
No seed treatment	556	628	698	-	12.9	25.5
Humate Ecorost	735	857	923	32.2	54.1	66.0
Micromac	764	868	961	37.4	56.1	72.8
Raykat Start	940	978	1010	69.1	75.9	81.7
Nutri – Fight PK	944	974	895	69.8	75.2	61.0
Humate Ecorost + Micromac	987	1002	1007	77.5	80.2	81.1
Humate Ecorost + Raykat Start	998	1092	1140	79.5	96.4	105.0
Humate Ecorost + Nutri – Fight PK	871	928	998	56.7	66.9	79.5

Table 6. Yield of spring barley depending on the methods of seed treatment and fertilizers, t/ha (average for 2015-2016)

Variant \ Background	Without fertilizers	$N_{30}P_{30}K_{30}$	$N_{30}P_{30}K_{30}$ + humate Ecorost	Yield increase to absolute control in background, t/ha		
No seed treatment	2.30	2.56	2.94	-	0.26	0.64
Humate Ecorost	2.73	2.98	3.38	0.43	0.68	1.08
Micromac	2.68	2.77	3.09	0.38	0.47	0.79
Raykat Start	2.44	2.54	2.86	0.14	0.24	0.56
Nutri – Fight PK	2.67	2.76	3.04	0.37	0.46	0.74
Humate Ecorost + Micromac	2.46	2.96	3.31	0.16	0.66	1.01
Humate Ecorost + Raykat Start	2.60	2.55	2.67	0.30	0.25	0.37
Humate Ecorost + Nutri – Fight PK	2.43	2.52	2.70	0.13	0.22	0.40
2015	LSD_{05} = 0.28 t/ha LSD_{05} Factor A (fertilizers) = 0.17 t/ha LSD_{05} Factor B (variant of treatment) = 0.10 t/ha					
2016	LSD_{05} = 0.29 t/ha LSD_{05} Factor A (fertilizers) = 0.16 t/ha LSD_{05} Factor B (variant of treatment) = 0.99 t/ha					

variants. On the background of $N_{30}P_{30}K_{30}$, complexes with Ecorost and Nutri – Fight PK and Raykat Start were outstanding. On the background of $N_{30}R_{30}K_{30}$ and treatment with Ecorost humate, the best variants in air-dry leafy mass were the following complexes: Ecorost + Raykat Start, Ecorost + Nutri – Fight PK. The complex of Ecorost and Raykat Start was the leader on all the backgrounds (the excess over the control on different backgrounds was 107.1, 84.6 and 61.0%, respectively).

The state of agrocenoses changes during the growing season, under the influence of growing conditions. The death of plants is most common. Since the preparations under study have stimulating effects, we considered it necessary to study their effect on the safety of barley plants.

On the background without fertilizers, the greatest safety of plants was on the variant with seed treatment with Nutri – Fight PK and complexes of Ecorost + Raykat Start and Ecorost + Nutri – Fight PK.

On the background of $N_{30}P_{30}K_{30}$, Raykat Start, Ecorost + Raykat Start and Ecorost + Micromac are in the top three. The largest number of plants on the background of $(NPK)_{30}$ + Ecorost was observed in variants using Micromac, Raykat Start and their complexes with Ecorost. All variants of the experiment had some positive effect of the preparations under study on the safety of plants.

The data on the accumulation of air-dry mass of plants in the earing phase (Table 5) indicate the effectiveness of seed treatments with the preparations under study.

On the background without fertilizers, the highest accumulation of the air-dry mass was observed in the variants with seed treatment with Raykat Start, Nutri – Fight PK and complexes of Ecorost + Raykat Start and Ecorost + Micromac. The excess over the control was 69.1, 69.8, 77.5 and 79.5%, respectively.

On the background of $N_{30}R_{30}K_{30}$, these four variants were also the best ones. The excess over the control was 55.7, 55.1, 59.6 and 73.9%, respectively. On the background of $N_{30}R_{30}K_{30}$ and treatment with humate Ecorost, the following variants were outstanding: Ecorost + Raykat Start, Ecorost +

Micromac, Ecorost + Nutri – Fight PK and Raykat Start. The increments were 63.3, 44.9, 44.3 and 43.0%, respectively.

Comparing the excess over the control in background, it can be noted that the use of fertilizers increased the number of plants and their air-dry mass.

The yield data for 2015–2016 are presented in Table 6. On the background of no fertilizers, the highest yields were obtained in the variants with seed treatment with Ecorost, Nutri – Fight PK and Micromac.

The yield increase amounted to 0.43 t/ha (18.7%), 0.37 t/ha (16.1%) and 0.38 t/ha (16.5%), respectively. The complex use of preparations provided lower yield increases.

The use of mineral fertilizers on all variants of seed treatment (except for the Ecorost + Raykat Start mixture) ensured an average yield increase of 0.17 t/ha, which was 6.7%. Higher yields were obtained in variants with seed treatment with Ecorost, Micromac, and the complex Ecorost + Micromac. The increases were 0.68 t / ha (29.6%), 0.47 t/ha (20.4%) and 0.66 t/ha (28.7%), respectively. Two variants with treatment with complexes gave way to the control, which can be explained by the formation of a large leafy mass and lodging of plants.

On the background of $N_{30}R_{30}K_{30}$ + Ecorost, the yield was higher than in the other backgrounds. The use of mineral fertilizers on average for seed treatment variants provided an increase in barley yield by 0.46 t/ha (20.0%). Among seed treatment variants the ones with Ecorost and the combination of Ecorost and Micromac had the highest rates with increases of 1.08 t/ha (47.0%) and 1.01 t/ha (43.9%). Three variants gave way to the control and the reasons were the same – excessive vegetative mass, lodging and, possibly, deficiency of mineral nutrition elements.

The analysis of the data in Table 7 indicates the positive effect of humate Ecorost, Micromac, Nutri – Fight PK, Raykat Start and their paired mixtures on the productive density.

On the background without fertilizers, the highest rates turned out to be on variants when seeds were treated with Nutri – Fight PK and humate Ecorost.

The introduction of $(NPK)_{30}$ when pre-sowing cultivation contributed to some increase in the productive density in all variants of the experiment. The variants with seed treatment with Nutri – Fight PK and Ecorost had higher rates.

On the background of nitroammophoska treatment with Ecorost, the highest density of productive stalks was noted. The control had 443 pcs. / m^2, the variant with seed treatment with Ecorost had 521 pcs. / m^2 and the variant with Nutri – Fight PK treatment had 466 pcs./m^2. Ecorost complexes with other preparations under study significantly reduced the productive density, even compared with the control. There was one reason – the discharge of vegetative metameres due to the deterioration of the life support regime of agrophytocenosis.

The number of grains in the ear is formed at the later stages of organogenesis and depends on weather conditions, general and productive tillering. The stronger the tillering and the greater the plant and tillering shoot extinction are, the better the availability of the vital factors for the main spike and the greater the number of grains are. Therefore, the variants with seed treatments with preparations and their mixtures had grains in the spike equal to or lower than the control. Relatively strong negative relationships and tendencies were found between grains of the spike and the mass of the air-dry matter in phases of tillering, stem elongation and ear formation.

The mass of 1000 seeds, as a final element of productivity, is greatly influenced not only by weather, the degree of mineral nutrition elements, and the mass of dry matter, but by the number of grains in the ear as well. The more grains a spike has, the less the mass of 1000 grains is. The multifactorial nature of the conditions for the formation of grain size makes it difficult to identify the leading and auxiliary factors, so it will be easier and more objective to identify the best grain size variants of the experiment. So, on the background without fertilizing, a larger grain was observed when treating barley seeds with Raykat Start or Micromac. The variant with seed treatment with a combination of Ecorost and

Table 7. Productive density depending on the methods of seed treatment and fertilizers (2015-2016), pcs. /m²

Background / Variant	Without fertilizers	$N_{30}P_{30}K_{30}$	$N_{30}P_{30}K_{30}$ + Ecorost	Difference with absolute control in background, %		
No seed treatment	361	402	443	–	11.4	22.7
Humate Ecorost	452	460	521	25.2	27.4	44.3
Micromac	410	440	463	13.6	21.9	28.3
Raykat Start	405	435	462	12.2	20.5	28.0
Nutri – Fight PK	448	467	466	24.1	29.4	29.1
Humate Ecorost + Micromac	392	444	455	8.6	23.0	26.0
Humate Ecorost + Raykat Start	465	385	436	28.8	6.6	20.8
Humate Ecorost + Nutri – Fight PK	395	417	455	9.4	15.5	26.0

Table 8. Biological productivity of spring barley (2015-2016), t/ha

Variant \ Background	Without fertilizers	$N_{30}P_{30}K_{30}$	$N_{30}P_{30}K_{30}$ + humate Ecorost	Yield increase to absolute control in background, t/ha		
No seed treatment	2.35	2.64	3.00	–	0.29	0.65
Humate Ecorost	2.84	3.05	3.48	0.49	0.70	1.13
Micromac A and B	2.72	2.82	3.15	0.37	0.47	0.80
Raykat Start	2.49	2.61	2.92	0.14	0.26	0.57
Nutri – Fight PK	2.73	2.86	3.15	0.38	0.51	0.80
Humate Ecorost + Micromac A and B	2.55	3.08	3.43	0.20	0.73	1.08
Humate Ecorost + Raykat Start	2.66	2.65	2.76	0.31	0.30	0.41
Humate Ecorost + Nutri – Fight PK	2.47	2.58	2.82	0.12	0.23	0.47

Raykat Start had the smallest grain (33.1 g). On the background of ammonium nitrate phosphate fertilizer, a larger grain was formed in the variants with seed treatment with Micromac and a mixture of Ecorost and Raykat Start. On the background of $N_{30}P_{30}K_{30}$, treated with humate Ecorost, the variants with seed treatment with Micromac and a mixture of Ecorost and Nutri – Fight PK were highlighted.

The mass of grain from the ear, as a derivative of the ear grain degree and the mass of 1000 seeds, is also rather difficult to analyze. On all the backgrounds of the mineral nutrition, the variant with seed treatment with Micromac stood out. The variant with seed treatment with Ecorost was somewhat inferior to it. On the backgrounds of $N_{30}P_{30}K_{30}$ and $N_{30}P_{30}K_{30}$ + Ecorost, the spike productivity parameters were higher than those in the control.

The analysis of all components of barley productivity with various fertilizer backgrounds and methods of seed treatment showed that the productive density was the leading element of the crop structure.

The biological yield obtained after threshing sheaves from trial plots (3 x 0.33 m^2) is presented in Table 8. Here the influence of the mineral nutrition backgrounds is clearly visible. The lowest yield in absolute control is 2.35 t/ha, against the background of $N_{30}P_{30}K_{30}$, where it increases by 0.29 t/ha (to 2.64 t/ha). On the background of $N_{30}R_{30}K_{30}$, treated with Ecorost, the yield in the variant without seed treatment increased by 0.65 t/ha and reached 3.0 t/ha.

Seed treatment with separate preparations contributed to some yield increase. The most stable and high rates are established on the variants of seed treatment with Ecorost and Ecorost + Micromac complex.

The complexes of humate Ecorost with microelements and growth stimulants reduced yields, but in five cases out of nine it was higher than that in the control.

Thus, according to the results of the investigations, it can be concluded that seed treatment with humates, microelements and growth stimulants stimulates growth processes in the initial stages of growth and development of barley. In the future, in overgrown agrocenoses, tillering shoots are reduced. Humate Ecorost affects growth processes more weakly, but steadily during the growing season, and a moderate vegetative mass is formed with a weakened reduction of density.

Complex microfertilizers and growth stimulants have a strong impact on the production processes in the initial phases of ontogenesis, an excessive vegetative mass is formed, and the reduction of tillering shoots is enhanced. When using the preparations under study in combination with humates, the stimulating effect becomes stronger, which leads to the formation of a large vegetative mass of barley and increased reduction. This, in turn, leads to a decrease in one of the main factors of productivity – the productive density.

Conclusion

Fertilizers and preparations used during field experiments shortened the time of onset of barley development phases. The stimulating effect of the innovative preparations under study on production processes (root system, air-dry mass, etc.) has been established. The use of binary complexes leads to an enhancement of the stimulating effect in the early phases of ontogenesis. In the case of some deficit of life support elements (moisture, nutrients), the reduction of vegetative metameres (tillering shoots, number of ears, number of grains per spike) is enhanced.

The use of mineral fertilizers provided some increase in yields on average for 2015–2016 by 0.17 t/ha, and the application of fertilizers treated with humic preparation caused 0.47 t/ha increase. The increase in the efficiency of mineral fertilizers treated with Ecorost can be explained by the fact that humic substances can enter a uniquely wide range of various interactions with various classes of organic compounds and form complexes with metals and complex soil minerals.

References

Abbott, L. K., Macdonald, L. M., Wong, M. T. F., Webb, M. J., Jenkins, S. N. & Farrell, M. (2018). Potential roles of biological amendments for profitable grain production – a review. *Agriculture, Ecosystems and Environment, 256,* 34-50.

Aguiar, N. O., Medici, L. O., Olivares, F. L., Dobbss, L. B., Torres-Netto, A., Silva, S. F., Novotny, E. H. & Canellas, L. P. (2016). Metabolic profile and antioxidant responses during drought stress recovery in sugarcane treated with humic acids and endophytic diazotrophic bacteria. *Annals of Applied Biology, 168(2),* 203-213.

Canellas, L. P., Olivares, F. L., Aguiar, N. O., Jones, D.L., Nebbioso, A., Mazzei, P. & Piccolo, A. (2015). Humic and fulvic acids as biostimulants in horticulture. *Scientia Horticulturae, 196,* 15-27.

Delfine, S., Tognetti, R., Desiderio, E. & Alvino, A. (2005). Effect of foliar application of N and humic acids on growth and yield of durum wheat. *Agronomie, 25(2),* 183-191.

El-Ramady, H., Alshaal, T., Elhawat, N., Ghazi, A., Elsakhwy, T., Omara, A. E., El-Nahrawy, S., Elmahrouk, M., Domokos-Szabolcsy, É. & Schnug, E. (2018). Plant nutrients and their roles under saline soil conditions (Book Chapter). *Plant Nutrients and Abiotic Stress Tolerance*, 297-324.

Hussain, S., Khalid, M. F., Hussain, M., Ali, M.A., Nawaz, A., Zakir, I., Fatima, Z. & Ahmad, S. (2018). Role of micronutrients in salt stress tolerance to plants (Book Chapter). *Plant Nutrients and Abiotic Stress Tolerance,* 363-376.

Idrees, M., Anjum, M. A. & Mirza, J. I. (2018). Potassium humate and NPK application rates influence yield and economic performance of potato crops grown in clayey loam soils. *Soil and Environment, 37(1),* 53-61.

Mohd Taufik, M. Y., Ahmed, O. H. & Nik Muhamad, A. M. (2011). Effect of amending urea with humic acids and acid sulphate on biomass production of masmadu (zea mays l.) and selected soil chemical properties. *International Journal of Physical Sciences, 6(20),* 4690-4694.

Mvila, B. G., Pilar-Izquierdo, M. C., Busto, M. D., Perez-Mateos, M. & Ortega, N. (2016). Synthesis and characterization of a stable humic-urease complex: Application to barley seed encapsulation for improving N uptake. *Journal of the Science of Food and Agriculture, 96(9),* 2981-2989.

Naujokienė, V., Šarauskis, E., Lekavičienė, K., Adamavičienė, A., Buragienė, S. & Kriaučiūnienė, Z. (2018). The influence of biopreparations on the reduction of energy consumption and CO_2 emissions in shallow and deep soil tillage. *Science of the Total Environment, 626,* 1403-1413.

Nikitina, I. M., Epshtein, S. A., Fomenko, N. A. & Kossovich, E. L. (2016). Humic acids of solid fossil fuels-perspectives for application in technology and environment protection. *Eurasian Mining, (2),* 33-36.

Noreen, S., Fatima, Z., Ahmad, S., Athar, H.-U.-R. & Ashraf, M. (2018). Foliar application of micronutrients in mitigating abiotic stress in crop plants (Book Chapter). *Plant Nutrients and Abiotic Stress Tolerance,* 95-117.

Olk, D. C., Dinnes, D. L., Rene Scoresby, J., Callaway, C. R. & Darlington, J. W. (2018). Humic products in agriculture: potential benefits and research challenges – a review. *Journal of Soils and Sediments, 18(8),* 2881-2891.

Prakash, P., Mitra, A., Nag, R. & Sunkar, S. (2018). Effect of seaweed liquid fertilizer and humic acid formulation on the growth and nutritional quality of Abelmoschus esculentus. *Asian Journal of Crop Science, 10(1),* 48-52.

Seyedbagheri, M. M., He, Z. & Olk, D. C. (2012). Yields of potato and alternative crops impacted by humic product application (Book Chapter). *Sustainable Potato Production: Global Case Studies 9789400741041,* 131-140.

Tavakoli, M. T., Chenari, A. I., Rezaie, M., Tavakoli, A., Shahsavari, M. & Mousavi, S. R. (2014). The importance of micronutrients in agricultural production. *Advances in Environmental Biology, 8(10),* 31-35.

Tripathi, D. K., Singh, S., Swati, S., Sanjay, M., Chauhan, D. K. & Dubey, N. K. (2015). Micronutrients and their diverse role in agricultural crops: advances and future prospective. *Acta Physiologiae Plantarum, 37(7),* 139.

Received: February, 22, 2019; *Accepted:* December, 12, 2019; *Published:* October, 31, 2020