Institute of Water Problems and Land Reclamation, NAAN Ukraine

REPORT

Effect of BIO-GEL humate-concentrate on melon growth and yield on non-irrigated lands and on tomato yield under drip irrigation (2016)

V.I. Knish, PhD (agriculture)

2016

Introduction

Agriculture of Ukraine is dependent on world trends in increasing the cost of energy resources, and, consequently, an increase in prices for mineral fertilizers. Therefore, farmers are facing the problem to find alternative agrotechnical measures to increase crop yields and reduce the cost of production. Along with the fertilization systems which use only traditional mineral fertilizers, most cultivation technologies resort to the fertilization systems of the third millennium which in addition to the main fertilizer use foliar nutrition with modern complex water-soluble mineral and organic fertilizers.

In practice there are several ways to enrich plants with trace elements, among them the most common ones are additives to mineral fertilizers, foliar nutrition, pre-sowing seed treatment. The latter method is the cheapest for implementation but one of the most effective. Pre-sowing seed treatment contributes to greater water and dissolved trace elements inflow into soil as the mineral elements on the seed surface dissolve much better than those in the soil. In turn, the salts of trace elements when they enter the seeds, activate the action of hydrolyzing enzymes, make them more viable, increase the energy of germination and the intensity of development.

Recently a new class of fertilizers has appeared – humic ones, their main difference being the presence of humic acid salts. In the general sense, humates are readily soluble physiologically active salts of humic acids. Humic acids together with fulvic acids are known to form the basis of humus, the most important factor of soil fertility. Organic fertilizers contain major and trace elements, various physiologically active substances useful for plants, microorganisms, antibiotics, etc.

Today on the Ukrainian agrarian market there is a great amount of humic preparations manufactured by both foreign and domestic companies. That is why only scientific research can determine their effectiveness in crop cultivation and work out the reasonable recommendations for their application. In our opinion a promising and effective product for cultivating vegetables and melons is BIO-GEL, natural humate-concentrate which was kindly proposed to us for tests by the individual entrepreneur Osipenko (Kherson).

1. Soil-climatic characteristics of the area and weather conditions during the research period

The determination of the BIO-GEL natural humate-concentrate effectiveness in growing melons, watermelons and tomatoes was conducted in field experiments on the Veliky Clin State Experimental Farm of the Southern State Experimental Center, NAAS (Kherson Region). The soils in the region are black earth and sandy-loam soil. The humus profile is up to 76 cm, the humus content is up to 1.0%. The climate of the region is very dry and hot. The average annual precipitation is 328 mm. The hydrothermal coefficient (HTC) is 0.5.

Agro meteorological conditions of the 2016 spring period were favorable enough for the replenishment of soil moisture. Only in the last two spring months the rainfall was 129.8 mm, the norm being 75 mm. In the spring rains fell fairly regularly and abundantly, in April the amount of precipitation was 56.8 mm, the norm being 33 mm, in May – 73.0 mm, the norm being 42 mm. The largest amount of precipitation (46 mm) was in the middle of April, the average annual norm for the second ten-day period being 11 mm, and in the middle of May (40 mm), the norm being 14 mm (table 1.1).

Table 1.1. Agronomical and climatic conditions in 2016

Month	Ten-day period	Temperature, °C		Precipitation, mm	
		average	average perennial	average	average perennial
April	I	11.3	8.8	1.0	10
	II	14.3	9.5	46.0	11
	III	12.4	11.9	9.8	12
	per month	***12.6***	***10.0***	***56.8***	***33***
May	I	14.5	14.1	17.0	15
	II	15.3	16.6	40.0	14
	III	18.5	17.4	20.0	13
	per month	***16.1***	***16.0***	***73.0***	***42***
June	I	17.7	19.2	8.0	13
	II	22.5	19.5	13.0	18
	III	26.5	21.2	14.0	14
	per month	***22.2***	***19.9***	***35.0***	***45***
July	I	22.4	21.3	22.0	22
	II	25.8	22.3	0	14
	III	25.0	22.1	0	13
	per month	***24.4***	***21.9***	***22.0***	***49***
August	I	26.1	22.4	0	7
	II	23.8	21.6	0	13
	III	24.7	20.0	0	18
	per month	***26.2***	***21.3***	***0***	***38***

September	I	21.9	18.6	0	16
	II	18.7	16.4	0	10
	III	13.2	14.2	22.0	14
	per month	***17.9***	***16.4***	***22.0***	***40***

While the average monthly temperature in April 2016 was by 2.6 ° C higher than the norm, in May it was about the average annual one. The summer period was characterized by higher temperature than the average perennial one and by a rather small precipitation amount. In general during the summer period of 2016 the total rainfall was 57 mm, the norm being 132 mm, which is 75 mm less than the long-term data for this period of the year. The lack of atmospheric precipitation and high day and night air temperatures significantly reduced the moisture content in the soil.

2. Schemes of experiments and research methods

2.1 Schemes of experiments

Research on the determination of BIO-GEL natural humate-concentrate effectiveness with melons, watermelons and tomatoes was conducted in three field experiments.

Experiment 1. The effect of BIO-GEL natural humate-concentrate on watermelon growth and yield on non-irrigated lands

Table 2.1 Scheme of experiment

Variant	Seeds treatment	Plants spraying at the stage of 5-6 leaves
1	No treatment	No spraying
2	Treatment with water	No spraying
3	BIO-GEL (1 l/t seeds/10 l water)	No spraying
4	BIO-GEL (2 l/t seeds/10 l water)	No spraying
5	No treatment	BIO-GEL (2 l/ha/300 l water)
6	No treatment	BIO-GEL (4 l/ha/300 l water)
7	BIO-GEL (1 l/t seeds/10 l water)	BIO-GEL (2 l/ha/300 l water)
8	BIO-GEL (1 l/t seeds/10 l water)	BIO-GEL (4 l/ha/300 l water)
9	BIO-GEL (2 l/t seeds/10 l water)	BIO-GEL (2 l/ha/300 l water)
10	BIO-GEL (2 l/t seeds/10 l water)	BIO-GEL (4 l/ha/300 l water)

Watermelon variety is Knyazhich. The area of a single experimental plot is 175 m^2. Accounting area is 100 m^2. The total experiment area is 5600 m^2. The experiment replication is four times. The width of the row spacing is 175 cm, the growing scheme is 175 x 100 cm (the area of plant nutrition is 1.75 m^2).

Experiment 2. The effect of BIO-GEL natural humate-concentrate on melon growth and yield on non-irrigated lands

Table 2.2 Scheme of experiment

Variant	Seeds treatment	Plants spraying at the stage of 5-6 leaves
1	No treatment	No spraying
2	Treatment with water	No spraying
3	BIO-GEL (1 l/t seeds/10 l water)	No spraying
4	BIO-GEL (2 l/t seeds/10 l water)	No spraying
5	No treatment	BIO-GEL (2 l/ha/300 l water)
6	No treatment	BIO-GEL (4 l/ha/300 l water)
7	BIO-GEL (1 l/t seeds/10 l water)	BIO-GEL (2 l/ha/300 l water)
8	BIO-GEL (1 l/t seeds/10 l water)	BIO-GEL (4 l/ha/300 l water)
9	BIO-GEL (2 l/t seeds/10 l water)	BIO-GEL (2 l/ha/300 l water)
10	BIO-GEL (2 l/t seeds/10 l water)	BIO-GEL (4 l/ha/300 l water)

Melon variety is Didona. The area of a single experimental plot is 175 m^2. Accounting area is 100 m^2. The total experiment area is 5600 m^2. The experiment replication is four times. The width of the row spacing is 175 cm; the growing scheme is 175 x 60 cm (the area of plant nutrition is 1.05 m^2).

Experiment 3. The effect of BIO-GEL natural humate-concentrate on tomato growth and yield under drip irrigation

Table 2.3 Scheme of experiment

Variant	Seeds treatment	Plants spraying at the stage of 5-6 leaves
1	No treatment	No spraying
2	Treatment with water	No spraying
3	BIO-GEL (1 l/t seeds/10 l water)	No spraying
4	BIO-GEL (2 l/t seeds/10 l water)	No spraying
5	No treatment	BIO-GEL (2 l/ha/300 l water)
6	No treatment	BIO-GEL (4 l/ha/300 l water)
7	BIO-GEL (1 l/t seeds/10 l water)	BIO-GEL (2 l/ha/300 l water)
8	BIO-GEL (2 l/t seeds/10 l water)	BIO-GEL (4 l/ha/300 l water)
9	No treatment	BIO-GEL (2 l/ha) application by fertigation
10	No treatment	BIO-GEL (4 l/ha) application by fertigation

Tomato variety is Anaconda. The area of a single experimental plot is 35 m^2. Accounting area is 20 m^2. The total experiment area is 1120 m^2. The experiment replication is four times. The sowing scheme is (145 + 30) x 30 cm (the area of plant nutrition is 0.26 m^2).

2.2 Methods of research

When carrying out the research, the standard scientific methods were used:

1. **Phenological observations**. The phases of plant growing and development were determined depending on the factors studied. The beginning of the phase was fixed when it was noted in 10% of plants in the area, mass - in 75% of plants.

The following stages were noted:

- with watermelon: the date of sowing, coming-up, the stage of 4-5 leaves, the beginning of creeping stems formation, the flowering of female flowers, ovary formation, fruit ripening, harvesting;

- with melon: the date of sowing, coming-up, the stage of 4-5 leaves, the beginning of creeping stems formation, the flowering of female flowers, ovary formation, fruit ripening, harvesting;
- with tomato: the date of sowing, coming-up, the stage of 5-6 leaves, budding, the beginning of flowering, the beginning of ovary formation, fruit ripening, the date of the first and last harvesting.

2. Water consumption by crops

Total water consumption is the amount of moisture in m^3/ha (or mm/ha) which was consumed by a melon, watermelon during the vegetation period taking into account the precipitation and by a tomato taking into account precipitation and irrigation. The total water consumption ΣW (mm/ha, m^3/ha) was determined by the formula:

$$\Sigma W = W_0 - W_k + \Sigma O, \text{ where}$$

W_0 - reserves of productive moisture in the meter layer of soil before sowing crops (mm/ha, m^3/ha);

W_k – reserves of productive moisture in the meter layer of soil at the end of the vegetation (mm/ha, m^3/ha);

ΣO – the amount of precipitation during the growing season.

Water consumption coefficient characterizing the water consumption needed for forming 1 t of fruit (m^3/t) is calculated on the basis of total water consumption and crop yields in the experiment variants.

Water consumption coefficient K_w (m^3/t) was determined by the formula:

$$K_w = \Sigma W : Y \text{ where}$$

ΣW is total water consumption (mm/ha, m^3/ha);

Y is yield (t/ha).

3. Soil biological activity was determined by the field adsorption method for determining CO_2 production by soil according to V.I. Shtatnov. For this isolating vessels and vessels for absorbing solution were taken. Plastic caps 15 cm tall and 20 cm diameter were used as insulating vessels. To avoid overheating, the caps were white. The vessels for the solution that absorbed CO_2 were Petri dishes. A vessel for absorbing solution was set on the soil surface using a stand, 0.25 ml of 0.1 N alkaline solution (KOH or NaOH) was poured into it, after that the vessel was immediately covered with an insulator, its edges being pressed into the soil to 1.5-2.0 cm depth or covered with a small soil layer on the outside. At the same time a vessel with alkali and an insulator was installed in a flat-bottomed vessel with a strong solution of cooking salt. After 4-5 hours the insulators were removed, 1 ml of 20% barium chloride solution (for binding absorbed CO_2) was poured into a vessel with the solution, stirred, transferred to a flask and titrated to phenolphthalein with 0.1 N HCl solution until the pink color disappeared. Titration was carried out directly in Petri dishes. Similarly the content of CO_2 in control vessels was determined. The amount of the released CO_2 was calculated according to the formula:

$$Ba = \frac{(a-b)}{St} \text{ where}$$

Ba – the amount of CO2 released, mg/m^2 x hour; *a* – amount of 0.1 N HCl solution which was used to titrate alkali in the control, ml; *b* – the same in the experiment, ml; *K* – the coefficient for converting 0.1 N alkaline solution to CO2 milligrams (K = 2.2); *S* – isolating vessel area, m^2; *t* – experiment duration, hour. At the same time soil moisture content and temperature were determined.

4. **Determination of melon and watermelon leaf surface area** was carried out by the method of O.Ya. Kashcheyev. Biometric measurements were performed periodically (according to the development stages), for the purpose 10 plants in 3 places diagonally were selected in 3-4 repetitions of each variant. In each sample plants were isolated in succession except those that had visible damages by diseases or pests. All 10 plants in the sample had the same nutrition area.

5. **Yield records** were conducted on accounting areas of the same size and configuration. The yields were listed in t/ha.

6. **The economic evaluation of agro-measures** and the calculation of the experiment economic efficiency were based on the main indicators: yield, gross output in monetary terms, labor productivity, cost of production, profitability of production.

7. **Statistical processing of research results** was carried out according to B. A. Dospechov (Field experiment technique with basics of statistical processing of research results).

3. Research results

3.1 The effect of BIO-GEL natural humate-concentrate on watermelon growth and yield on non-irrigated lands

The research has shown that pre-sowing seed treatment speeds up watermelon coming-up. Thus, treating seeds with water (control 2) promoted coming-up one day earlier than in control 1. Pre-sowing seed treatment with BIO-GEL (3, 4, 7, 8, 9 and 10) promoted coming-up 2 days earlier than in control 1 and 1 day earlier than in control 2. Moreover, the effect of the product on watermelon coming-up did not depend on the dose (table 3.1).

Table 3.1. Duration of interphase periods in watermelon plants, days

	Experiment variant	Sowing-coming-up	Coming-up-flowering	Flowering-ripening
1	Control 1	9	40	36
2	Control 2 (treatment with water)	8	38	35
3	Seed treatment with BIO-GEL (1 l/t)	7	35	36
4	Seed treatment with BIO-GEL (2 l/t)	7	35	36
5	Spraying plants with BIO-GEL (2 l/ha)	9	38	35
6	Spraying plants with BIO-GEL (4 l/ha)	9	38	35
7	Seed treatment with BIO-GEL (1 l/t) + spraying plants with BIO-GEL (2 l/ha)	7	34	35
8	Seed treatment with BIO-GEL (1 l/t) + spraying plants with BIO-GEL (4 l/ha)	7	34	35
9	Seed treatment with BIO-GEL (2 l/t) + spraying plants with BIO-GEL (2 l/ha)	7	33	35
10	Seed treatment with BIO-GEL (2 l/t) + spraying plants with BIO-GEL (4 l/ha)	7	33	35

Using BIO-GEL in the basic technology of watermelon cultivation helped to shorten interphase growth periods which testifies to its effect on melon earliness. The least effect on shortening the coming-up – flowering period amounted to 2 days and resulted from using BIO-GEL for spraying plants (in variants 5 and 6 this period duration was 38 days, while in control 1 it was 40 days). The greatest effect on shortening the coming-up – flowering period was 7 days, it was due to applying BIO-GEL for pre-sowing seed treatment, the dose being 2 l/t, + spraying plants with BIO-GEL, the dose being 2 l/ha and 4 l/ha (variants 9 and 10). The same tendency for shortening growth phases due to BIO-GEL use was noted in the next interphase period: flowering – fruit ripening.

In general, the watermelon vegetation period in control 1 was 76 days, in control 2 – 73 days. Just pre-sowing watermelon seed treatment with BIO-GEL, the dose being 1 l/t and 2 l/t (variants 3 and 4), promoted fruit ripening 5 days earlier than in control 1 and 2 days earlier than in control 2.

Spraying watermelon plants with BIO-GEL, the dose being 2 l/ha and 4 l/ha (variants 5 and 6), was similar to control 2 (73 days) as to its effect on the vegetation period duration and appeared less efficient than pre-sowing seed treatment (variants 3 and 4) in which vegetation period duration was 71 days.

The greatest effect on the watermelon vegetation period duration was caused by BIO-GEL combined use: in pre-sowing seed treatment and plants spraying. In variants 7 and 8 pre-sowing seed treatment, the dose being 1 l/t, + plants spraying, the dose being 2 l/ha and 4 l/ha, resulted in the 69-day vegetation period, in variants 9 and 10 pre-sowing seed treatment, the dose being 2 l/t, + plants spraying, the dose being 2 l/ha and 4 l/ha, resulted in 68-day vegetation period.

Thus, BIO-GEL application for pre-sowing seed treatment (2 l/t) + plants spraying (2 l/ha and 4 l/ha) helped to shorten the watermelon vegetation period by 8 days compared to control 1 (no treatments) and by 5 days compared to control 2.

The main component influencing soil life is soil microorganisms. In the process of their life they cause gradual changes in soil composition and properties. Soil microorganism activity is accompanied by the release of carbon dioxide due to their vital activity, its registration may indicate soil biological activity.

Soil biological activity according to the experiment variants starting from coming-up to fruit ripening is characterized by stable changes. The peak of microorganism activity is recorded at the watermelon flowering stage, regardless of the experiment variants.

It has been established that at the 4-5 leaves stage the soil microbiological activity was higher in the variants where pre-sowing treatment with organic fertilizer was used. Thus, at this stage in control variants 1 and 2 and in variants 5 and 6 where spraying with BIO-GEL was used, soil biological activity was 20.9 – 24.5 mg CO_2/m^2 x hour, while in case of just pre-sowing seed treatment with humic fertilizer it was from 41.5 to 42.9 mg CO_2/m^2 x hour, that is, it doubled (98.6-105.2%) (table 3.2).

Table 3.2. Soil microbiological activity, mg CO_2/m^2 x hour

№	Experiment variant	Growth stages		
		4-5 leaves	Flowering	Ripening
1	Control 1	20.9	22.8	19.4
2	Control 2 (seed treatment with water)	21.3	24.6	22.6
3	Seed treatment with BIO-GEL (1 l/t)	41.5	44.9	42.2
4	Seed treatment with BIO-GEL (2 l/t)	42.9	48.8	44.4
5	Spraying plants with BIO-GEL (2 l/ha)	24.0	26.8	23.1
6	Spraying plants with BIO-GEL (4 l/ha)	24.5	26.6	21.6
7	Seed treatment with BIO-GEL (1 l/t) + Spraying plants with BIO-GEL (2 l/ha)	44.2	51.8	43.0
8	Seed treatment with BIO-GEL (1 l/t) + Spraying plants with BIO-GEL (4 l/ha)	45.3	54.6	44.4
9	Seed treatment with BIO-GEL (2 l/t) + Spraying plants with BIO-GEL (2 l/ha)	49.1	52.6	42.8
10	Seed treatment with BIO-GEL (2 l/t) + Spraying plants with BIO-GEL (4 l/ha)	49.4	56.6	46.6

The greatest soil biological activity at the stage of 4-5 leaves was recorded with the combined BIO-GEL use, that is, in variants 7, 8, 9, 10, it was 42.2 $mgCO_2/m^2$ x hour, 45.3 $mgCO_2/m^2$ x hour, 49.1 $mgCO_2/m^2$ x hour, 49.4 $mgCO_2/m^2$ x hour, respectively.

The peak of the soil biological activity in all variants was recorded at the watermelon flowering stage. The greatest CO_2 release from soil was recorded in variant 10 after seed treatment with BIO-GEL (2 l/t) + spraying plants with BIO-GEL (4 l/ha), it was 56.6 $mgCO_2/m^2$ x hour, which is 2.4 times higher than in control 1.

Studies have shown that the growth of watermelon leaves throughout the vegetative period can be divided into 4 stages. Passing through these stages the plant first slowly forms 3-5 real leaves and with the help of them stores substances for enhanced growth, then it quickly forms the maximum leaf surface to create assimilation potential aimed at the formation of plant generative organs. After that the intensity of leaf surface formation significantly slows down and the assimilated growth potential is redirected to provide generative organs. From this period the growth of leaf surface goes on very slowly and gradually is balanced.

At the 4-5 leaves stage the greatest watermelon leaf surface was in variants 3, 4, 7, 8, 9 and 10, that is, in the variants with pre-sowing seed treatment with BIO-GEL and amounted to 89 m^2/ha and 92 m^2/ha.

At the flowering stage there were considerable differences in watermelon leaf surface in various variants. At the same time its highest rates are noted at the combined application of BIO-GEL, that is, in variants 7, 8, 9, 10, they amounted to 7428 – 7828 m^2/ha (table 3.3).

Table 3.3. Watermelon leaf surface formation, m^2/ha

№	Experiment variant	Growth stages		
		4-5 leaves	Flowering	Ripening
1	Control 1	76	6171	11199
2	Control 2 (seed treatment with water)	78	6342	11942
3	Seed treatment with BIO-GEL (1 l/t)	91	6628	12014
4	Seed treatment with BIO-GEL (2 l/t)	92	6857	12056
5	Spraying plants with BIO-GEL (2 l/ha)	80	6900	12799
6	Spraying plants with BIO-GEL (4 l/ha)	78	7171	13199
7	Seed treatment with BIO-GEL (1 l/t) + Spraying plants with BIO-GEL (2 l/ha)	90	7428	13428
8	Seed treatment with BIO-GEL (1 l/t) + Spraying plants with BIO-GEL (4 l/ha)	89	7600	13771
9	Seed treatment with BIO-GEL (2 l/t) + Spraying plants with BIO-GEL (2 l/ha)	92	7728	14114
10	Seed treatment with BIO-GEL (2 l/t) + Spraying plants with BIO-GEL (4 l/ha)	92	7828	14178

The maximum assimilation surface of the watermelon plant was formed in the phase of fruit ripening and its highest rates are noted at the combined BIO-GEL use, that is, in variants 7,8, 9, 10 ranging from 13428 to 14178 m^2/ha. The greatest leaf surface was formed in variant 10 after pre-sowing seed treatment with BIO-GEL (2 l/t) + spraying watermelon plants with BIO-GEL (4 l/ha), in this case it made 14178 m^2/ha, which is by 2979 m^2/ha, or by 26.6% more than in control 1. A bit smaller is the leaf surface in variant 9 after pre-sowing seed treatment with BIO-GEL (2 l/t) + spraying plants with BIO-GEL (2 l/ha) which made 14114 m^2/ha.

In the Ukrainian southern steppe water supply is very important for forming any crop yield, including watermelons, its area on non-irrigated lands amounts to 90%. Moisture reserves were formed both during the autumn-winter period of 2015-2016 and in spring 2016. During the watermelon vegetation period the precipitation amounted to 130 mm which makes 1300 m^3/ha. Given that rainfall during the watermelon vegetation period and the evaporation from soil in different experiment variants were the same, the difference in water consumption by crops can be attributed to the effect of different variants of BIO-GEL application. In addition, the reserves of productive moisture in the meter soil layer before sowing watermelon in all experiment variants were almost identical and amounted to an average of 86.2 mm. The fact that watermelon plants left different amounts of moisture in the soil in different variants at the end of their vegetation periods may indirectly testify to the plant root system development and ability to consume water.

The largest total water consumption was recorded in variant 10 with pre-sowing seed treatment with BIO-GEL (2 l/t) + spraying plants with BIO-GEL (4 l/ha), it made 1889 m^3/ha and was by 71 m^3/ha larger than in control 1 (table 3.4).

Table 3.4. Total water consumption and water consumption coefficient of watermelon

№	Experiment variant	Water reserves in 0-100 cm soil layer, mm		Rainfall during vegetation, mm	Total water consumption by watermelon, m^3/ha	Water consumption coefficient, m^3/t
		before sowing	during ripening			
1	Control 1	86.2	34.4	130	1818	106
2	Control 2 (seed treatment with water)	86.2	34.0	130	1822	102
3	Seed treatment with BIO-GEL (1 l/t)	86.2	33.3	130	1829	97
4	Seed treatment with BIO-GEL (2 l/t)	86.2	33.0	130	1832	94
5	Spraying plants with BIO-GEL (2 l/ha)	86.2	33.2	130	1830	91
6	Spraying plants with BIO-GEL (4 l/ha)	86.2	34.2	130	1820	88
7	Seed treatment with BIO-GEL (1 l/t) + Spraying plants with BIO-GEL (2 l/ha)	86.2	29.7	130	1865	88
8	Seed treatment with BIO-GEL (1 l/t) + Spraying plants with BIO-GEL (4 l/ha)	86.2	28.9	130	1873	85
9	Seed treatment with BIO-GEL (2 l/t) + Spraying plants with BIO-GEL (2 l/ha)	86.2	29.1	130	1871	83
10	Seed treatment with BIO-GEL (2 l/t) + Spraying plants with BIO-GEL (4 l/ha)	86.2	27.3	130	1889	83

More indicative of water consumption characteristic of watermelon is the water consumption coefficient which indicates the amount of water used to form 1 ton of fruit. Thus, the lowest water consumption coefficient was recorded in variants 9 and 10 (pre-sowing seed treatment with BIO-GEL, the dose being 2 l/t, + spraying plants with BIO-GEL, the dose being 2 l/ha and 4 l/ha), in this case it was 83 m^3/t, while in control 1 it was 106 m^3/t, which means that plants used by 23 m^3 less water than in control 1 and by 19 m^3 less water than in control 2.

Positive effect of BIO-GEL on forming fruit has been noted in various experiment variants. Thus, only one pre-sowing seed treatment with BIO-GEL, the dose being 1 l/t, increased watermelon yield by 1.7 t/ha, or by 9.9% compared to control 1. Higher dose in pre-sowing seed treatment (2 l/t) increased watermelon yield by 2.2 t/ha, or by 12.8% compared to control 1. It should be noted that the use of ordinary drinking water for pre-sowing treatment of watermelon seeds (control 2) contributed to a significant increase in yields of 0.6 t / ha (HIP_{05} - 0.51 t), or 3.5%.

BIO-GEL use for pre-sowing seed treatment was quite effective for increasing watermelon yield compared to control 2. Thus, pre-sowing seed treatment with BIO-GEL (1 l/t) increased the yield by 1.1 t/ha, or 6.2% compared to control 2. The dose increase to 2 l/t in pre-sowing seed treatment increased watermelon yield by 1.6 t/ha, or 9.0% compared to control 2 (table 3.5).

Table 3.5. Watermelon yield depending on the dose and method of BIO-GEL use

	Experiment variant	Yield, t/ha	+/- to control 1		+/- to control 2	
			t/ha	%	t/ha	%
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	Spraying plants with BIO-GEL (2 l/ha)	20.2	+3.0	+17.4	+2.4	+13.5
6	Spraying plants 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) + Spraying plants 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) + Spraying plants 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) + Spraying plants 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) + Spraying plants with BIO-GEL (4 l/ha)	22.8	+5.6	+32.5	+5.0	+28.1
	HIP_{50} t/ha = 0.51					

A bit greater effect of BIO-GEL use on watermelon yield was achieved on spraying plants at the 4-5 leaves stage than on pre-sowing seed treatment. Thus, spraying watermelon plants with BIO-GEL (2 l/ha) brought about 20.2 t/ha yield, that is, by 3.0 t/ha or 17.4% more than in control 1 and by 1.3 t/ha more than in variant 3 where pre-sowing seed treatment was carried out, the dose being 1 l/t. Higher BIO-GEL dose (2 l/t) in pre-sowing seed treatment in variants 3 and 4 where the yields were 18.9 and 19.4 t/ha, respectively, and 4 l/ha in variants 5 and 6 where the yields were 20.2 and 20.6 t/ha did not provide a significant increase in watermelon yield (HIP_{05} – 0.51 t). The greatest effect on the watermelon yield was achieved by BIO-GEL combined use, that is, pre-sowing seed treatment and plant spraying, depending on the dose the increase was from 4.0 t / ha to 5.6 t / ha compared with control 1.

The highest watermelon yield was achieved in variants 9 and 10 where BIO-GEL was used both for pre-sowing seed treatment (2 l/t) + for spraying plants (2 l/ha and 4 l/ha), the yield in these cases amounted to 22.6 and 22.8 t/ha, that is, 32% more on average than in control. The significant difference between the yield obtained in variant

9 (22.6 t / ha) and variant 10 (22.8 t / ha) was not recorded (HIP_{05} - 0.51 t) which testifies to the inexpediency of increasing the BIO-GEL dose from 2 liters / ha to 4 l / ha for spraying watermelon plants.

Even at rather low purchasing prices of watermelons (900 UAH / ton on average) formed in August 2016 and significant production costs, relatively high economic efficiency of cultivation has been obtained. The production costs in our experiment were determined by the cost of watermelon cultivation according to the basic technology and additional costs for carrying out activities provided by the experiment scheme. In addition, account was also taken of costs of harvesting and shipping the yield gains. Thus, from the economic point of view the smallest additional production costs were when BIO-GEL was used for pre-sowing seed treatment. Considering the fact that 1-2 l BIO-GEL is required for treating 1 t of seeds, its cost being 70 UAH/l, while the amount of seeds per 1 hectare is just 1 kg, that is, 1-2 ml of BIO-GEL is required, which costs 0.07-0.14 UAH/ha.

More expensive is using BIO-GEL for spraying, in this case the hectare cost of BIO-GEL is 140-280 UAH/ha. Besides, we must take into account the cost of making the solution and applying it (fuel, salary to the mechanic, depreciation cost, etc).

Gross profit directly depends on the yield, which, in turn, is determined by the effect of BIO-GEL application methods in the technology of growing watermelon. The highest gross income (205230 UAH/ha) was obtained in variant 10 (pre-sowing seed treatment with BIO-GEL, the dose being 2 l/t, + spraying plants with BIO-GEL, the dose being 4 l/ha) where the yield was the highest. However, the most telling in relation to profit is net profit. The highest net profit was obtained in variant 10 (9370 UAH/ha) which is by 4370 UAH/ha more than in control 1. But in variant 9 where smaller dose (2 l/ha) was used for spraying, the net profit was only by 55 UAH/ha lower, whereas the cost of 2 l of BIO-GEL is 140 UAH (table 3.6).

Table 3.6. Economic efficiency of watermelon cultivation

	Experiment variant	Yield, t/ha	Production cost, UAH/ha	Gross profit, UAH/ha	Net profit, UAH/ha	Cost, UAH/t	Profitability, %
1	Control 1	17.2	10480	15480	5000	609	48
2	Control 2 (seed treatment with water)	17.8	10490	16020	5530	589	53
3	Seed treatment with BIO-GEL (1 l/t)	18.9	10520	17010	6490	557	62
4	Seed treatment with BIO-GEL (2 l/t)	19.4	10550	17460	6910	544	65
5	Spraying plants with BIO-GEL (2 l/ha)	20.2	10820	18180	7360	536	68
6	Spraying plants with BIO-GEL (4 l/ha)	20.6	10970	18540	7570	532	69
7	Seed treatment with BIO-GEL (1 l/t) + Spraying plants with BIO-GEL (2 l/ha)	21.2	10910	19080	8170	515	75
8	Seed treatment with BIO-GEL (1 l/t) + Spraying plants with BIO-GEL (4 l/ha)	22.1	11100	19890	8790	502	79
9	Seed treatment with BIO-GEL (2 l/t) + Spraying plants with BIO-GEL (2 l/ha)	22.6	11025	20340	9315	488	84
10	Seed treatment with BIO-GEL (2 l/t) + Spraying plants with BIO-GEL (4 l/ha)	22.8	11150	20520	9370	489	84

Thus, from an economic point of view the most effective was BIO-GEL application in variant 9 where it was used for pre-sowing seed treatment at a dose of 2 l/t and for plant spraying at a dose of 2 l/ha. In this experiment variant the production profitability amounted to 84%, the production cost being 488 UAH/t of fruit.

CONCLUSIONS

1. Pre-sowing seed treatment with BIO-GEL encourages watermelon coming-up two days before the control.

2. BIO-GEL use in the basic technology of watermelon cultivation promotes its early maturity. The most significant effect has been achieved on treating seeds with BIO-GEL (2 l/t) and spraying plants with BIO-GEL (2 l/ha or 4 l/ha). In this case the total vegetation period has been reduced by 8 days compared to control 1 (no treatments) and by 5 days compared to control 2 (seed treatment with water).

3. BIO-GEL use in pre-sowing seed treatment is conducive to soil bacteria higher biological activity. The peak of CO_2 production by soil bacteria in watermelon crops has been recorded in the flowering stage, its highest intensity (56.6 mg CO_2 / m^2 x year) being in the variant when seeds were treated with BIO-GEL (2 l/t) + plants were sprayed with BIO-GEL (4 l/ha), in this case CO_2 production was 2.5 times higher than in control 1.

4. The greatest leaf surface has been registered in the variant where seeds were treated with BIO-GEL (2 l/t) + plants were sprayed with BIO-GEL (4 l/ha). In this case it amounts to 14178 m^2/ha, which is 2979 m^2/ha, or 26.6% bigger than in control 1. A bit smaller has been the leaf surface in the variant where seeds were treated with BIO-GEL (2 l/t) + plants were sprayed with BIO-GEL (2 l/ha), in this case it amounted to 14114 m^2/ha.

5. The lowest water consumption coefficient has been recorded in variants 9 and 10 (the BIO-GEL use in pre-sowing seed treatment, the dose being 2 l/t, + spraying plants with BIO-GEL, the dose being 2-4 l/ha), in which case water consumption amounted to 83 m^3/t, whereas in control 1 – 106 m^3/t. Thus, watermelon plants consume 23 m^3 water less than in control 1 and 19 m^3 water less than in control 2 to produce watermelons when applying BIO-GEL.

6. The highest yield has been obtained in variants 9 and 10 with BIO-GEL used for pre-sowing seed treatment (2 l/t) + for spraying (2-4 l/ha). In this case the yield amounted to 22.6 and 22.8 t/ha, thus exceeding the control by 32% on average. Any significant difference between yields in variants 9 and 10 has not been recorded, which testifies to the inexpediency of increasing the BIO-GEL dose from 2 to 4 l/ha for spraying watermelon plants.

7. The greatest cost-effectiveness has been registered in the variant with BIO-GEL use in pre-sowing seed treatment (2 l/t) + plants spraying with BIO-GEL (2 l/ha), in which case the production profitability amounted to 84%, the product cost being 488 UAH/t.

3.2 BIO-GEL effect on melon cultivation on non-irrigated lands.

Studies have shown that pre-sowing seed treatment speeds up melon coming-up. Thus, seed treatment with water (control 2) and with BIO-GEL (variants 3, 4, 7, 8, 9 and 10) contributed to melon coming-up a day earlier than in control 1 (table 3.7).

Table 3.7. Duration of melon interphase growth periods

	Experiment variant	Growth periods		
		sowing-coming-up	coming-up-flowering	flowering-ripening
1	Control 1	8	34	32
2	Control 2 (seed treatment with water)	7	33	31
3	Seed treatment with BIO-GEL (1 l/t)	7	33	29
4	Seed treatment with BIO-GEL (2 l/t)	7	33	29
5	Spraying plants with BIO-GEL (2 l/ha)	8	33	30
6	Spraying plants with BIO-GEL (4 l/ha)	8	33	30
7	Seed treatment with BIO-GEL (1 l/t) + Spraying plants with BIO-GEL (2 l/ha)	7	32	28
8	Seed treatment with BIO-GEL (1 l/t) + Spraying plants with BIO-GEL (4 l/ha)	7	32	28
9	Seed treatment with BIO-GEL (2 l/t) + Spraying plants with BIO-GEL (2 l/ha)	7	32	28
10	Seed treatment with BIO-GEL (2 l/t) + spraying plants with BIO-GEL (4 l/ha)	7	32	28

Using BIO-GEL in the basic technology of melon cultivation helped to shorten interphase growth periods, which testifies to its effect on melon earliness. The least effect on shortening the coming-up – flowering period amounted to 1 day and resulted from using BIO-GEL for pre-sowing seed treatment (in variants 3 and 4) and only for plant spraying (variants 5 and 6). The greatest effect on shortening the coming-up – flowering period was 2 days, it was due to applying BIO-GEL for pre-sowing seed treatment + spraying plants with BIO-GEL (variants 7, 8, 9 and 10). The same tendency for shortening growth phases due to BIO-GEL use was noted in the next interphase period: flowering – fruit ripening.

In general, the melon vegetation period in control 1 was 66 days, in control 2 – 64 days. Just pre-sowing melon seed treatment with BIO-GEL, the dose being 1 l/t and 2 l/t (variants 3 and 4) promoted fruit ripening 4 days earlier than in control 1 and 2 days earlier than in control 2.

The greatest effect on the melon vegetation period duration was caused by BIO-GEL combined use: in pre-sowing seed treatment and plants spraying, this period lasting only 60 days in variants 7, 8, 9, 10. Thus using BIO-GEL for pre-sowing seed treatment + for spraying plants shortened melon vegetation period by 6 days compared to control 1 (no treatment) and by 4 days compared to control 2.

In the phase of 5-6 leaves the greatest leaf surface was recorded in variants 3, 4, 7, 8, 9 and 10, that is, in the variants with pre-sowing seed treatment with BIO-GEL and amounted to 94 m^2/ha – 102 m^2/ha.

In the flowering phase considerable differences were recorded in the melon leaf surface, it was the greatest in variants 7, 8, 9, 10 on BIO-GEL combined use and amounted to 7486-7676 m^2/ha (table 3.8).

Table 3.8. Melon leaf surface formation, m^2/ha

	Experiment variant	Growth periods		
		5-6 leaves	flowering	ripening
1	Control 1	88	6942	10365
2	Control 2 (seed treatment with water)	88	6948	10390
3	Seed treatment with BIO-GEL (1 l/t)	94	7258	11230
4	Seed treatment with BIO-GEL (2 l/t)	96	7462	11320
5	Spraying plants with BIO-GEL (2 l/ha)	88	7236	11330
6	Spraying plants with BIO-GEL (4 l/ha)	88	7356	11410
7	Seed treatment with BIO-GEL (1 l/t) + Spraying plants with BIO-GEL (2 l/ha)	98	7486	11890
8	Seed treatment with BIO-GEL (1 l/t) + Spraying plants with BIO-GEL (4 l/ha)	100	7515	12100
9	Seed treatment with BIO-GEL (2 l/t) + Spraying plants with BIO-GEL (2 l/ha)	102	7612	12210
10	Seed treatment with BIO-GEL (2 l/t) + spraying plants with BIO-GEL (4 l/ha)	102	7676	12365

The greatest assimilation surface was formed in the ripening phase, the greatest figures were recorded on BIO-GEL combined use, that is in variants 7, 8, 9, 10, and amounted to 11890 – 12365 m^2/ha. The greatest leaf surface was recorded in variant 10 on pre-sowing seed treatment with BIO-GEL (2 l/t) + spraying plants with BIO-GEL (4 l/ha) and amounted to 12365 m^2/ha, which was by 2000 m^2/ha, or 19.3% more than in control 1. A bit smaller was the leaf surface in variant 9 on pre-sowing seed treatment (2 l/t) + spraying plants with BIO-GEL (2 l/ha) and amounted to 12210 m^2/ha.

The formation of moisture reserves took place both during the 2015-2016 autumn-winter period and due to the precipitation during the 2016 spring period. During the melon vegetation period 130 mm of precipitation was recorded, that is 1300 m^3/ha. Provided that the amount of precipitation during the melon growing period and evaporation from the soil surface in the experiment variants were the same, the difference in water consumption of the studied crop can be attributed to the impact of different variants of BIO-GEL use. In addition, the reserves of productive moisture in the meter soil layer before melon sowing in all experiment variants were almost identical and amounted to an average of 86.2 mm. The fact that the melon plants in the experimental variants after the end of their vegetation left a different amount of moisture in the soil may be an indirect indicator of the root system development and its ability to water consumption.

The greatest total water consumption by melon crops was noted in variant 10 with pre-sowing seed treatment with BIO-GEL (2 l/t) + spraying plants with BIO-GEL (4 l/ha), in this case it amounted to 1919 m^3/ha which is by 70 m^3/ha more than in control 1 (table 3.9).

Table 3.9. Total water consumption by melon crops and water consumption coefficient

	Experiment variant	Productive moisture reserves in 0-100 cm soil layer, mm		Precipitation during the vegetation period, mm	Total water consumption on melon ripening, m^3/ha	Water consumption coefficient, m^3/t
		before sowing	on ripening			
1	Control 1	86.2	31.3	130	1849	134
2	Control 2 (seed treatment with water)	86.2	30.2	130	1860	127
3	Seed treatment with BIO-GEL (1 l/t)	86.2	29.7	130	1865	124
4	Seed treatment with BIO-GEL (2 l/t)	86.2	28.6	130	1876	122
5	Spraying plants with BIO-GEL (2 l/ha)	86.2	27.3	130	1889	119
6	Spraying plants with BIO-GEL (4 l/ha)	86.2	27.7	130	1885	116
7	Seed treatment with BIO-GEL (1 l/t) + Spraying plants with BIO-GEL (2 l/ha)	86.2	26.6	130	1896	110
8	Seed treatment with BIO-GEL (1 l/t) + Spraying plants with BIO-GEL (4 l/ha)	86.2	25.9	130	1903	106
9	Seed treatment with BIO-GEL (2 l/t) + Spraying plants with BIO-GEL (2 l/ha)	86.2	24.1	130	1921	104
10	Seed treatment with BIO-GEL (2 l/t) + spraying plants with BIO-GEL (4 l/ha)	86.2	24.3	130	1919	103

More indicative in the melon water consumption characteristic is water consumption coefficient which shows the amount of water consumed in forming 1 t of fruit. Thus, the lowest water consumption coefficient was noted in variants 9 and 10 (BIO-GEL applied for pre-sowing seed treatment at the dose of 2 l/t + spraying plants with BIO-GEL at the doses of 2 l/ha and 4 l/ha), in these cases it amounted to 104 and 103 m^3/t, respectively, while in control 1 it was 134 m^3/t. Thus, for forming a ton of melons the plants consumed by 31 m^3 water less than in control 1 and by 24 m^3 water less than in control 2.

Positive effect of BIO-GEL application on plant development in different experiment variants resulted in fruit yields. Thus, the only pre-sowing seed treatment with BIO-GEL (1 l/t) increased the melon yield by 1.2 t/ha, or by 8.7% compared to control 1. Increasing the BIO-GEL dose in pre-sowing seed treatment to 2 l/t increased melon yield by 1.6 t/ha, or by 11.6% compared to control 1.

It should be noted that the use of drinking water for pre-sowing seed treatment (control 2) increased the yield by 0.8 t/ha (HIP_{05} – 0.45 t), or by 5.8%. BIO-GEL application for pre-sowing seed treatment appeared quite effective in comparison to control 2. Thus, pre-sowing seed treatment with BIO-GEL at the dose of 1 l/t increased melon yield by 0.4 t/ha, or by 2.7% compared to control 2. When the dose for pre-sowing seed treatment was increased to 2 l/t, the melon yield increased by 0.8 t/ha, or by 5.5% compared to control 2 (table 3.10).

Table 3.10. Melon yield according to BIO-GEL dose and application method

	Experiment 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	Spraying plants with BIO-GEL (2 l/ha)	15.9	+2.1	+15.2	+1.3	+8.9
6	Spraying plants 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) + Spraying plants 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) + Spraying plants 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) + Spraying plants 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) + spraying plants with BIO-GEL (4 l/ha)	18.6	+4.8	+34.8	+4.0	+27.4
	HIP_{05} t/ha = 0.45					

A bit greater effect on melon yield was achieved on spraying plants with BIO-GEL at the 5-6 leaves stage than on pre-sowing seed treatment. Thus, spraying melon plants with BIO-GEL at the dose of 2 l/ha promoted the yield of 15.9 t/ha which is by 2.1 t/ha, or by 5.2% more than in control 1 and by 0.9 t/ha more than in variant 3 where seeds were treated before sowing, the dose being 1 l/t. Higher BIO-GEL dose (2 l/t) (variants 3 and 4 with melon yields of 15.0 and 15.4 t/ha, respectively) and 4 l/ha (variants 5 and 6 with melon yields of 15.9 and 16.3 t/ha) did not result in considerably higher yields (HIP_{05} = 0.45 t). The greatest effect on melon yields was achieved on the BIO-GEL combined application for pre-sowing treatment and spraying where the yield increase amounted to 3.4 – 4.8 t/ha compared to control 1.

The greatest melon yield was achieved in variants 9 and 10 where BIO-GEL was used both for pre-sowing seed treatment (2 l/t) + spraying plants (2 l/ha and 4 l/ha), in this case the yields were 18.4 and 18.6 t/ha which is on average by 34% more than in the control. No significant difference between the yields in variant 9 (18.4 t/ha) and variant 10 (18.6 t/ha) was noted (HIP_{05} = 0.45 t). This indicates the unreasonableness of BIO-GEL dose increase from 2 l/ha to 4 l/ha for spraying melon plants.

Though the purchase prices in July-August, 2016 were not high (1000 UAH/t on average) while production costs were rather high, the cost effectiveness appeared quite sufficient for the crop. The production costs included the cost of melon growing according to the basic technology and the cost of conducting the experiment. Besides, according to the experiment variants account was taken of the cost of harvesting yield gains due to BIO-GEL use. Thus, from the economic viewpoint the smallest additional production costs were caused by pre-sowing seed treatment with BIO-GEL. If 1 or 2 l are used for treating 1 t of seeds, BIO-GEL price being 70 UAH/l, and 1 kg of seeds is necessary for 1 ha, 1-2 ml of BIO-GEL is enough for 1 ha, which amounts to 0.07-0.14 UAH/ha (table 3.11).

Table 3.11. Economic efficiency of melon cultivation

	Experiment variant	Yield, t/ha	Production cost, UAH/ha	Gross profit, UAH/ha	Net profit, UAH/ha	Cost, UAH/t	Profitability, %
1	Control 1	13.8	10480	20700	10220	759	97
2	Control 2 (seed treatment with water)	14.6	10490	21900	11410	718	109
3	Seed treatment with BIO-GEL (1 l/t)	15.0	10520	22500	11980	701	114
4	Seed treatment with BIO-GEL (2 l/t)	15.4	10550	23100	12550	685	119
5	Spraying plants with BIO-GEL (2 l/ha)	15.9	10820	23850	13030	680	120
6	Spraying plants with BIO-GEL (4 l/ha)	16.3	10970	24450	13480	673	123
7	Seed treatment with BIO-GEL (1 l/t) + Spraying plants with BIO-GEL (2 l/ha)	17.2	10910	25800	14890	634	136
8	Seed treatment with BIO-GEL (1 l/t) + Spraying plants with BIO-GEL (4 l/ha)	18.0	11100	27000	15900	617	143
9	Seed treatment with BIO-GEL (2 l/t) + Spraying plants with BIO-GEL (2 l/ha)	18.4	11025	27600	16575	599	150
10	Seed treatment with BIO-GEL (2 l/t) + spraying plants with BIO-GEL (4 l/ha)	18.6	11150	27900	16750	599	150

More expensive is using BIO-GEL for spraying where the product cost per hectare amounts to 140-280 UAH. Besides, you should take into account the expenses on preparing the solution and its application (fuel, mechanic wages, depreciation, etc).

Gross profit depends directly on the yield which, in its turn, depends on the BIO-GEL effect in various experiment variants. The highest gross income was obtained in variant 10 (pre-sowing seed treatment with BIO-GEL at the dose of 2 l/t + spraying plants with BIO-GEL at the dose of 4 l/ha), in this case the income was 27900 UAH/ha. However, the most telling in relation to profit is net profit. The highest net profit was also obtained in variant 10, which was 16,750 UAH / ha, and was 6530 UAH / ha more than in control 1. At the same time, in variant 9, where BIO-GEL was used at twice the lower dose (2 l / ha) for spraying plants, the net profit was only 175 UAH / ha less, while the cost of 2 liters of the product was 140 UAH. Thus, from the economic point of view, the most effective was BIO-GEL use in variant 9 where it was used for pre-sowing seed treatment at a dose of 2 l / ton and for spraying plants at a dose of 2 l / ha. In this variant the profitability was 150%, the fruit cost being 599 UAH/t.

CONCLUSIONS

1. Pre-sowing seed treatment with BIO-GEL encourages melon coming-up one day before the control.

2. BIO-GEL use in the basic technology of melon cultivation promotes its early maturity. The most significant effect has been achieved on treating seeds with BIO-GEL and spraying plants with BIO-GEL. In this case the total vegetation period has been reduced by 6 days compared to control 1 (no treatments) and by 4 days compared to control 2 (seed treatment with water).

3. The greatest leaf surface has been registered in the variant when seeds were treated with BIO-GEL (2 l/t) + plants were sprayed with BIO-GEL (4 l/ha). In this case it amounted to 12365 m^2/ha, which is 2000 m^2/ha, or 19.3% bigger than in control 1. A bit smaller was the leaf surface in the variant where seeds were treated with BIO-GEL (2 l/t) + plants were sprayed with BIO-GEL (2 l/ha), in this case it amounted to 12210 m^2/ha.

4. The lowest water consumption coefficient has been recorded in variants 9 and 10 (the BIO-GEL use in pre-sowing seed treatment, the dose being 2 l/t, + spraying plants with BIO-GEL, the dose being 2-4 l/ha), in which case water consumption amounted to 104 and 103 m^3/t, whereas in control 1 – 134 m^3/t. Thus, the melon plants consumed 31 m^3 water less than in control 1 and 24 m^3 water less than in control 2 to produce watermelons when applying BIO-GEL.

5. The highest yield has been obtained in variants 9 and 10 with BIO-GEL used for pre-sowing seed treatment (2 l/t) + for spraying (2-4 l/ha). In this case the yield amounted to 18.4 and 18.6 t/ha, thus exceeding the control by 34% on average. Any significant difference between yields in variants 9 and 10 has not been recorded, which testifies to the inexpediency of increasing the BIO-GEL dose from 2 to 4 l/ha for spraying watermelon plants.

6. The greatest cost-effectiveness has been registered in the variant with BIO-GEL use in pre-sowing seed treatment (2 l/t) + plants spraying with BIO-GEL (2 l/ha), as well as in the variant with BIO-GEL use in pre-sowing seed treatment (2 l/t) + plants spraying with BIO-GEL (4 l/ha), in which case the production profitability amounted to 150%, the product cost being 599 UAH/t.

Experiment 3. BIO-GEL effect on tomato growth and yield under drip irrigation.

The studies have shown that pre-sowing tomato seed treatment speeds up coming-up. Thus, after seed treatment with water (control 2) seeds came up 1 day and after seed treatment with BIO-GEL (variants 3, 4, 7, 8) seeds came up 2 days earlier than in control 1 (table 3.12).

Table 3.12. Duration of tomato interphase periods, days

	Experiment variant	Growth periods		
		sowing-coming-up	coming-up-flowering	flowering-ripening
1	Control 1	11	72	51
2	Control 2 (seed treatment with water)	10	70	49
3	Seed treatment with BIO-GEL (1 l/t)	9	68	47
4	Seed treatment with BIO-GEL (2 l/t)	9	68	47
5	Spraying plants with BIO-GEL (2 l/ha)	11	70	49
6	Spraying plants with BIO-GEL (4 l/ha)	11	70	49
7	Seed treatment with BIO-GEL (1 l/t) + Spraying plants with BIO-GEL (2 l/ha)	9	68	47
8	Seed treatment with BIO-GEL (2 l/t) + Spraying plants with BIO-GEL (4 l/ha)	9	68	47
9	BIO-GEL introduction (2 l/ha) by fertigation method	11	72	50
10	BIO-GEL introduction (4 l/ha) by fertigation method	11	72	50

Of the three methods of BIO-GEL use in the basic tomato cultivation technology (seed soaking, plant spraying and fertigation) two methods (soaking and spraying) promoted interphase growth period shortening and plant development, which testifies to BIO-GEL effect on crop earliness, while BIO-GEL application by fertigation did not affect the beginning of the next growth phase and its duration. The least significant effect on coming-up – flowering phase shortening (2 days) was caused by using BIO-GEL only for spraying plants (variants 5 and 6) as well as by soaking seeds in water (control 2). The greatest effect on shortening the coming-up – flowering period (4 days) was caused by applying BIO-GEL for pre-sowing seed treatment, the dose being 2 l/t and 4 l/t (variants 3 and 4), and by BIO-GEL combined application for pre-sowing seed treatment and for plant spraying (variants 7 and 8). The same tendency to shortening interphase duration due to BIO-GEL application was noted in the flowering – ripening interphase period.

In general, tomato vegetation period in control 1 amounted to 123 days, in control 2 – to 119 days. Pre-sowing seed treatment with BIO-GEL at the dose of 1 l/t and 2 l/t (115 days in variants 3 and 4) made it possible to get ripe tomatoes 8 days earlier than in control 1 and 4 days earlier than in control 2. The same duration of the vegetation period (115 days) was recorded after BIO-GEL combined use (variants 7 and 8). Thus, BIO-GEL use for pre-sowing seed treatment and for spraying plants shortened the total vegetation period by 8 days compared to control 1 and by 4 days compared to control 2.

Determination of the tomato plant dry matter weight in dynamics allowed to determine the dry matter growth rates according to the growth periods. The highest growth rates were noted in the flowering phase and ranged from 307.9 to 357.0 g / m2 (Table 3.13).

Table 3.13. Increase in tomato plant dry matter weight, g/m^2

	Experiment variant	Growth periods		
		5-6 leaves	flowering	ripening
1	Control 1	52.5	307.9	54.9
2	Control 2 (seed treatment with water)	52.7	315.0	55.4
3	Seed treatment with BIO-GEL (1 l/t)	76.7	330.2	63.0
4	Seed treatment with BIO-GEL (2 l/t)	104.0	338.7	66.5
5	Spraying plants with BIO-GEL (2 l/ha)	107.8	342.9	69.9
6	Spraying plants with BIO-GEL (4 l/ha)	122.5	342.5	70.0
7	Seed treatment with BIO-GEL (1 l/t) + Spraying plants with BIO-GEL (2 l/ha)	129.9	355.0	78.1
8	Seed treatment with BIO-GEL (2 l/t) + Spraying plants with BIO-GEL (4 l/ha)	137.6	357.0	82.4
9	BIO-GEL introduction (2 l/ha) by fertigation method	146.3	342.7	79.4
10	BIO-GEL introduction (4 l/ha) by fertigation method	148.8	345.8	80.2

Dry matter weight increased due to BIO-GEL use and depended on the application method. The highest increase was recorded in the flowering period in variant 8 when seeds were treated with BIO-GEL (2 l/t) + plants were sprayed with BIO-GEL (4 l/ha) and in variant 7 when seeds were treated with BIO-GEL (1 l/t) + plants were sprayed with BIO-GEL (2 l/ha). In these cases the dry matter weight increase amounted to 357 g/m^2 and 355 g/m^2, respectively, while in control 1 – 307.9 g/m^2 and in control 2 – 315.0 g/m^2.

The positive effect of BIO-GEL application on tomato plant growth in various experiment variants affected the fruit formation. Thus, pre-sowing seed treatment (1 l/t) increased tomato yield by 5.2 t/ha, or by 9.2% compared to control 1. Higher BIO-GEL dose (2 l/t) in pre-sowing seed treatment also increased tomato yield compared to control 1 but this increase (0.8 t / ha) was within the experimental error (HIP - 1.89 tons).

It should be noted that, as distinct from melon crops, the use of ordinary drinking water for pre-sowing treatment of tomato seeds (control 2) did not contribute to a significant increase in yield.

While the tomato yield on using BIO-GEL for pre-sowing seed treatment (variants 3 and 4) increased by an average of 10% compared to control 1, the yield on using BIO-GEL for fertigation (variants 9 and 10) – by 12% and for spraying plants (variants 5 and 6) – by 15%. The greatest effect on tomato yields was caused by BIO-GEL combined use, that is its use both for pre-sowing seed treatment and for spraying plants (variants 7 and 8) where the yield increased by 23% on average (table 3.13).

Table 3.13. Tomato yield depending on the dose and method of BIO-GEL application

	Experiment variant	Yield, t/ha	+/- to control 1		+/- to control 2	
			t/ha	%	t/ha	%
1	Control 1	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	Spraying plants with BIO-GEL (2 l/ha)	64.1	+7.9	+14.0	+7.3	+12.8
6	Spraying plants 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) + Spraying plants 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) + Spraying plants with BIO-GEL (4 l/ha)	70.0	+13.8	+24.5	+13.2	+23.2
9	BIO-GEL introduction (2 l/ha) by fertigation method	62.4	+6.2	+11.0	+5.6	+9.8
10	BIO-GEL introduction (4 l/ha) by fertigation method	63.2	+7.0	+12.4	+6.4	+11.3
						HIP_{05} t/ha = 1.89

It should be noted that various methods of BIO-GEL application did not cause significant yield increase. Thus, as a result of pre-sowing seed treatment with BIO-GEL (1 l/t) the tomato yield was 61.4 t/ha, while the dose of 2 l/t resulted in 62.2 t/ha, HIP being 1.89 t. The same concerns spraying plants with BIO-GEL as the difference between the doses of 2 l/ha and 4 l/ha was 0.9 t/ha. The same concerns the fertigation method where the difference between variants was 0.8 t/ha, HIP being 1.89 t.

The highest tomato yields (68.8 and 70.0 t/ha) were in variants 7 and 8, they were by 22.4% and 24.5% higher than in control 1. There is no significant difference between the yields obtained in variants 7 and 8, which suggests that it is inappropriate to increase BIO-GEL dose in pre-sowing seed treatment from 1 l/t to 2 l/t and from 2 l/ha to 4 l/ha in spraying tomato plants.

Though the purchase prices were not high in September-October, 2016 (about 1000UAH/t), while the production costs were considerable, the positive economic efficiency was obtained. The production costs in our experiment were determined by the cost of growing tomatoes according to the basic technology and the additional costs of carrying out the operations under the experiment scheme. Besides, account was taken of the costs of harvesting and shipping tomato increased yields due to BIO-GEL use. Thus, from an economic point of view, the smallest additional production costs were caused by pre-sowing seed treatment. While only 1 or 2 l of BIO-GEL is required to treat 1 ton of seeds, BIO-GEL price being 70 UAH/l, and the necessary amount of seeds per hectare is about 1 kg, we need only 1-2 ml of BIO-GEL for treating this amount of seeds, which is 0.07-0.14 UAH/ha (table 3.14).

Table 3.14. Economic efficiency of tomato cultivation

	Experiment variant	Yield, t/ha	Production cost, UAH/ha	Gross profit, UAH/ha	Net profit, UAH/ha	Cost, UAH/t	Profitability, %
1	Control 1	56.2	47800	56200	8400	850	17
2	Control 2 (seed treatment with water)	56.8	47880	56800	8920	843	19
3	Seed treatment with BIO-GEL (1 l/t)	61.4	48200	61400	13200	785	27
4	Seed treatment with BIO-GEL (2 l/t)	62.2	48300	62200	13900	776	29
5	Spraying plants with BIO-GEL (2 l/ha)	64.1	48940	64100	15160	763	31
6	Spraying plants with BIO-GEL (4 l/ha)	65.0	49080	65000	15920	755	32
7	Seed treatment with BIO-GEL (1 l/t) + Spraying plants with BIO-GEL (2 l/ha)	68.8	50120	68800	18680	728	37
8	Seed treatment with BIO-GEL (2 l/t) + Spraying plants with BIO-GEL (4 l/ha)	70.0	50360	70000	19640	719	39
9	BIO-GEL introduction (2 l/ha) by fertigation method	62.4	48140	62400	14260	771	30
10	BIO-GEL introduction (4 l/ha) by fertigation method	63.2	48380	63200	14820	765	31

More expensive is using BIO-GEL for fertigation in which BIO-GEL application does not require additional expenses (the product is applied in the course of watering) but the cost of the product amounts to 140 UAH/ha (variant 9) or 280 UAH/ha (variant 10).

The most expensive method of BIO-GEL application is spraying because in addition to the product cost (140 UAH/ha in variant 5 and 280 UAH/ha in variant 6) it includes the expenses on the solution preparation and its application (fuel, mechanic wages, depreciation, etc). The combined use of BIO-GEL does not differ much from plant spraying as to its cost.

Gross profit depends directly on the yield which in its turn depends on the BIO-GEL doses and its application methods. The greatest gross profit (70000 UAH/ha) was obtained in variant 8 (pre-sowing seed treatment with BIO-GEL at the dose of 2 l/t + spraying plants with BIO-GEL at the dose of 4 l/ha) due to the highest yield. However, the most telling in relation to profit is net profit. The highest net profit was also obtained in variant 8, it amounted to 19640 UAH/ha, which is by 11240 UAH/ha more than in control 1.

In variant 7 where smaller BIO-Gel doses were used for pre-sowing seed treatment the net profit was by 960 UAH/ha less. Thus, in variant 8 the additional production cost was by 240 UAH higher than in variant 7 (the cost of 2 l of BIO-GEL 140 UAH + the cost of harvesting the additional yield) but the additional net profit was 720 UAH/ha (960 – 240 UAH/ha).

Thus, from the economic point of view the most efficient method of using BIO-GEL was in variant 8 (pre-sowing seed treatment at the dose of 2 l/t + spraying plants at the dose of 4 l/ha). This variant ensured the highest net profit of 19640 UAH/ha and the highest profitability level of 39% at the lowest production cost of 7199 UAH/t.

CONCLUSIONS

1. Pre-sowing seed treatment promotes tomato coming-up two days earlier than in the control.

2. BIO-GEL use in the basic technology of tomato cultivation promotes its early maturity. The most significant effect has been achieved in the variants with pre-sowing seed treatment with BIO-GEL and the combined BIO-GEL use (seed treatment + plant spraying). In this case the total vegetation period has been reduced by 8 days compared to control 1 (no treatments) and by 4 days compared to control 2 (seed treatment with water).

3. The greatest plant dry matter increase has been recorded in the flowering phase in variant 8 when seeds were treated with BIO-GEL (2 l/t) + plants sprayed with BIO-GEL (4 l/ha). In this case it amounted to 357 g/m^2, while in control 1 – only 307.9 g/m^2 and in control 2 – 315.0 g/m^2.

4. BIO-GEL application by pre-sowing seed treatment method is conducive to increasing tomato yield by 10% while by fertigation method – by 12%, by spraying method – by 15%, by combined method (seed treatment + spraying) – by 23% compared to control 1.

5. The highest tomato yield (70.0 t/ha) has been registered in variant 8 (seed treatment with BIO-GEL, the dose being 2 l/t, + plants spraying, the dose being 4 l/ha). In this case the yield obtained was by 24.5% higher than in control 1.

6. The greatest cost-effectiveness has been registered in the variant with BIO-GEL use in pre-sowing seed treatment (2 l/t) + plants spraying with BIO-GEL (4 l/ha), the net profit amounting to 19640 UAH/ha while the production profitability amounting to 39% at the lowest product cost of 7199 UAH/t.