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Spis treści

ROZDZIAŁ VII

BIO–GEL – a new type of organic fertilizer

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ABSTRACT

A new technology for the production of the BIO-GEL organic fertilizer which is based on physical phenomena with no chemicals used has been suggested. The technology involves reproduction of “wild” microorganisms in peat, biohumus, sapropel, fertile soil. In the course of the production process natural bacteria are hardened at temperatures above 70° C and at low temperatures below -20° C. BIO-GEL has combined the previously incompatible properties of inoculants, fungicides and humates.

Field studies conducted for several years on sandy testing grounds at extremely high temperatures in the south of Ukraine have shown that the new fertilizer has pronounced properties of a natural herbicide, acts as a natural adaptogen, especially efficient after chemical weeding and under extreme weather conditions, intensifies herbicide effect enabling its dose reduction by 30-50%, increases crop yield by 8-38%.

Experiments were carried out on cereals, legumes, vegetables, melons, forest plantations, including organic farming. The experiments included both seed treatment and plant treatment during vegetation. In addition we have studied the effect of the biological preparation against the control when used alone or in combination with known chemical weed and pest killers.

Keywords: organic fertilizer, fertility, soil bacteria, native microflora, non-chemical humates

1. INTRODUCTION

Ecologically friendly technologies in plant cultivation are based on the concepts of biological farming and ensure ecological balance in the environment, stabilization of soil fertility indicators, obtaining biologically safe products. Environmentally friendly technologies in crop cultivation have different names depending on the components they include. Recently the most common names have become: biological or organic agriculture (system of organic fertilizers without the use of agrochemicals), the technology of biologically safe products (no or few pesticides applied), cultivation technology in the areas of man-made pollution. Ecologically friendly technologies in crop cultivation are based on using natural biological laws, minimal use or complete rejection of chemicals, regulation of plant growth and protection.

It has been proven that one cannot go over sharply from traditional farming based on chemicals to biological one. Thus a transitional period to biologization is necessary during which the impact of chemicals on plants and soil is gradually reduced.

So today, when the significance of organic fertilizer system is growing rapidly, there is a return to unjustly forgotten fertilizers: humates. About a dozen companies engaged in the manufacture and sale of humic fertilizer are present on the Ukrainian fertilizer market. Having different trade names, all of them are of chemical origin.

The positive impact of humic acids and their derivatives (fulvic acids) was conclusively proven in scientific studies by L.A Hrystyeva [1 – 6] and her school in the late 40-ies early 50-ies. Humic acid or humates promote the absorption of macro- and microelements by plants, especially under unfavorable conditions. First of all, these are lack of moisture, high or low temperature of air and soil, lack of trace elements, so on. Later L.A. Hrystyeva's followers proved the positive effect of humic compounds on overcoming the stress conditions by plants caused by treatment with fungicides and herbicides [7 – 10].

However, humates of chemical origin potentially pollute soil with insoluble potassium and sodium compounds that inhibit the biological activity of the soil. Besides, on getting into water they negatively interact with bivalent ions of calcium and iron, turning the working solution of humates into the suspension which in a few hours splits to pure water and sodium or potassium salts of bivalent metals. These circumstances promote an increased interest in humic compounds of non-chemical origin, i.e. obtained without the use of concentrated acids and alkalis.

Here we should note a "historical" mistake or at least inconsistency in using the term of "humic acids" instead of "humic acid salts" by many manufacturers.

As is well known [1], organic humic and fulvic acids make the basis of humus which is the main indicator of soil fertility. These compounds are poorly active, poorly soluble in water,

which ensures soil fertility preservation for years. In contrast, chemically formed salts of these acids commonly known as potassium or sodium humates have actively expressed chemical properties including the ability to enter into chemical reactions.

It would be interesting to note that L.A.Hrystyeva and her followers made their experiments using lowland peat and water from the southern the left-bank Ukraine where the Dnipro water is perfectly purified by large amounts of sandy sediment, though in the 50-ies the water in the Dnipro was quite clean. Unfortunately today the situation in farm production has changed drastically because of industrialization and chemicalization. Higher water level caused by irrigation promoted ten-fold groundwater mineralization resulting in the destruction of unique Ukrainian black earth. Using humates of chemical origin with such water is conducive to faster mineral compounds deposition on soil surface which creates a kind of “armor” preventing the gas exchange between the soil and the atmosphere. In this case natural soil microbiota becomes the first victim, which accelerate topsoil degradation.

2. MAIN MATERIALS

The experiments made with water from the Ingulets irrigation system have demonstrated convincingly that the unjustified use of chemical humates accelerates irrigated soils pollution, simultaneously reducing the effectiveness of chemical weed and pest killers most of which are not compatible with humates alkaline compounds.

It is this reason that stimulated the creation of BIO-GEL, the new product which is a source of water-soluble humic compounds (fig. 1.1. – 1.4.). The raw materials for the product are natural organic compounds such as peat, sapropel, California vermicompost worms, etc. The product is made by using only physical methods and no chemicals. Its raw ingredients contain large amounts of natural microorganisms which live in organic symbiosis supplementing and reinforcing the effects of microbiota.

Fig. 1.1. Ingulets irrigation system

Fig. 1.2. Chemical humate, powder

Fig. 1.3. Liquid chemical humate

Fig. 1.4. BIO-GEL

The suggested non-chemical technology of the raw material processing makes it possible to preserve the microbiota and to increase its amount substantially during processing. “Gentle” thermal processing at low and high temperatures makes it possible to harden natural microorganisms adapting them to late spring frosts, droughts, high summer temperatures. This technology which does not differentiate between “useful” and “useless” microflora contributes to environment preservation and higher quality and quantity of yields.

Fundamental research of Ukrainian scientists led by prof. V.P. Patyka [11 – 13] at the Zabolotny Institute of Microbiology and Virology, National Academy of Sciences of Ukraine (NAS), and V.V. Volkogon, corresponding member at the Institute of Agricultural Microbiology and Agro-Industrial Production National Academy of Agrarian Sciences of Ukraine (NAAS) [14, 15] as well as many foreign scientists [16, 17] have contributed substantially to the world microbiology by accelerating soil natural restoration and increasing agriculture efficiency. These methods are based on extracting and reproducing bacteria and fungi which are useful for certain plants on artificial nutrient media. Years of field trials have led to the conclusion that such artificial inoculants effectiveness makes only 65-70%, that is, they work only under favorable conditions.

But these inoculants fail under drought, high or low temperatures, flood. In addition, the transition from artificial nutrient media based on meat and pectin agar to low-calorie "diet" of real soils leads to a rapid decrease in initial titer and significant increase in so-called "lag stage", that is, the stage of bacteria adaptation to new conditions. Besides, the artificial shift of microorganisms natural distribution in either direction and its negative consequences should also be considered.

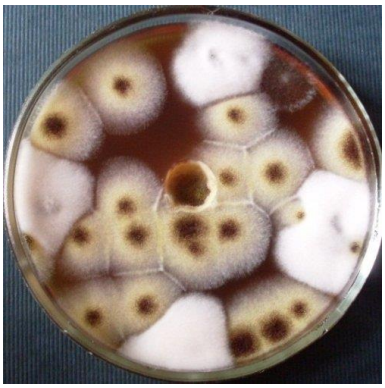
This is the second reason of BIO-GEL product creation which does not differentiate between “good” and “bad” microorganisms and preserves them for their symbiotic existence.

Under processing some raw materials become available in the form of humic, fulvic and lignin compounds. Natural macro- and microelements become water-soluble and available to plants.

Institutions of the NAS of Ukraine have analyzed in detail the BIO-GEL organic and mineral composition and determined its biological activity. Thus, the Palladine Institute of Biochemistry has ascertained that BIO-GEL contains fulvic and humic acids, enzymes, amino acids, proteins and carbohydrates, vitamins B_1, B_2, B_3 (PP), E, A as well as carotenoids, macro- and microelements.

The Zabolotsky Institute of Microbiology and Virology, NAS, Ukraine, has stated that BIO-GEL stimulates seeds germination and development, protects them from pesticide toxic effect, possesses fungicidal and bacteriostatic (slows the development of pathogenic bacteria) properties (fig. 2). This institution has confirmed experimentally BIO-GEL cellulose

activity (its ability to process plant residues after harvest). This allows to classify the product as an effective "stubble destructor" and humus-maker that improves soil structure.



Alternaria

Botrytis cinerea

Fusarium

Fig. 2 BIO-GEL effect on plant pathogenic fungi

The Zabolotny Institute of Microbiology and Virology, NAS, Ukraine, has proved experimentally that BIO-GEL organic preparation contains a great amount of bacterial mictobiota (the end title up to 10^{-10}), which allows to classify it as a natural inoculant. The broad spectrum of bacterial microbiota includes saprophytic pseudomonades, yellow-pigment saprophytes with prevailing Sarcinae, yeast, lactic acid and other saprophytes, azotobacter and various Rhizobia.

In 2013-2016 academic institutions of the NAAS of Ukraine conducted laboratory and field research in different soil-ecological zones to determine the impact of BIO-GEL on vegetation, crop production and yield quality of grains, cereals, leguminous and industrial crops, vegetables and melons (fig. 3.1. – 3.3.).

Fig. 3.1. Water

Fig. 3.2. Chemical

Fig. 3.3. BIO-GEL

The Irrigated Farming Research Institute, NAAS, carried out research in the southern steppe zone to determine BIO-GEL efficiency for soybean crops grown under irrigation as organic (using no weed and pest killers) and under integrated protection (using weed and pest killers) [18]. It is noted that presowing seed treatment with BIO-GEL lengthens the vegetation period on the average by 3 days and strengthens soybean resistance to diseases. The highest yield was obtained when BIO-GEL was used for presowing seed

treatment (1% solution) and for plants spraying (foliar nutrition) at 2 leaves stage (1% solution), the yield being by 0.28 t/ha higher than in the control.

BIO-GEL appeared to be highly effective when used with other preparations. Thus, seed treatment with ABM inoculant and BIO-GEL + foliar nutrition at budding stage resulted in the soybean yield of 2,53 t/ha, which is 0.68 t/ha higher than in the control (fig. 4).

Fig. 4 BIO-GEL as a natural adaptogen

Another experiment with soybeans has proved that BIO-GEL application can reduce agro-chemical load on the soil. Thus, it has been stated that on using Bazagran herbicide, the dose being 3.0 l/ha, its effectiveness is 91.6% compared to the control, while on applying half of its dose (1.5 l/ha) together with 1% BIO-GEL solution the herbicide effectiveness is 89.4% the difference being within the error (table 1).

Table 1. Bazagran herbicide effectiveness (bentazol, 480 g/l)

Variant	Weeds before harvesting, pc/m^2	Herbicide effectiveness, % to control
Control(no chemicals)	41.6	-
Bazagran, (3.0 l/ha)	3.5	91.6
Bazagran, (1.5 l/ha)+ BIO-GEL (1% solution)	4.4	89.4

Besides, it has been established that BIO-GEL acts as a fungicide, which is confirmed by the smaller number of plants affected by bacterial and fungicidal diseases (fig. 5.1. – 5.2.).

Fig. 5.1. A well-known chemical fungicide does not stop the soybean disease, the yield partially

Fig. 5.2. BIO-GEL with fungicidal properties stops the disease and prevents affecting pods, the yield is preserved.

The Kirovograd State Experimental Station, NAAS, [19] studied the BIO-GEL effectiveness in cultivating grains, soybeans and sunflowers on non-irrigated lands. The yield of the Kosovitsa winter wheat grown on fallow land was affected positively by BIO-GEL both under integrated protection and on applying weed and pest killers. Thus, under integrated protection the wheat average yield was 7.63 t/ha (basic technology, control), while on BIO-GEL application it increased by 0.44-9.73 t/ha, or 5.8-9.6%. The highest yield (8.36 t/ha) was obtained on wheat foliar nutrition with BIO-GEL at tillering stage (1 l/ha) and at the start of earing stage (1 l/ha) (table 2).

In the variants when no weed and pest killers were used (organic farming) the Kosovitsa winter wheat yield on fallow land was 7.47 t/ha (control), while BIO-GEL application increased the yield by 0.52-0.73 t/ha, or by 7.0-9.8%. BIO-GEL use for foliar nutrition at tillering stage resulted in protein content increase by 0.5% and gluten content increase by 2.2% (fig. 6).

Similar results have been obtained in cultivating spring barley.

Table 2. Kosovitsa winter wheat yield on treatment by BIO-GEL, t/ha

Variants	Yield	+/- to control	
		t/ha	%
1. Control (integrated protection)	7.63	-	-
2. IP + foliar nutrition with BIO-GEL at tillering stage, 1 l/ha, 0.5% concentration	8.07	+0.44	5.8
3. IP + foliar nutrition with BIO-GEL at tillering stage, 2 l/ha, 1% concentration	8.19	+0.56	7.3
4. IP + foliar nutrition with BIO-GEL at tillering stage, 1 l/ha (0.5% concentration) + foliar nutrition with BIO-GEL at the start of earing stage (1 l/ha, concentration 0,5 %)	8.36	+0.73	9.6
HIP_{05}		0.24	

Fig. 6.1. Water

Fig. 6.2. BIO-GEL,

Fig. 6.3. BIO-

The studies of the preparation effect on the Medeya soybean variety testifies to the fact that the number of beans formed depends on BIO-GEL use. Thus, the average number of beans increased by 2.6-8.4 pc after presowing seed treatment and by 1.1-2.2 pc after foliar nutrition with BIO-GEL at 2-5 leaves stage. The weight of 1000 soybeans in the experiment variants varied from 133.9 g (control) to 147.3 g (seed treatment with BIO-GEL, 2 l/t, 1.0% concentration) (table 3.).

The Medeya soybean variety grown according to the basic technology (control) yielded 2.05 t/ha. The presowing seed treatment with BIO-GEL, the concentrations being 0.5 and 1.0%, increased the yield considerably by 0.52 and 0.50 t/ha, or 25.4 and 24.4%, respectively, while only foliar nutrition at 3-5 leaves stage with BIO-GEL, the dose being 1 l/ha (0.5% concentration), increased the yield by 0.29 t/ha, or by 14.1%.

The studies of BIO-GEL effect on the Orzhitsya 237 MB corn hybrid growth and yield testifies to the fact that the average grain weight increased from 137.3 g (control) to 148.3 g (foliar nutrition at 5-6 leaves stage with BIO-GEL, 1 l/ha). The grains weight on BIOI-GEL application increased by 8.3 – 11.0 g, or 6.0-8.0%.

The highest corn yield (10/22 t/ha) was obtained in the variant where IP was combined

with foliar nutrition by BIO-GEL, the dose being 1 l/ha, in this case the yield was 0.58 t/ha higher than the control (table 4).

Table 3. Medeya soybean variety yield depending on BIO-GEL application, t/ha

Variants	Yield	+/- to control	
		t/ha	%
1. Control (Integrated protection (IP)	2.05	-	-
2. IP + seed treatment with BIO-GEL, 1 l/t (10% concentration)	2.57	+0.52	25.4
3. IP + seed treatment with BIO-GEL, 2 l/t (20% concentration)	2.55	+0.50	24.4
4. IP + foliar treatment at 3-5 leaves stage with BIO-GEL, 1 l/ha (0.5% concentration)	2.34	+0.29	14.1
HIP_{05}		0.12	

Table 4. Orzhitsya 237 MB corn hybrid yield depending on BIO-GEL application, t/ha

Variants	Yield	+/- to control	
		t/ha	%
1. Control (Integrated protection (IP)	9.64	-	-
2. IP + foliar nutrition at 5-6 leaves stage with BIO-GEL, 1 l/ha (0.5% concentration)	10.22	+0.58	6.0
3. IP + foliar nutrition at 5-6 leaves stage with BIO-GEL, 2 l/ha (1.0% concentration	9.78	+0.14	1.5
HIP_{05}		0.33	

The National Scientific Center at the Institute of Agriculture, NAAS, [19] has ascertained that when cultivating millet, BIO-GEL application is most expedient for a single foliar nutrition at tillering stage, the dose being 1.0 l/ha. In this case the yield was the highest and made 5.70 t/ha, the gain being 28.1% compared to the variant without BIO-GEL application.

With buckwheat the most efficient BIO-GEL application is foliar nutrition at flowering stage, the doses being 1.0 and 1.5 l/ha, which ensures the yield of 2.13-2.15 t/ha. In this case the yield gain is 31.0-31.6% compared to the variant without BIO-GEL application.

The Southern Agricultural Station at the Institute of Water Problems and Melioration, NAAS, carried out experiments under southern steppe conditions to determine BIO-GEL effectiveness in cultivating melons, watermelons and tomatoes [20, 21].

As a result of the studies the optimal dose and method of BIO-GEL application in

cultivating watermelons on non-irrigated lands has been determined. The trials have been performed on BIO-GEL use for presowing seed treatment and its effect on soil microbiological activity as well as BIO-GEL use for top-dressing and for combined application and its effect on watermelons growth, development, water consumption, yield amount and quality and BIO-GEL economic efficiency.

It has been ascertained that presowing seed treatment with BIO-GEL speeds up watermelon germination compared to the untreated seeds. Presowing treatment with BIO-GEL alone, the dose being 1 l/t or 2 l/t, reduces the period of watermelon ripening by 5 days, while the combined BIO-GEL use (seed treatment with 2 l/t + foliar nutrition with 2 l/ha or 4 l/ha) reduces this period by 8 days compared to the control (no BIO-GEL use).

Soil microorganisms are known to excrete some carbon dioxide as a result of their vital functions, which testifies to soil biological activity and, consequently, to the intensity of nutrients biological transformation. It has been found out that soil microbiological activity starting from the plant vegetation beginning and up to its gradual extinction depends on the BIO-GEL dose and application method. At the 5-6 leaves stage if the seeds had been treated with BIO-GEL it was higher than if the seeds had not been treated. Thus, in the control variants the soil biological activity of the watermelon plantation was 20.9 mg CO_2/m^2 per year, whereas in the plots with seeds previously treated with humic fertilizer it made 42.9 mg CO_2/m^2 per year, that is, twice more. The highest soil biological activity falls on the flowering stage in all variants. The highest intensity of CO_2 production in this period was in the variant in which seeds were treated with BIO-GEL (2 l/t) + plants were spayed (4 l/ha), in this case it amounted to 56.6 mg CO_2/m^2, which is twice as big as the control.

In the southern Ukrainian steppe of paramount importance for growing any crops is water supply. This concerns watermelons as well, as about 90% watermelon plantations are not irrigated. Given that the amount of precipitation and evaporation from the soil surface during the growing season in all experiment variants was the same, the difference in the water consumption by plants can be attributed just to BIO-GEL different uses. After the vegetation period the plants left different amounts of water in the ground, which can serve as an indirect indicator of the root system capacity and its ability to consume water.

The greatest water consumption was noted in variant 10 where seeds were treated with BIO-GEL (2 l/t) and plants were sprayed with BIO-GEL (4 l/ha). In this variant it amounted to 1889 m^3/ha, which is 71 m^3/ha more than in control 1. More indicative is the coefficient of water consumption which indicates the amount of moisture used to form 1 ton of fruit. It was the lowest in variants 9 and 10 where BIO-GEL was used for seed treatment, the dose being 2 l/t and plant spraying, the dose being 2 and 4 l/ha, and amounted to 83 m^3/t, whereas in control 1 it was 106 m^3/t. Thus, for the production of 1 ton watermelon fruits,

when using BIO-GEL, the plants consumed by 23 m^3 groundwater less than in control 1 and by 19 m^3 less than in control 2.

BIO-GEL affected positively watermelon vegetation and yield. A single treatment of seeds with BIO-GEL (1 l/t) resulted in the yield increase by 1.7 t/ha, or 9.9%, compared to control 1. When the BIO-GEL dose for seed treatment was increased to 2 l/t the watermelon yield increased by 2.2 t/ha, or 12.8%, compared to control 1.

BIO-GEL use for presowing seed treatment appeared quite effective as to its effect on watermelon yield compared to control 2. Thus, presowing seed treatment with BIO-GEL, the dose being 1 l/t, increased watermelon yield by 1.1 t/ha, or by 6.2% compared to control 2. Higher BIO-GEL dose (2 l/t) increased watermelon yield by 1.6 t/ha, or by 9.0% compared to control 2 (table 5).

Table 5. Watermelon yield depending on BIO-GEL application

№	Variant	Yield, t/ha	+/- to control 1		+/- to control 2	
			т/га	%	т/га	%
1	Control 1	17.2	-	-	-0.6	-3.5
2	Control 2 (seed treatment with water	17.8	+0.6	+3.5	-	-
3	Seed treatment with BIO-GEL (1 l/t)	18.9	+1.7	+9.9	+1.1	+6.2
4	Seed treatment with BIO-GEL (2 l/t)	19.4	+2.2	+12.8	+1.6	+9.0
5	Foliar nutrition with BIO-GEL (2 l/ha)	20.2	+3.0	+17.4	+2.4	+13.5
6	Foliar treatment with BIO-GEL (4 l/ha)	20.6	+3.4	+19.8	+2.8	+15.7
7	Seed treatment with BIO-GEL (1 l/t) + foliar treatment with BIO-GEL (2 l/ha)	21.2	+4.0	+23.2	+3.4	+19.1
8	Seed treatment with BIO-GEL (1 l/t) + foliar nutrition with BIO-GEL (4 l/ha)	22.1	+4.9	+28.5	+4.3	+24.1
9	Seed treatment with BIO-GEL (2 l/t) + foliar nutrition with BIO-GEL (2 l/ha)	22.6	+5.4	+31.4	+4.8	+27.0
10	Seed treatment with BIO-GEL (2 l/t) + foliar treatment with BIO-GEL (4 л/ha)	22.8	+5.6	+32.5	+5.0	+28.1
HIP $_{05}$ t/ha = 0.51						

The highest yield was obtained in the variants where BIO-GEL was applied for presowing seed treatment, the dose being 2 l/t, + foliar nutrition, the dose being 2 l/ha or 4 l/ha. In this case the yield amounted to 22.6 and 22.8 t/ha which exceeded the control by 32% on the average.

There is no significant difference between yields in variants 9 (22.6 t/ha) and 10 (22.8

t/ha), (HIP_{05} – 0.51 t), which testifies to inexpediency of increasing BIO-GEL dose from 2 l/ha to 4 l/ha for foliar nutrition.

BIO-GEL application affected watermelons quality. The best quality was ensured in the variant with the BIO-GEL combined application: presowing seed treatment (2 l/t) + foliar nutrition (2 l/ha) where the content of dry soluble substances made 11.6%, total amount of sugars – 10.6%, vitamin C – 8.7 mg/100 g, while in the control only 10.8%, 9.90% and 7.8 mg/100 g, respectively.

The amount of nitrates in all experiment variants was much lower that the permissible one (60 mg/kg). The BIO-GEL combined use even decreased the amount of nitrates compared to the control: 30 and 32 mg/kg against 36 mg/kg in the control.

Proceeding from the two-year research we can recommend to use BIO-GEL humate-concentrate in watermelon cultivation on non-irrigated lands as it ensures:

- watermelon germination 2 days earlier and fruit ripening 8 days earlier than in the control;

- 2 – 2.5 times increase in soil microorganism biological activity, which testifies to soil processes intensification and nutrient regime improvement;

- lower coefficient of water consumption, that is, the amount of ground water required for forming 1 t watermelons is 20-22% lower;

- 9.9 % higher yields after presowing seed treatment and 32.5% higher yields after combined BIO-GEL use;

- higher fruit quality, lower nitrate content;

- the highest economic effect after presowing seed treatment with BIO-GEL (2 l/t) and spraying plants with BIO-GEL (2 l/ha), which ensures 84% production profitability and 488 UAH/t (about 17 euro)/t production price.

When studying the BIO-GEL effect in melons cultivation it has been established that it improves vegetation conditions, speeds up ripening, increases melons productivity [20, 21]. Thus, only presowing melon seed treatment with BIO-GEL, the dose being 1 l/t, promoted fruit ripening 4 days earlier than in control 1. While presowing seed treatment with BIO-GEL + foliar nutrition, the dose being 2 l/ha, made the total vegetation period 4 days shorter than in control 2.

The largest area of leaf surface was formed in the variant of seed treatment with "Bio-gel" (2 l/t) + foliar nutrition (4 l/ha), in this case it made 12365 m^2/ha, which is 2000 m^2/ha, or 19.3% greater than in control 1.

The greatest water consumption was registered in the variant where BIO-GEL was used for seed treatment (2 l/t) + foliar nutrition (4 l/ha) and made 1919 m^3/ha, which is 70 m^3/ha more than in control 1. The plants consumed on the average 31 m^3 water less than in control 1 and 24 m^3 water less than in control 2 for the formation of 1 ton melons.

Quite noticeable is the BIO-GEL effect in various experiment variants on melons growth, development and yield. Thus, only presowing seed treatment with BIO-GEL, the dose being 1 l/t, promoted yield increase by 1.2 t/ha, or by 8.7% compared to control 1. Higher BIO-GEL dose in presowing treatment (2 l/t) ensured melons yield increase by 1.6 t/ha, or by 11.6% compared to control 1 (table 6).

BIO-GEL had a bit greater effect on melon yield when used in foliar nutrition at 5-6 leaves stage than in presowing seed treatment. Thus, foliar nutrition with BIO-GEL (2 l/ha) made it possible to get 15.9 t/ha yield which is by 2.1 t/ha, or 15.2% more than in control 1 and 0.9 t/ha more than in variant 3 where presowing seed treatment was made with BIO-GEL (1 l/t). The BIO-GEL dose increase from 1 to 2 l/t did not provide yield gain. The greatest impact on melon yield was ensured by the combined used of BIO-GEL, that is, presowing seed treatment and foliar nutrition where the gain amounted to 3.4 t/ha – 4.8 t/ha compared to control 1 depending on the preparation dose.

Table 6. Melons yield depending on BIO-GEL dose and application method

№	Variant	Yield, t/ha	+/- to control 1		+/- to control 2	
			t/ha	%	t/ha	%
1	Control 1	13.8	-	-	-0.8	-5.5
2	Control 2 (seed treatment with water)	14.6	+0.8	+5.8	-	-
3	Seed treatment with BIO-GEL (1 l/t)	15.0	+1.2	+8.7	+0.4	+2.7
4	Seed treatment with BIO-GEL (2 l/t)	15.4	+1.6	11.6	+0.8	+5.5
5	Foliar nutrition with BIO-GEL (2 l/ha)	15.9	+2.1	+15.2	+1.3	+8.9
6	Foliar nutrition with BIO-GEL (4 l/ha)	16.3	+2.5	+18.1	+1.7	+11.6
7	Seed treatment with BIO-GEL (1 l/t) + Foliar nutrition with BIO-GEL (2 l/ha)	17.2	+3,4.	+24.6	+2.6	+17.8
8	Seed treatment with BIO-GEL (1 l/t) + Foliar nutrition with BIO-GEL (4 l/ha)	18.0	+4.2	+30.4	+3.4	+23.3
9	Seed treatment with BIO-GEL (2 l/t) + Foliar nutrition with BIO-GEL (2 l/ha)	18.4	+4.6	+33.3	+3.8	+26.0
10	Seed treatment with BIO-GEL (2 l/t) + Foliar nutrition with BIO-GEL (4 l/ha)	18.6	+4.8	34.8	+4.0	+27.4
	HIP_{05} t/ha = 0.45					

The highest yield was obtained on applying BIO-GEL for presowing seed treatment (2 l/t) + foliar nutrition (2 l/ha), in which case the yield was 18.4 t/ha, which is by 34% more than the control. It is inexpedient to increase the BIO-GEL dose from 2 to 4 l/ha in foliar nutrition.

The greatest economic effect has been obtained on using BIO-GEL for presowing treatment (2 l/t) + foliar nutrition (2 l/ha), in this case the efficiency makes 150% at the cost price of 599 UAH/t (about 20 euro).

Proceeding from the research [22], we have determined the optimal dose and the method of BIO-GEL application in tomatoes cultivation technology with drip irrigation. The research has ascertained that presowing tomato seed treatment promotes tomato germination two-days earlier than in control 1.

Among the three methods of using BIO-GEL (soaking seeds, foliar nutrition and fertigation), soaking seeds and foliar nutrition appeared to reduce the interfacial periods of plants growth and development which testifies to its effect on the earliness of vegetables. Only presowing treatment of tomato seeds with BIO-GEL, the dose being 1 l/t and 2 l/t, made it possible to get ripe fruits 8 days earlier than in control 1 and 4 days earlier than in control 2.

The highest weight gains of dry substance in tomato plants were registered at flowering stage in the variant with seed treatment with BIO-GEL (2 l/t) + foliar nutrition (2 l/ha). They made 357 gm^2 and 355 g/m^2, respectively, whereas in control 1 it was 307.9 $г/м^2$ and in control 2 – 315.0 $г/м^2$.

The BIO-GEL positive effect on tomato growth and development in various experiment variants affected the yield as well. Thus, BIO-GEL application for presowing seed treatment resulted in 10% higher yields, by fertigation – in 12% higher yields, by foliar nutrition – in 15% higher yields, while the combined BIO-GEL use (seed treatment + foliar nutrition) resulted in 23% higher yield compared to control 1.

The highest tomato yield (70.0 t/ha) was obtained in the variant with seed treatment (2 l/t) + foliar nutrition (4 l/ha) which was by 24.5% higher than control 1 (table 7).

Table 7. Tomato yield depending on BIO-GEL dose and application method

№	Variant	Yield, t/ha	+/- to control 1		+/- to control 2	
			t/ha	%	t/ha	%
1	Control 1 (no treatment)	56.2	-	-	-0.6	-1.9
2	Control 2 (seed treatment with water)	56.8	+0.6	+1.1	-	-
3	Seed treatment with BIO-GEL, (1 l/t)	61.4	+5.2	+9.2	+4.6	+8.1
4	Seed treatment with BIO-GEL (2 l/t)	62.2	+6.0	+10.6	+5.4	+9.5
5	Foliar nutrition with BIO-GEL, (2 l/ha)	64.1	+7.9	+14.0	+7.3	+12.8
6	Foliar nutrition with BIO-GEL, (4 l/ha)	65.0	+8.8	+15.6	+8.2	+14.4
7	Seed treatment with BIO-GEL (1 l/t) + foliar nutrition with BIO-GEL (2 l/ha)	68.8	+12.6	+22.4	+12.0	+21.1
8	Seed treatment with BIO-GEL (2 l/t) + foliar nutrition with BIO-GEL (4 l/ha)	70.0	+13.8	+24.5	+13.2	+23.2
9	BIO-GEL application (2 l/ha) by fertigation method	62.4	+6.2	+11.0	+5.6	+9.8
10	BIO-GEL application (4 l/ha) by fertigation method	63.2	+7.0	+12.4	+6.4	+11.3
	$НІР_{05}$ т/га = 1,89					

The greatest economic benefit of BIO-GEL use in tomato cultivation technology has been obtained in the variants with presowing seed treatment, the dose being 2 l/t, + foliar nutrition, the dose being 4 l/ha. It is in this experiment variant that the greatest net income (19640 UAH/ha) and the highest level of production profitability (39%) have been obtained at the lowest production price (719 UAH/t).

3. CONCLUSION

Based on research conducted in academic institutions of the National Academy of Sciences and National Academy of Agrarian Sciences of Ukraine it has been ascertained that BIO-GEL natural humate-concentrate can be widely used for growing crops to produce environmentally friendly and organic products.

When applied to seeds and plants during the growing season, BIO-GEL contributes to the intensification of metabolic processes in cells and the increase in cell membrane permeability. This increases nutrients supply into the cells, accelerates the synthesis of

nucleic acids, which ultimately leads to more intensive plant growth and development. Particularly noteworthy are BIO-GEL adaptogenic properties, its ability to bind ions of heavy metals, radionuclides, to accelerate crop detoxification. Foliar nutrition of plant with BIO-GEL in tank mixtures with pesticides allows to halve the rate of agricultural chemicals, preventing their phytotoxic effect on plants, minimizes or removes stress and burns of crop plants. BIO-GEL application to seeds and vegetating plants enriches them with humic compounds, macro- and micronutrients.

In addition to its fungicidal properties BIO-GEL enhances the effect of fungicidal preparations by positive effect of enzymes and amino acids on the immune system of plants.

BIO-GEL is a powerful inoculant which acts as a starter feed (prebiotic) for rhyzobial bacteria. Due to the high content of active micro-organisms BIO-GEL is an intense destructor of plant residues capable to restore the soil structure.

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