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The use of humic products is an important method of biologization of soybean cultivation technologies

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At the present stage of development of agricultural production is characterized by the aggravation of economic and environmental problems, most scientists and practitioners agree that the most effective way to improve soil fertility and crop productivity is the biologicalization of agriculture [1, 2].

This approach to agriculture modernization is based on its adaptation to soil and climatic conditions of the regions and the rational use of the natural resource potential of agricultural landscapes, increasing their resistance to anthropogenic pressure, improving agricultural technologies, taking into account the adaptive potential of plants, increasing the efficiency of natural regulation of the agrocenoses biological component [3, 4].

The basis of such technologies is the widespread use of biological products, growth regulators and bacterial fertilizers, which increase the plant immunity to the most dangerous pathogens; their use from an economic point of view becomes more profitable and environmentally friendly [5, 6].

Currently, humic fertilizers - humates are widely used as growth stimulants and biofertilizers. This group of natural high molecular substances is characterized by high physiological activity due to their structural, physical and chemical properties [7, 8]. Humates activate the metabolism and reproduction of useful soil microflora, increase the plant defence against adverse physical (heat, cold), chemical (salinity, heavy metals, radionuclides) and biological (fungal, bacterial and viral diseases) factors and contribute to high crop yields [9, 10].

In the State Catalogue of Pesticides and Agrochemicals Approved for Use in the Russian Federation lists over 70 types of humic acid-based fertilizers [11]. The most popular humic fertilizers are as follows: Humistim (Russia), Potassium Humate Suffler (Russia), EKO-SP (Russia), Fulvigrain Classic (Germany), Humiful Pro (Spain), etc.

Due to the trend of import substitution currently emerging in agricultural production, there is an urgent need for a comparative assessment of efficiency of humic fertilizers of domestic (EKO-SP) and foreign production (Fulvigrain Classic, Humiful Pro) their effect on the yield and quality of the resulting products. The efficient application of different grades of humic fertilizers on soybean crops was performed in 2019-2021

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EKO-SP (EKOR-SP LLC, (Russia) is a natural organic green-labelled product, produced from plant raw materials (lowland peat), contains humic and fulvic acids, plant hormones, amino and simple organic acids, microelements as chelates, useful soil microflora. EKO-SP is a plant immunity inducer, it has adaptogenic properties, promotes anti-stress resistance of plants to diseases and adverse environmental conditions, it has high chemical purity and solubility, increases yield and product quality. The product is used for seed and foliar treatment of plants and can be used nearly at all stages of the vegetation period (from seed treatment to additional fertilization after plants have been under stress).

Fulvigrain Classic (Germany) is a universal anti-stress agent containing salts of humic (16%) and fulvic acids (4%), microelements, amino acids and auxins. The product is used for seed treatment and foliar fertilization of plants; it helps increase plant resistance to stresses of different origin. Fulvigrain Classic increases the plant ability to absorb nutrients, ensures the development of vegetative mass through auxin and helps to overcome temperature stresses. The product promotes cytokinin activity, stimulates cell division, the rudiment of generative organs, and improves grain and seed quality.

Humic and fulvic acid-based Humiful Pro (Spain) is produced by treating brown coal with potassium hydroxide solution and then enriching the extract with macro- and microelements. The product helps restore soil structure and enhances plant immunity. Humic acids and monobacteria in Humiful Pro composition stimulate the development of useful soil microflora, providing plants with nutrients in an accessible manner. It is used for seed treatment, foliar and root fertilization, and for soil improvement.

The test plot soil was represented by typical heavy loamy granulometric composition on carbonate loess-like loam. At the beginning of the field experiment, the content of humus (according to Tyurin) in the arable layer was 5.3%, alkaline-hydrolyzable nitrogen - 69 mg/kg, phosphorus and potassium mobile forms (according to Chirikov) – 8.8 mg/kg and 14.5 mg/kg, respectively, the soil medium reaction was weakly acidic - the pH was 5.4.

The cultivation technology of soybean corresponded to the recommended one for farms of the Central Chernozem region. The soybean variety - Kazachka was used, the sowing rate was 0.6 million germinating seeds per hectare, the background of mineral nutrition was N30P30K30.

As a result of the laboratory research it was found that treatment of soybean seeds with humic acid based fertilizers contributed to the increase of emergence energy (on the 3rd day of sprouting) by 2-7%, laboratory germination of seeds (on the 7th day of germination) by 2-6% compared to the check variant, and further it provided stimulating effect on seedling growth.

Humiful Pro (0.1 kg/t) had the best stimulating properties; treatment of spring barley seeds increased emergence energy by 7% and laboratory germination by 6%. The effect of humic fertilizers EKO-SP (0.3 l/t) and Fulvigrain Classic (0.8 l/t) on emergence energy and laboratory germination of seeds was slightly lower and practically equal: treatment of soybean seeds with these products increased emergence energy by 4-5% and laboratory germination by 3-4% (Fig. 1).

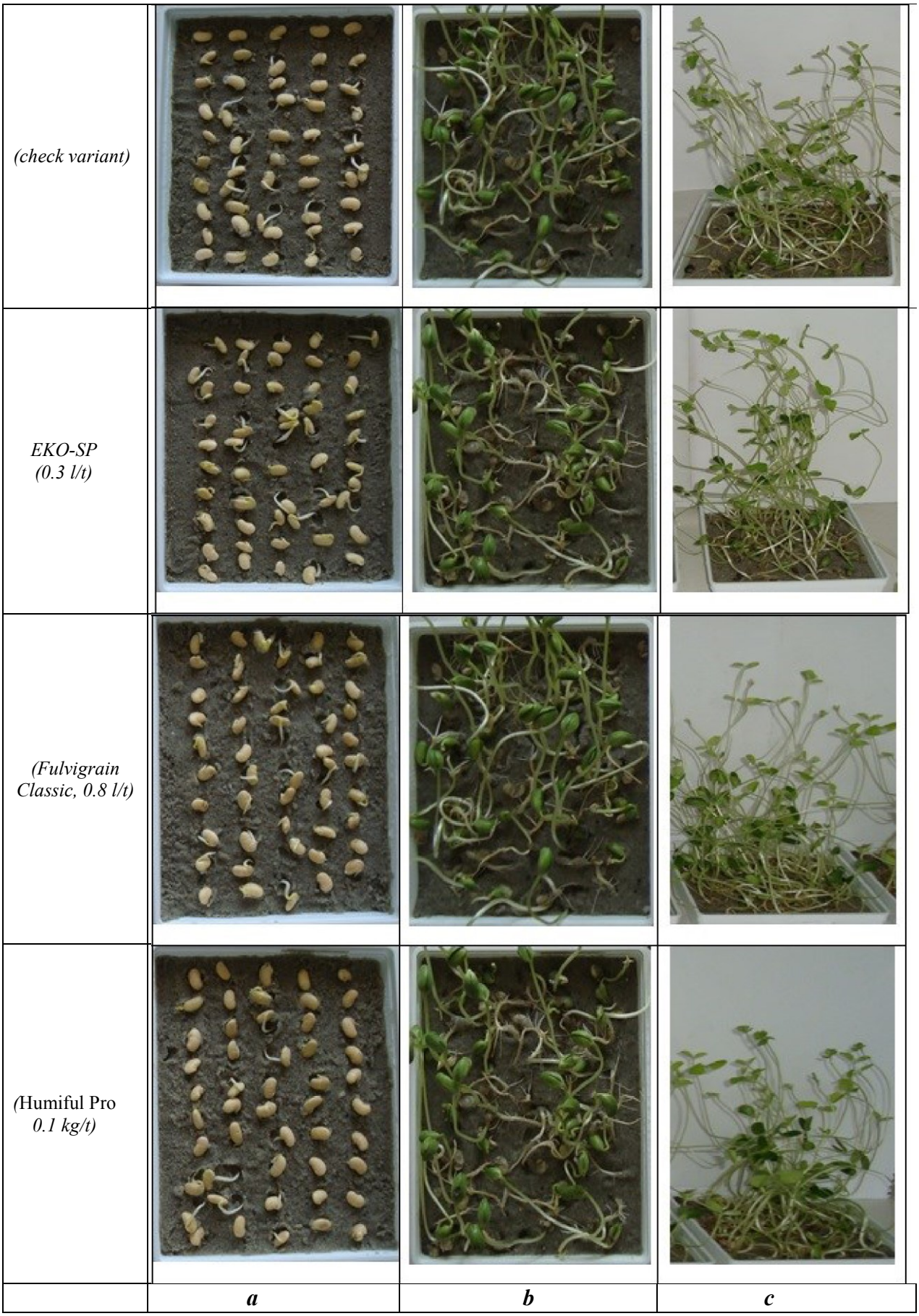

Figure 1. Effect of humic fertilizers on emergence energy and laboratory germination of soybean seeds (a - on day 3, b - on day 7, c - on day 14 of sprouting)

The treatment of seeds with humic fertilizers increased the field germination of soybean seeds by 3.5%, promoted better growth and development of plants, formation of more powerful vegetative mass and

root system in comparison with the check variant. Observations of soybean symbiotic activity during the years of the experiment showed that the use of humic fertilizers formed favourable conditions for the normal life activity of nodule bacteria on plant roots. This, in turn, increased the activity of legume-rhizobial symbiosis and increased the number and mass of nitrogen-fixing nodules on soybean plants. Seed treatment and repeated treatment of crops with humic fertilizers at the phase of 3rd and 6th ternate leaves increased the number of nodules by 10.71-11.55 pcs./plant and the weight of nitrogen fixing nodules by 1.05-1.16 g/plant compared to the check variant (Table 1, Fig. 2).

1. Effect of humic fertilizers on the number and weight of nodules on soybean roots (fruit formation phase), 2019-2021.

Experiment variant	**Number of nodules, pcs.**	**Weight of nodules, g**
1. Check variant	24.50	0.73
2. EKO-SP - seed treatment (0.3 l/t) + seed treatment in the 3rd ternate leaf phase (1.2 l/ha)+ seed treatment in the 6th ternate leaf phase (1.2 l/ha)	36.05	1.89
3. 2. Fulvigrain Classic - seed treatment (0.8 l/t) + seed treatment in the 3rd ternate leaf phase (0.4 l/ha)+ seed treatment in the 6th ternate leaf phase (0.4 l/ha)	35.21	1.78
4. 2. Humiful Pro - seed treatment (0.1 l/t) + seed treatment in the 3rd ternate leaf phase (0.1 l/ha)+ seed treatment in the 6th ternate leaf phase (0.1 l/ha)	35.47	1.83

Figure 2. Effect of humic fertilizers on nitrogen-fixing nodule formation, 2021.

Calculations of the amount of fixed nitrogen using the Hopkins-Peters coefficient showed that as a result of symbiotic activity of nodule bacteria during the vegetation period soybean binds

from 65.1 to 92.1 kg/ha of nitrogen, which was 50-60% more than the plants needed. The use of humic fertilizers on soybean crops activated the symbiotic activity of nodule bacteria and increased the amount of nitrogen bound by soybean plants.

The lowest rates of nitrogen fixation were obtained in the check variant - 65.1 kg/ha. The seed treatment and repeated treatment of soybean crops in the phase of the 3rd and 6th ternate leaves with humic fertilizers increased the amount of fixed air nitrogen to 90.8-92.1 kg/ha. The highest amount of fixed nitrogen by soybean plants (92.1 kg/ha) was observed in the variant with EKO-SP humic fertilizer.

The use of EKO-SP humic substances and Fulvigrain Classic humic fertilizer on soybean crops provided a better yield structure. Treatment of seeds and soybean crops at the phase of the 3rd and 6th ternate leaves with these fertilizers increased the number of beans per plant by 1.3-1.5 pcs., (in the check variant - 18.9 pcs.), the number of grains per plant by 0.15-0.18 pcs. (in the check variant - 1.88 pcs.), weight of grains per plant by 0.74 -1.01 g (the check variant - 4.48 g), weight of 1000 grains by 1.5-4.5 g (in the check variant - 125.7 g). The effect of seed treatment and repeated treatment of soybean with Humiful Pro humic fertilizer on the yield structure elements was slightly lower - the number of beans per plant in this variant was 19.8 pcs., the number of grains per one bean 2.0 pcs., weight of grains per plant - 4.98 g, weight of 1000 grains - 126.0 g.

The most important morphological feature of soybeans that determines the possibility and efficiency of mechanized harvesting is the height of the lower beans. Application of humic fertilizers on soybean crops had a positive effect on this indicator. Thus, the height of the lower bean, fastening to the soybean plant in variants with seed treatment and repeated treatment of crops with humic fertilizers in the phase of the 3rd and 6th ternate leaf was 22.6-24.0 cm or 0.7-2.1 cm higher than in the check variant - 21.9 cm.

Higher yield structure values in variants with humic fertilizers provided higher soybean yields. Thus, seed treatment and double treatment of soybean crops with humic fertilizers at the phase of the 3rd and 6th ternate leaf increased the yield by 0.26-0.34 t/ha or 10.9-14.3%, compared to the check variant (2.37 dt/ha). The highest soybean yield was obtained in variants with seed treatment and repeated treatment of crops at the phase of the 3rd and 6th ternate leaf with humic fertilizers EKO-SP (2.71 t/ha) and Fulvigrain Classic (2.68 t/ha) while the soybean yield in the check variant was 2.37 t/ha (Table 2).

2. Effect of humic fertilizers on the yield and quality of soybean grain, 2019-2021

Experimental variants	**Yield, t/ha**	**Addition to check variant, t/ha**	**Content, %**	
			protein	**fat**
1. Check variant	2.37		35.5	22.1
2. EKO-SP - seed treatment (0.3 l/t) + seed treatment in the 3rd ternate leaf phase (1.2 l/ha)+ seed treatment in the 6th ternate leaf phase (1.2 l/ha)	2.71	0.34	37.2	22.8
3. Fulvigrain Classic - seed treatment (0.8 l/t) + seed treatment in the 3rd ternate leaf phase (0.4 l/ha)+ seed treatment in the 6th ternate leaf phase (0.4 l/ha)	2.68	0.31	36.6	22.5
4. Humiful Pro - seed treatment (0.1 l/t) + seed treatment in the 3rd ternate leaf phase (0.14 l/ha)+ seed treatment in the 6th ternate leaf phase (0.1 l/ha)	2.63	0.26	36.7	22.6
HCP05		0.09	0.5	0.2

The efficiency of seed treatment and repeated treatment of soybean crops with Humiful Pro humic fertilizer was slightly lower, the increase in yield from its use was 0.26 t/ha or 10.9%, compared with the check variant. The use of humic products on soybean crops had a significant impact on grain quality: grain protein content increased by 1.1-1.7%, fat content increased by 0.4-0.7%. Higher

content of protein (37.2%) and fat (22.8%) in soybean grain was obtained in the variant with the treatment of seeds and double treatment of crops with the agrochemical on the basis of humus substances EKO-SP, which is by 1.7% and 0.7% higher than in soybean grain of the check variant.

The effect of Humiful Pro and Fulvigrain Classic humic products on the quality of soybean grain was lower. The treatment of soybean crops with these humic fertilizers increased the protein content of the grain by 1.1-1.3%, oil content - by 0.4-0.5% respectively. The economic efficiency of humic fertilizers on soybean crops depended on their effect on yield, fertilizer cost and application rates (Table 3).

3. Economic efficiency of humic fertilizers on soybean crops, 2019-2021

Variants	Yield, t/ha	Cost of gross output rub.	Production costs, rub.	Cost of production, rub/t	Net income rub./ha	Profitability level, %
1. Check variant	2.37	88875	35208	1485.56	53667	152.4
2. EKO-SP (0.3 l/t) + (1.2 l/ha) in the 3rd ternate leaf phase + (1.2 l/ha) in the 6th ternate leaf phase	2.71	101625	36616	13511.44	65009	177.5
3. Fulvigrain Classic (0.8 l/t) + (0.4 l/ha) in the 3rd ternate leaf phase + (0.4 l/ha) in the 6th ternate leaf phase	2.68	100500	36826	13741.04	63674	172.9
4. Humiful Pro (0.1 l/t) + (0.1 l/ha) in the 3rd ternate leaf phase + (0.1 l/ha) in the 6th ternate leaf phase	2.63	98625	36209	13767.68	62416	172.4

Thus, seed treatment and repeated trearment at the phase of the 3rd and 6th ternate leaves with humic fertilizers increased the soybean yield by 0.26-0.34 t/ha, thereby increasing the value of gross output by 9750-12750 rub./ha and providing 62416-65009 rub./ha of qualified net income, with a profitability level of 172.4-177.5%. Considering the significant cost reduction due to application of humic fertilizers in tank mixtures with pesticides, the economic efficiency of their use increased.

The highest economic indicators were provided by seed treatment and repeated foliar fertilization of soybeans with EKO-SP humic fertilizer, the conventional net income from its application amounted to 65009 rub./ha, the profitability level was 177.5%. The economic efficiency of seed treatment and double treatment of soybean crops with Humiful Pro and Fulvigrain Classic humic fertilizers was lower, the amount of qualified net income was 62416-63674 rub./ha, at the profitability level of 172.4 and 172.9%, respectively.

Conclusions

Thus, the study results prove high efficiency of domestic humic fertilizer EKO-SP in soybean cultivation compared with foreign humic fertilizers (Humiful Pro and Fulvigrain Classic). This efficiency provides the basis for the biologization of crop cultivation technologies based on the extensive use of Russian humic fertilizers and prerequisites for import substitution in this industrial sector.

References

1. Chekmarev P.A., Lukin S.V. Results of agricultural biologization program in Belgorod region//Farming Agriculture. 2014. No. 8. p. 3-6.

2. Kiryushin V.I. Complex assessment methods for agricultural lands//Soil Science No.7. 871-879.

3. Masyutenko N.P., Kuznetsov A.V., Masyutenko M.N., Breskina G.M. Methodological aspects of forming ecologically balanced agricultural landscapes//Farming Agriculture. 2016. No. 7. p. 5-9

4. IvanovA.A. Scientific farming in Russia: results and prospects. //Farming Agriculture. 2014. No. 3, p. 25-29.

5. Okazova Z.P. Biological products in modern agriculture//Current Problems of Science and Education. -2013.- No. 6.

6. Allakhverdiev S.R., Eroshenko V.I. Modern technologies in organic farming//International Journal of Fundamental and Applied Research. 2017. No. 1-1. p. 76-79.

7. Ermakov E. I. Development of ideas on the effect of humic substances on plant metabolism and productivity/E. I. I. Ermakov, A. I. Popov// Bulletin of the Russian Academy of Agricultural Sciences. 2003. No. 2. - p. 16-20.

8. Grekhova, I.V. Humic preparation from lowland peat//Theoretical and Applied Ecology. 2015. No. 1. p. 87-90.

9. Yakimenko O.S., Terekhova V.A., Pukalchik M.A., Gorlenko M.V., Popov A.I. Comparison of two integral biotic indices in evaluating the effectiveness of humic products in a model experiment//Soil Science. 2019. No. 7. p. 781-792

10. Butovets E.S., Lukyanchuk L.M., Ziangirova L.M. Testing of humic products on soybean in conditions of Primorski Krai//Bulletin of Krasnoyarsk State Agrarian University. 2020. No. 10. p. 42-50.

11. State Catalogue of Pesticides and Agrochemicals Approved for Use in the Russian Federation, Moscow, 2021. p.50-53. UDC 631.811.095.337.633.11

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