Research Station, NAAN, Ukraine, Kropivnitsky

REPORT

on Studying the effect of BIO-GEL application in cereals, soybean and sunflower cultivation

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2015

INTRODUCTION

The production of competitive agricultural products can be based only on higher farming standards. Greater soil fertility is a must for implementing advanced agricultural technologies accompanied with rational use of local soil and climate reserves, intensification measures and crop rotation.

In the recent years the share of winter cereals among arable lands in Kropivnitsky region was 30-40%. Winter wheat was grown on 250-355 thousand hectares. Starting from 2007 the area under winter barley has increased from 27 to 123 thousand hectares. Thus, 20% of arable lands are occupied now by winter barley and winter wheat which necessitates the optimization of their cultivation technologies, especially considering climate changes in the zone of insufficient moisture.

According to the research data the potential of modern varieties of winter wheat is realized only by 30-40%. The main reason consists in the fact that different technologies of crops cultivation do not allow to fully realize plant biological properties which affects crop productivity under adverse weather conditions.

Spring barley is one of the main grain fodder crops since its grain is balanced as to the amino acid composition and approaches the standardized concentrated feeds as far as its fodder properties. It is important that the protein of barley is complete in terms of the amino acid composition and as to the content of such amino acids as lysine and tryptophan it exceeds all other cereals. The productivity of spring barley is determined to a great extent by its biological properties. Among other spring cereals it is the earliest, very drought-resistant and capable of using moisture more productively for the formation of an organic matter unit. Conditions that meet the requirements of spring barley during the entire vegetation period and ensure high yields are extremely rare, especially in the zone of unstable moisture. Low grain yield is coursed by a complex of meteorological, agro-technological and agro-biological factors.

The most effective way to solve the world problem of protein shortage is the production of legumes. According to the area under legumes these crops are second only to grain. Legumes are an important component of crop rotation and contribute to improving the nitrogen balance of the soil. In world agriculture legumes play a significant role in the structure of crops, the production of grain, vegetable protein, replenishment of soil nitrogen resources. They are the cheapest source of vegetable protein, an important factor in strengthening the economies of producing countries.

The main leguminous crops are known for high competitiveness, low cost of protein, are in great demand on the market, have an affordable price. In the world legumes occupy almost 15% of arable land.

One of the most important crops in the world agriculture which is the basis of the vegetable protein pyramid is soy. Soybean ranks first in the world production of oil, oilcake and combined feed, it increases soil fertility and protects the environment against pollution, effectively consumes fertilizers. Due to this the world soybean production is constantly growing. Increasing soybean production is a reliable way to avoid the food and energy crisis, to form resources of vegetable protein and vegetable oil.

Soybean crops occupy 121 million hectares of the world arable lands. In Ukraine soybean production is growing as well. In terms of production Ukraine ranks first in Europe and has entered the 9 largest soybean producers in the world. In Ukraine the area of soy crops increased from 1 million 130 thousand hectares in 2011 to 2 million 147 thousand hectares in 2015, the yield being 1.84 tons per hectare. The area of soybean crops is constantly increasing in the Kropivnitsky region too. If in 2011 the area of soy crops was 123.73 thousand hectares in 2015 it amounted to 176.2 thousand hectares, at the yield of 1.66 tons / ha.

Sunflower is the main oilseed in Ukraine. The seeds of its zoned varieties and hybrids contain 50-52% of oils while selective ones - up to 60%. Compared with other oilseeds, sunflower seeds produce the largest oil yield per unit area (750 kg / ha on average in Ukraine). Sunflower oil accounts for 98% of total oil production in Ukraine.

The topical problem is studying the effect of biologically active substances on crops growth and development under the unstable humidity of the northern steppe.

Today when the share of organic farming is growing rapidly there is a return to the unjustly forgotten fertilizers such as humic compounds. There are 5 or 7 producers of potassium and nitrogen humates of chemical origin on the fertilizer market. The positive effect of humic acids, as well as their derivatives - fulvic acids, is convincingly proved in scientific works by L.A. Christeva and the students of her school. Humic acids or humates promote the assimilation of macro and micronutrients, especially in the case of unfavorable conditions for their life activity. First and foremost, this is a lack of moisture in the soil, high air temperature, deficiency of one or another microelement, etc.

Later, the positive effect of humic compounds in reducing the stress of plants treated with different fungicides and herbicides was shown by Azanov A.G., etc.

Fulvic acids, or fulvates, significantly increase the permeability of water soluble nutrients through the membranes of different plant cells, thus reducing their required concentration.

In the framework of the modern theory of organic farming the process of soil fertility restoration with the help of nitrophilic bacteria occupies a special place. Organic soil fertility fully depends on the amount and labor ability of these bacteria which in addition to atmospheric nitrogen actively absorb carbon dioxide, thus satiating soils with active organic forms.

At the same time it should be noted that chemical humates can have a negative effect contaminating soil with insoluble nitrogen and potassium compounds.

Another reason for limiting the use of such humates is their negative interaction with bivalent ions of calcium and iron. The latter ones quickly transfer the chemical solution of humates into emulsions and suspensions in sprayers.

It is these reasons that cause an increased interest in humic compounds of non-chemical origin, that is, obtained without the use of concentrated alkalis and acids. Accordingly, nitrogen-fixing bacteria in this case are not suppressed by chemical compounds of potassium and sodium and are actively reproducing.

The BIO-GEL natural adaptogen is made from ecologically pure peat and sapropel of organic origin due to large pressures and low temperatures without any chemical additives.

During the processing a part of the raw material is converted into available forms of humic, fulvic and lignin compounds. Natural macro and trace elements of raw materials are converted into water-soluble forms and become available for consumption by plants.

Conditions and methods of experiment

1.1 Soil and climatic conditions of the experiment zone

The lands of the Kropivnitsky State Agricultural Experimental Station, NAAS, are located in the black earth zone of the northern steppe in right-bank Ukraine, in the subzone of ordinary black earth turning into deep one. The geographical position of the institution is 48°34 'north latitude and 32 °19' eastern longitude.

High content of calcium, considerable resources of humus, neutral reaction of soil solution, high biological activity, great buffering ability, good moisture content, heat capacity and other properties of ordinary black earth in combination with unique climatic features (soil drying in summer and freezing in winter) are conducive to reserving great amounts of nutrients due to physical, chemical and biological processes as well as preventing from their transition into lower layers. Such soils are characterized by high potential fertility and in case of their rational cultivation can be successfully used for growing field, forage and vegetable crops.

The soil of the experiment plots is ordinary black earth with medium humus content, deep, heavy loamy. Humus content in the arable layer is 4.64%, hydrolysable nitrogen – 11.6 mg per 100 g soil, mobile phosphorous and potassium – 12.7 and 12.8 mg per 100 g soil respectively, pH – 5.7. The amount of absorbed bases in these soils ranges from 33.0 to 36.6 mg per 100 g soil. The content of boron averages 1.94 mg; manganese – 2.1 and zinc – 0.25 mg per 100 g soil. Soil density is 1.19 g / cm^3. Ecological-agrochemical evaluation is 96 points.

For each 10 centimeter layer of ordinary heavy-loamy black earth the density index varies within the range of 1.13-1.26 g / cm^3. The value of this soil indicator is mainly determined by the structure of soil particles. Specific gravity of soil solids ranges from 2.523 to 2.782 g / cm^3 without preserving clear patterns. Spacing in these soils is inversely proportional to their bulk density and is characterized by indicators of 51.1-59.1%. In lower soil layers spacing decreases due to the compaction and structure of soil particles.

The climate of the zone is moderate continental. The average annual temperature is 7.9°C, the annual amount of precipitation is 499 mm, the main rainfall occurring in the period from May to September.

With the transition of average daily temperatures through the mark of 10 ºC in the third decade of April, favorable conditions for intensive growth and development of crops are formed. During this period late spring frosts can occur, although in some years they can happen in May.

Summer is hot, the July average temperature is +20°C. The transition of the average daily temperature through the point of +15°C is considered the beginning of summer. The weather in summer is usually fair with some clouds, the rains falling in the form of showers.

The non-frosty period is 184 days. In autumn the first frosts start in the second ten-day period of September, while the transition through +5°C happens in the third ten-day period of September. The vegetation period finishes in the second ten-day period of October.

Winter is characterized by frequent thaws, the average January temperature is minus 5.4 ºC, the snow cover is thin, it usually sets starting from December 18 and disappears completely before March 18. Almost every year in September there are cold snaps with frost. Depending on changes in the air temperature the temperature of the soil changes as well as the depth of its freezing. The snow cover usually lasts for 75 days. In severe winters the soil freezes to the depth of 125 cm.

The Kropivnitsky region is characterized by rainless periods of 10-20 days in April-June and July-August, the probability being 30-70%. The hydrothermal coefficient of Selyaninov has changed over the past decades in the range of 0.3-1.3 which means excessive moisture or drought. Fierce drought occurs approximately once every 5 years. Three years out of ten are characterized by the 30% lack of the long-term annual rainfall while in dry years the lack equals 45%. Some precipitation falling during the year is lost due to surface runoff.

The maximum of solar radiation is in July, the minimum is in December. The duration of sunshine in December is 20-70 hours, in July - 230-350 hours.

Deficiency of precipitation is most often in the summer. Quite often there are hot dry winds, hailstorms, thunderstorms and high air temperatures. During a year there are 10-25 or sometimes 30-35 days with strong winds. In the region of the Institute location northern, northwestern and eastern winds predominate, they lead to blowing up the top layer of the uncovered soil, crop lodging and snow blowing off fields. Hot dry winds blow mainly from east or southeast.

But in general climatic conditions are rather favorable for agriculture and for cultivating basic agricultural crops.

1.2 Weather conditions during the vegetation period of 2014-2015

The weather conditions of the autumn period 2014-2015 were unfavorable for winter wheat because of insignificant amount of rainfall.

September was characterized by warm weather and lack of rainfall. The average air temperature was 17.6°C which is 2.9° higher than the long-term average one. The amount of rainfall was only 11 mm, or 29% of the usual rate. October and November temperatures did not differ from the usual ones. The rainfall amounted to 37 and 26% of the usual rate (table 1).

Table 1. Meteorological conditions during the experiment period, 2014-2015

Month	Ten-day period	Air temperature, °C		Rainfall, mm		
		actual	long-term	total actual	% of rate	long-term average
2014						
August	I	28.1	-	2.5	-	-
	II	25.3	-	0.5	-	-
	III	19.9	-	13.5	-	-
	average	***24.4***	***19.4***	***16.5***	***34.4***	***48***
September	I	21.7	-	0	-	-
	II	18.3	-	0	-	-
	III	12.8	-	11.0	-	-
	average	***17.6***	***14.7***	***11.0***	***28.9***	***38***
October	I	9.3	-	0	-	-
	II	11.0	-	9.5	-	-
	III	4.4	-	0.6	-	-
	average	***8.2***	***8.1***	***10.1***	***37.4***	***27***
November	I	6.5	-	0.1	-	-
	II	2.8	-	8.4	-	-
	III	-3.3	-	0.8	-	-
	average	2	2.3	9.3	26.6	35
December	I	-4.9	-	3.6	-	-
	II	2.7	-	4.4	-	-
	III	-1.5	-	11.5	-	-
	average	***-1.2***	***-2.3***	***19.5***	***46.4***	***42***
2015						
January	I	-5.7	-	6.4	-	-
	II	1.2	-	8.7	-	-
	III	0.7	-	19.5	-	-
	average	***-1.3***	***-5.7***	***34.6***	***108.1***	***32***
February	I	-1.6	-	26.0	-	-
	II	-4.7	-	0	-	-
	III	3.4	-	4.8	-	-
	average	***-1.0***	***-4.3***	***30.8***	***99.4***	***31***
March	I	3.9	-	12.1	-	-
	II	5.7	-	27.2	-	-
	III	6.3	-	47.5	-	-

	average	***5.3***	***0.5***	***86.3***	***319.6***	***27***
April	I	5.5	-	31.5	-	-
	II	11.2	-	11.7	-	-
	III	14.0	-	0.2	-	-
	average	***11.3***	***8.9***	***43.4***	***120.6***	***36***
May	I	15.1	-	16.5	-	-
	II	18.2	-	6.2	-	-
	III	21.5	-	61.0	-	-
	average	***18.3***	***15.3***	***83.7***	***186.0***	***45***
June	I	23.0	-	0.5	-	-
	II	21.1	-	12.0	-	-
	III	19.1	-	68.0	-	-
	average	***21.1***	***18.6***	***80.5***	***122.0***	***66***
July	I	24.4	-	52.0	-	-
	II	21.1	-	11.3	-	-
	III	25.0	-	28.0	-	-
	average	23.5	20.0	91.3	126.8	72
August	I	25.0	-	0	-	-
	II	23.2	-	3.0	-	-
	III	23.8	-	0.1	-	-
	average	***24.4***	***19.4***	***3.1***	***6.5***	***48***
September	I	22.6	-	21.5	-	-
	II	19.7	-	0.3	-	-
	III	20.2	-	24.3	-	-
	average	***20.8***	***14.7***	***46.1***	***121.3***	***38***

The average temperature in autumn was 9.3°C which is 0.9 ° higher than the usual one. The total amount of rainfall in autumn was 30.4 mm which is 30% of the usual amount.

Active winter wheat vegetation stopped on November, 14 which is 12 days later than the average long-term date. Longer vegetation period in autumn was beneficial for crops, especially for poorly developed plants.

In the second half of the second ten-day period in November the conditions for the first stage of hardening were quite good for the plants that had come up. During the first ten-day period in December the temperature was going down gradually which fitted the second stage of hardening.

The winter of 2014-2015 was characterized by sharp changes of weather and lack of precipitation. The average temperature in December was by 1.1° higher than the usual one, the precipitation was 46% of the rate. January and February were characterized by unusually warm rainy weather. In January the average air temperature was by 4.4° higher than the rate, in February – by 3.3° higher, the precipitation equaled the usual rate.

The average winter temperature was –1.2°C which is 4.1° higher than the usual temperature. The precipitation amount was 84.9 mm which is 80.6% of the rate.

The weather conditions in winter did not affect negatively winter crops. During the greatest cold spells in the first ten-day period in December and in the first ten-day period in January the minimum soil temperature at the tillering node depth did not decrease below -10°, was above the critical freezing temperatures for winter wheat plants but was approaching and somewhere equaling the critical freezing temperatures for winter barley. As a result due to damage to plants and seedlings the winter barley plants were almost completely killed.

Spring renewal of the winter wheat vegetation took place on March, 2 which is 20 days earlier than the average annual indicators.

In 2015 the spring was very warm and rainy. The average March temperature was by 4.8° higher than the rate. April and May temperatures were by 1.3 – 3.0° higher than the rate. The precipitation in March amounted to 320% of the rate, in April and May – 120% and 186% of the rate, respectively. The average spring temperature was by 3.1° higher than the rate, the amount of precipitation during the spring was 213.4 mm which is 197% of the rate. The weather conditions were quite favorable for the growth of spring crops.

In April the weather was unstable, rainy and with sharp temperature fluctuations. The first ten-day period was cool, the second and third – moderately warm. During the first and the second ten-day periods there were strong winds while in the second half of the month there were late frosts. The average air temperature was 10.2°C which is 1.3° higher than the rate. On April 23-24 there was average temperature transition through +10°C. The maximum air temperature reached +24-26°C, the minimum average temperature at night dropped to minus 1-3°C. The soil surface temperature was minus 2-7°C.

The amount of precipitation in April was 43.4 mm, or 120% of the rate. The moisture reserves in the 0-10 cm soil layer were 8-18 mm. The amount of moisture in the arable layer was sufficient: 24-36 mm. The meter soil layer contained 168-172 mm productive moisture at the time of early sowing and 148-162 mm at the time of the optimum sowing.

The amount of precipitation in May was 83.7 mm which is 186% of the monthly rate. The average May temperature was 18.3°C which is by 3° higher than the rate. The highest temperature was 30-31°C.

June was characterized by moderately warm, on some days hot weather, at the end of the month it was rather cool. The first half of the month was dry, while the second half – rainy. The total monthly amount of rainfall was 80.5 mm which is 122% of the monthly rate. The average June temperature was 21.1°C which is 2.5° higher than the rate. The highest air temperature was 32-33°C.

The average monthly temperature of July was 23.5°C which is 3.5° higher than the rate. The highest temperature on certain days was 34-37°C. The precipitation amounted to 91.3 mm which is 127% of the rate.

In August the weather was hot and dry. The average monthly temperature was 24.0°C which is 4.6° higher than the rate. The highest temperature on certain days was 34-37°C. The precipitation amounted to just 6.5% of the rate (3.1 mm). Such dry weather in the central part of Ukraine was observed only in 1948 and in 2009.

In general the summer period was characterized by warm and hot weather. In all moths the average temperature was higher than the rate, the total precipitation in summer amounted to 174.9 mm, or 94% of the rate.

September was mainly hot. The amount of rainfall in September was 46.1 mm, that is, 121% of the rate. The average monthly temperature was 20.8°C which is by 6.1° higher than the rate. It was the second warmest September after 1994. The temperature sometimes reached 35-37°C which is higher than the absolute maximum over the whole observation period. The soil surface temperature was 54-58°C.

The meteorological summer ended on September 28-29 as the temperature dropped below +15°C which is 15-18 days later than usual.

Thus the weather conditions during the vegetation period of 2015 were beneficial for spring crops as the precipitation occurred in the periods critical for plants development. The drought in August could not greatly affect soybean and sunflower yields.

1.3 Methods of research

The experiments were carried out by the Kropivnitsky State Agricultural Experimental Station according to the following schemes.

The preparation of the BIO-GEL working solution was conducted in the following way:

- For treating seeds 10 l of working solution were made, the solution contained 1 l (10%) or 2 l (20%) of BIO-GEL product. 1000 kg of seeds were treated with 10 l of BIO-GEL solution.
- For spraying vegetating plants 200 l of working solution were used per hectare, it contained 1 l (0.5%) or 2 l (1.0%) of BIO-GEL or sodium humate of chemical origin (GUMAT-ROST).

Regretfully as the experiments started at the end of spring field work the seeds of most samples were not treated, except for soybeans which were not yet sown on the experimental plots.

Experiments scheme

A. Winter wheat

1. Control (integrated plant protection)
2. IPP + spraying plants at the tillering stage with BIO-GEL, 1 l/ha (0.5%)
3. IPP + spraying plants at the tillering stage with BIO-GEL, 2 l/ha (1.0%)
4. IPP + spraying plants at the tillering stage with BIO-GEL, 1 l/ha (0.5%) + spraying plants at the beginning of the earing stage with BIO-GEL, 1 l/ha (0.5%)

The number of variants 4 x 3 repetitions = 12 plots.

Area under crop: 20 m^2, discount area: 15 m^2.

B. Winter wheat (organic)

1. Control (no PPP)
2. Spraying plants at the tillering stage with BIO-GEL, 1 l/ha (0.5%)
3. Spraying plants at the tillering stage with BIO-GEL, 2 l/ha (1.0%)
4. Spraying plants at the tillering stage with BIO-GEL, 1 l/ha (0.5%) + spraying plants at the beginning of the earing stage with BIO-GEL, 1 l/ha (0.5%)
5. Spraying plants at the tillering stage with BIO-GEL, 2 l/ha (1.0%)

The number of variants 5 x 3 repetitions = 15 plots.
Area under crop: 20 m^2, discount area: 15 m^2.

C. Spring Barley

1. Control (integrated plant protection)
2. IPP + spraying plants at the tillering stage with BIO-GEL, 1 l/ha (0.5%)
3. IPP + spraying plants at the tillering stage with BIO-GEL, 2 l/ha (1.0%)

The number of variants 3 x 3 repetitions = 9 plots.
Area under crop: 20 m^2, discount area: 15 m^2.

D. Soybean

1. Control (integrated plant protection)
2. IPP + seed treatment with BIO-GEL, 1 l/t (10%)
3. IPP + seed treatment with BIO-GEL, 2 l/t (20%)
4. IPP + spraying plants at the stage of 3-5 leaves with BIO-GEL, 1 l/ha (0.5%)
5. IPP + spraying plants at the stage of 3-5 leaves with BIO-GEL, 2 l/ha (1.0%)

The number of variants 5 x 3 repetitions = 15 plots.
Area under crop: 25 m^2, discount area: 20 m^2.

E.Sunflower

1. Control (integrated plant protection)
2. IPP + spraying plants at the stage of 2-3 leaf pairs with BIO-GEL, 1 l/ha (0.5%)
3. IPP + spraying plants at the stage of 2-3 leaf pairs with BIO-GEL, 2 l/ha (1.0%)

The number of variants 3 x 3 repetitions = 9 plots.
Area under crop: 25 m^2, discount area: 20 m^2.

Winter wheat precursor: fallow land; spring barley precursor: soybean; soybean precursor: winter wheat; sunflower precursor: winter wheat.

Sterilization of spring barley and winter wheat was carried out with *Lamardor 400FS*, 0.2 l/t; sterilization of soybeans and sunflower – with *Maxim XL*, 1 l/t. Winter wheat and spring barley crops were treated with *GranStar Gold* herbicide (25 g/ha) and *Rex Duo* fungicide(0.5 l/ha) at the tillering stage. *Bazagran* postemergent herbicide (2.5 l/ha) was applied to soybean plants before flowering stage. Sunflower crops were treated with *Harness* soil herbicide (2.5 l/ha).

Winter wheat, soybeans and spring barley were harvested with Sampo-130 combine harvester, sunflowers were harvested manually and threshed later. Harvest recalculation was done for 100% pure grain and 14% humidity for grain crops, 12% for soybeans, 8% for sunflower. The data obtained in the experiments were processed by the dispersion analysis method by B.O Dospekhov. The experiment was laid by the method of successive variants and repetitions. The total number of variants in the field experiments was 23, the number of plots was 69.

2. Experiment results

2.1 The effect of BIO-GEL application in winter wheat cultivation

Solving the problem of high-yielding crops formation is associated primarily with providing on a unit area such number of productive stems which would ensure plants complete closure, thus securing the most effective nutritive area use and good illumination of leaves, stems, ears for highest photosynthesis productivity.

The plant density is an important element of crop cultivation technology. With the optimum number of plants per unit area maximum yield can be achieved while high quality is preserved.

Number of plants per unit area is an important factor which controls the use of moisture, light, the intensity of the assimilation process, yield formation. The number of plants preserved till harvesting depended mainly on the weather conditions during wintering and the spring-summer period and amounted in the control (integrated plant protection) to 366 plants per m^2. BIO-GEL application during the tillering phase contributed to plant survival, their number was by 12-28 plants/m^2 (3.3-7.7%) bigger than in the control. Still more plants (394 pc/m^2) were preserved till harvesting in the variant, in which crops were sprayed with BIO-GEL (1+1 l/ha, 0.5+0.5% concentration) in the tillering phase and at the beginning of the earing phase (table 2).

Table 2. Formation of the *Kosovitsa* soft winter wheat variety density depending on BIO-GEL application

Variants	Number	
	plants	stems, pc/m^2
1. Control (integrated plant protection)	366	584
2. IPP + spraying crops with BIO-GEL (1 l/ha, 0.5%) at tillering stage	378	612
3. IPP + spraying crops with BIO-GEL (2 l/ha, 1.0%) at tillering stage	388	652
4. IPP + spraying crops with BIO-GEL (1 l/ha, 0.5%) at tillering stage + spraying crops with BIO-GEL at the beginning of earing (1 l/ha, 0.5%)	394	665

The main components of cereal productivity are the number of productive stems per unit area. The density of productive wheat stems in field conditions can vary in a fairly wide range - from 150 to 800 stems per 1 m^2or even more. This value depends on plant density, variety peculiarities, plant provision with moisture, light, nutrients and other factors. The number of shoots after coming-up cannot be fully preserved till ripening, while the yield depends on their survival during the vegetation period.

Winter wheat is characterized by intensive tillering. Side shoots can have the same productivity as the main ones, the stems equal in height and development. The resource saving technologies fully realize such biological feature. The number of productive stems which ensure winter wheat yield formation depended on BIO-GEL concentration used in the experiments. Thus, if in the control their number equaled 584 pc/m^2, the application of BIO-GEL increased their number by 28-81 pc/m^2, or 4.8-13.9%. The greatest effect on stem density (665 pc/m^2) was achieved on fallow lands with IPP applied after spraying crops with BIO-GEL (0.5% concentration) at the stage of tillering and the beginning of earing.

In the organic farming system, in the variant without the use of plant protection products the number of plants that were preserved until harvesting was 332 pc /m^2, and stems – 580 pc /m^2, respectively (table 3).

Table 3. Formation of the *Kosovitsa* soft winter wheat variety density in the organic farming system

Variants	Number	
	plants	stems, pc/m^2
1. Control (no integrated plant protection)	332	580
2. Spraying crops with BIO-GEL (1 l/ha, 0.5%) at tillering stage	340	644
3. Spraying crops with BIO-GEL (2 l/ha, 1.0%) at tillering stage	348	654
4. Spraying crops with BIO-GEL (1 l/ha, 0.5%) at tillering stage + spraying crops with BIO-GEL at the beginning of earing (1 l/ha, 0.5%)	372	660
5. Spraying crops with GUMAT-ROST (1 l/ha, 1.0%) at tillering stage	380	660

Spraying crops with BIO-GEL in different concentrations and its use at tillering and earing stages helped to preserve by 8-48 pc/m^2, or by 2.4-12.0% more plants, by 64-80 pc/m^2, or 11.0-13.8% more stems. Greater number of plants is recorded in the variant where plants were sprayed with GUMAT-ROST product (1 l/ha, 1.0%) at the tillering stage, it amounted to 380 pc/m^2 which is by 48 pc/m^2, or by 14.5% higher than the control (332 pc/m^2).

Winter wheat productivity is characterized by its structure, mainly by the length of its main ear, the number of grains in it and their weight as well as the weight of 1000 grains.

The length of the main ear shows the effect of weather conditions at the time of its formation. Higher plant resistance to abiotic factors contributes to longer ears. Thus, in the control (IPP) the length of the main ear was 8.0 cm, while BIO-GEL application at the tillering stage (2.0 l/ha) + at the beginning of earing (1+1 l/ha) made it longer by 0.4-0.5 cm, or by 5.0-6.3% (table 4).

Table 4. Effect of BIO-GEL product on the structure of the *Kosovitsa* soft winter wheat variety yield

Variant	Ear length, cm	Grain number in main ear, pc	Weight of grains on the main ear, g	Weight of 1000 grains, g
Control (integrated plant protection)	8.0	30.7	1.39	39.0
IPP + spraying crops with BIO-GEL (1 l/ha, 0.5%) at tillering stage	8.0	32.2	1.47	39.5
IPP + spraying crops with BIO-GEL (2 l/ha, 1.0%) at tillering stage	8.4	33.3	1.52	41.2
IPP + spraying crops with BIO-GEL (1 l/ha, 0.5%) at tillering stage + spraying crops with BIO-GEL (1 l/ha) at earing stage	8.5	36.7	1.60	42.2

The number of grains in the ear characterizes productivity as the yield greatly depends on this number. As a rule the more grains in the ear, the higher the yield. The results show that the number of grains changed depending on the BIO-GEL concentration and the phase of its application and amounted to 32.2-36.7 pc/ear which is by 1.6-6.0 pc (4.9-19.5%) more than in the control (30.7 pc).

The weight of grains in one ear is directly proportional to their number, that is why the greater number of beards in the ear contribute to the greater number of grains and their bigger weight. The weight of the main ear grains of the *Kosovitsa* winter wheat variety under IPP (control) in 2015 was 1.39 g. Spraying crops with BIO-GEL increased it by 0.08-0.21 g (5.8-15.1%).

At the last stages of crop growth higher yields are obtained due to grain fullness, that is, when grains are well developed and big. Grain fullness can be characterized by such indicator as the weight of 1000 grains. The research shows that the weight of 1000 grains changes from 39.0 g (IPP) to 42.2 g after spraying crops at the tillering stage and the beginning of earing stage with BIO-GEL, 1 + 1 l/ha. On the whole BIO-GEL application increased the weight of 1000 grains by 0.5-3.2 g (1.3-8.2%).

The ear length in winter wheat is an unsteady indicator which depends on the vegetation conditions. In organic agriculture with no PPP the winter wheat ear length was 7.8 cm, while BIO-GEL application in different concentrations increased it by 0.5-0.8 cm (6.4-10.3%) and GUMAT-ROST – by 0.3 cm (3.8%) (table 5).

Of great importance in getting high yields is the number of grains in the ear which depends both on the weather conditions and on cultivation technologies. The data obtained shows that the number of grains in the main ear varied depending on BIO-GEL concentration and the ways of its application from 33.4 to 37.7 pc and the gain amounted to 3.1-7.4 pc (10.2-24.4%) compared to the control (30.3 pc). On GUMAT-ROST application the number of grains in the main ear increased by 4.4 pc (14.1%).

The weight of grains in the main ear varied from 1.36 to 1.55 g. The application of BIO-GEL and GUMAT-ROST increased grain weight by 0.07-0.19 g (5.1-14%).

Characterizing the elements of winter wheat yield note should be taken of the weight of 1000 grains. It can change considerably depending on the growth conditions. It increased on applying the products under study. The difference amounted to 0.7-2.5 g (1.8-6.4%). The bigger weight of 1000 grains (41.5 g) was recorded in the variant where crops were sprayed with BIO-GEL, 1 l/ha (0.5%) at the tillering stage.

Table 5. BIO-GEL effect on the *Kosovitsa* soft winter wheat variety yield structure in organic farming

Variant	Ear length, cm	Grain number in main ear, pc	Weight of main ear grains, g	Weight of 1000 grains, g
1.Control (no PPP)	7.8	30.3	1.36	39.0
2.Spraying crops at tillering stage with BIO-GEL, 1 l/ha (0.5 %)	8.3	37.7	1.54	41.5
3.Spraying crops at tillering stage with BIO-GEL, 2 l/ha (1.0 %)	8.4	33.4	1.43	39.7
4.Spraying crops at tillering stage with BIO-GEL, 1 l/ha (0.5 %) + spraying crops at earing stage with BIO-GEL, 1 l/ha (0.5 %)	8.6	35.3	1.55	39.7
5.Spraying crops at tillering stage with GUMAT-ROST, 1 l/ha (1.0 %)	8.1	34.7	1.52	41.2

Winter wheat yield is the final stage of the complex ontogenesis process which fully testifies to the effectiveness of the measures taken during vegetation process.

The interaction of the productivity elements which were formed under the complex effect of abiotic and biotic factors and agrotechnical methods resulted in various yields.

Under the weather conditions of 2015 the *Kosovitsa* winter wheat variety grown on fallow lands with IPP yielded 7.63 t/ha. The use of BIO-GEL in addition to IPP increased the yield by 0.44-0.73 t/ha (5.8-9.6%). Greater yield (8.36 t/ha) was obtained in the variant where crops were sprayed with BIO-GEL at the tillering stage and at the beginning of earing stage (1 + 1 l/ha) (table 6).

Table 6. *Kosovitsa* soft winter wheat variety yield in organic farming, t/ha

Variant	Yield	+/- to control	
		t/ha	%
1. Control (no PPP)	**7.47**	-	-
2. Spraying crops at tillering stage with BIO-GEL, 1 l/ha (0.5% concentration)	**7.99**	+0.52	7.0
3. Spraying crops at tillering stage with BIO-GEL, 2 l/ha (1.0% concentration)	**8.07**	+0.60	8.0
4. Spraying crops at tillering stage with BIO-GEL, 1 l/ha (0.5% concentration) + spraying crops at earing stage with BIO-GEL, 1 l/ha (0.5%)	**8.20**	+0.73	9.8
5. Spraying crops at tillering stage with GUMAT-ROST, 1 l/ha (1.0%)	**8.20**	+0.73	9.8
HIP_{05}		0.27	

The highest wheat yield *.20 t/ha) was ensured by twofold spraying with BIO-GEL (tillering, 1 l/ha + beginning of earing, 1 l/ha) and one spraying with GUMAT-ROST at the tillering stage (1 l/ha).

An important characteristic of winter wheat grain quality is content and quality of gluten and protein. These characteristics are standardized for wheat grade 1 – 5 and are taken into account when selling as the baking properties of wheat flour are determined by the quantity and quality of gluten which forms the mechanical basis of the dough and the structure of baked bread.

When winter wheat was grown on fallow lands with IPP it was stated that in 2015 the grain protein content was 13.2-13.9% and gluten content – 27.7-28.9%. The amount and quality of gluten and the content of protein depended to some extent on the time of BIO-GEL organic product application and its concentration, the increase compared to the control being 0.3-0.7 and 0.5-1.2%, respectively. The higher quality characteristics of wheat grain with integrated plant protection were in the variant where crops were sprayed with BIO-GEL at the tillering stage, 2 l/ha (1.0%). The analysis of the gluten quality showed that the grains treated with BIO-GEL belonged to the second grade (table 8).

Table 8. ***Kosovitsa*** **soft winter wheat variety quality depending on BIO-GEL application**

Variant	Protein content, %	Gluten content, %	FDM, units
1. Control (integrated plant protection)	13.2	27.7	102
2. IPP + spraying crops at tillering stage with BIO-GEL, 1 l/ha (0.5%)	13.5	28.7	100
3. IPP + spraying crops at tillering stage with BIO-GEL, 2 l/ha (1.0%)	13.9	28.9	99
4. IPP + spraying crops at tillering stage with BIO-GEL, 1 l/ha (0.5%) + spraying crops at the beginning of earing stage with BIO-GEL, 1 l/ha (0.5%)	13.9	28.2	97

Without using insecticides and fungicides the protein content was 13.0%, the gluten content was 26.4%, the fiber deformation measurement was 96. BIO-GEL use for spraying plants at the tillering stage (1 and 2 l/ha) promoted higher protein content by 0.1 and 0.5%, gluten content – by 2.2 and 1.6%. Spraying plants at the tillering stage with BIO-GEL, 1 l/ha, or 0.5% concentration, and spraying plants at the beginning of the earing stage, 1 l/ha, or 0.5% concentration, was not as effective as to the contents of protein and gluten (table 9).

Table 9. ***Kosovitsa*** **soft winter wheat variety quality in organic farming**

Variant	Protein content, %	Gluten content, %	FDM, units
1. Control (no PPP)	13.	26.4	96
2. Spraying crops at tillering stage with BIO-GEL, 1 l/ha (0.5%)	13.1	28.6	97
3. Spraying crops at tillering stage with BIO-GEL, 2 l/ha (1.0%)	13.5	28.0	96
4. Spraying crops at tillering stage with BIO-GEL, 1 l/ha (0.5%) + spraying crops at the beginning of earing stage with BIO-GEL, 1 l/ha (0.5%)	13.3	27.5	97
5. Spraying crops at tillering stage with GUMAT-ROST, 1 l/ha (1.0%)	13.9	29.7	100

The highest protein content (13.9%) and gluten content (29.7%) was in the variant where crops were sprayed with GUMAT-ROST (1 l/ha, 1.0% concentration) at the tillering stage with no IPP used.

2.2 Effect of BIO-GEL product on spring barley productivity

In forming the optimum plant density of essential importance are germinating capacity, good, even and timely sprouts, which affects spring barley productivity.

One of the most important characteristics is the number of productive stems per unit area before harvesting as it determines the yield. But plants reaction to weather conditions and biologically active substances is different, thus the number of plants and stems per unit area is different too. The research conducted in the northern Ukrainian steppe has established that the density of the *Sozonovsky* spring barley variety plants varied with different concentrations of BIO-GEL product.

It has been established that spraying plants at the tillering stage with BIO-GEL (1 l/ha, 0.5%) increased plant and stem density per unit area compared to the control (364 and 522 pc/m^2) by 32 and 22 pc/m^2 (8.8 and 4.2%), while with BIO-GEL rate increase to 2 l/ha(1.0% concentration) – by 37 and 50 pc/m^2 (10.2-9.6%) (table 10).

Table 10. Formation of *Sozonovsky* spring barley variety stem density depending on BIO-GEL application

Variant	Number	
	plants, pc/m^2	stems, pc/m^2
Control (integrated plant protection)	364	522
IPP + spraying at tillering stage with BIO-GEL, 1 l/ha, 0.5% concentration	396	544
IPP + spraying at tillering stage with BIO-GEL, 2 l/ha, 1.0%	401	572

The productivity of the ear depends mainly on its length which, in its turn, depends on the variety peculiarities. Besides, the ear length also depends on hydrothermal conditions during the vegetation period, that is, on temperature, illumination intensity and day length. The main ear length of the *Sozonovsky* spring barley variety in 2015 weather conditions was 6.9 cm while BIO-GEL application (1 and 2 l/ha) promoted its increase by 1.0-1.3 cm (14.5-18.8%) (table 11).

Table 11. BIO-GEL effect on yield structure of *Sozonovsky* spring barley variety

Variant	Ear length, cm	Number of grains in main ear, pc	Weight of main ear grains, g	Weight of 1000 grains, g
Control (integrated plant protection)	6.9	17.4	1.09	53.8
IPP + spraying at tillering stage with BIO-GEL, 1 l/ha, 0.5% concentration	7.9	18.6	1.20	55.2

IPP + spraying at tillering stage with BIO-GEL, 2 l/ha, 1.0% concentration	8.2	18.2	1.18	55.7

There is a direct connection between the ear elements (length and grain number) and the crop productivity. Grain ovary is formed in the period between tillering and the beginning of flowering. The number of grains depends on the variety, weather conditions (day length and temperature) during the flowering period until the beginning of stem elongation period, on affection during flowering. The research shows that BIO-GEL application did not have a significant effect on grain number in the main ear, compared to the control (17.4 grains) it increased by 0.8-1.2 grains (4.6-6.9%).

Weight of grains in the main ear is a complex characteristic which includes the weight of a single grain and the number of grains in the ear. Each element of the ear structure contributes to productivity which is represented by the weight of grains per plant. It is the main value which determines the yield per unit area. The spring barley yield depends primarily on the main ear productivity. The weight of the ear grains depend on numerous factors: ear length, number of grains in it, their size as well as on cultivation conditions. In its turn, the weight of the ear grains affects the weight of grains per plant and the yield since there is a positive correlation between the weight of the ear and the yield. Plants spraying with BIO-GEL had a positive effect on the weight of grains in the main ear. Thus, in the control variant (IPP) the weight of the main ear grains was 1.09 g, while BIO-GEL application increased it by 0.09-0.11 g, or by 8.3-10.1%. The greatest weight of the main ear grains (1.20 g) was ensured by spraying plants at the tillering stage with BIO-GEL, 1 l/ha (0.5% concentration).

The weight of 1000 grains characterizes grain fullness and shows its size. Big weight of 1000 grains is the guarantee of nutrient reserve, good and even sprouts and plant stable development during the vegetation period. It is formed at the last stages of plant vegetation, during the ripening phase and depends on weather conditions. The weight of 1000 grains of the *Sozonovsky* spring barley variety was 53.8-55.7 g. The effect of BIO-GEL on this indicator was not essential, compared to the control it increased by only 1.4-1.9 g (2.6-3.5%).

Spring barley yield depends on the hereditary characters reaction to weather conditions during vegetation period. But yield characteristics do not always agree with plant productivity elements. It is possible to compensate the shortcomings of the crop initial growth stages by improved cultivation technologies. The yield of the *Sozonovsky* spring barley variety under 2015 weather conditions was 5.27 t/ha in the control (integrated plant protection). The application of BIO-GEL for spraying plants at the tillering stage increased the yield to 5.45 and 5.68 t/ha, the yield gain amounted to 0.18-0.41 t/ha (3.4-7.8%) according to the variants (table 12).

Table 12. ***Sozonovsky*** **spring barley variety yield, t/ha**

Variant	Yield, t/ha	+/- to control	
		t/ha	%
1. Control (integrated plant protection)	5.27	-	-
2. IPP + spraying at tillering stage with BIO-GEL, 1 l/ha, 0.5%	5.45	+0.18	3.4
3. IPP + spraying at tillering stage with BIO-GEL, 2 l/ha,1.0%	5.68	+0.41	7.8
HIP_{05}		0.16	

Higher yield of the *Sozonovsky* spring barley variety was due to the combination of integrated plant protection and spraying plants at the tillering stage with BIO-GEL, 2 l/ha (1.0% concentration).

2.3 Effect of BIO-GEL product on soybean productivity

The effectiveness of soybean cultivation depends on the day length, warmth and moisture. Plant survival depends on the variety flexibility and the effect of certain agronomical methods. During the vegetation period the number of plants per unit area is gradually decreasing, which depends on natural factors.

Taking into account the great probability of drought it is important to use products that increase plant adaptive characteristics and its survival which ensures high yields. BIO-GEL application strengthened soybean adaptability to drought which at the time of harvesting resulted in greater number of plants per unit area. Thus, in the control the number of plants per unit area was 58 pc/m^2 at the time of harvesting, the plant survival equaling 75.8%, while BIO-GEL use in pre-sowing seed treatment resulted in the plant number increase by 12-14 pc/m^2 (20.7-24.1%), the survival rate being 91.5-94.1%. In the 2015 weather conditions BIO-GEL application for spraying plants at the 3-5 leaves stage, the dose being 1 l/ha, did not have a great effect on plant survival (4 pc/m^2, or 6.9%), with the dose of 2 l/ha the number of plants was approximately the same as in the control, the survival equaling 81.0% and 75.8%, respectively. Greater number of plants before harvesting (72 pc/m^2) and greater survival (94.1%) were recorded in the variant with pre-sowing seed treatment with BIO-GEL, 2 l/t (1.0% concentration) (table 13).

Table 13. ***Medeya*** **soybean variety survival depending on BIO-GEL product use, %**

Variant	Number of plants before harvesting, pc/m^2	Survival, %
1. Control (integrated plant protection)	58	75.8
2. IPP + seed treatment with BIO-GEL, 1 l/t (0.5% concentration)	70	91.5

3. IPP + seed treatment with BIO-GEL, 2 l/t (1.0% concentration)	72	94.1
4. IPP + spraying at 3-5 leaves stage with BIO-GEL, 1 l/ha, (0.5%)	62	81.0
5. IPP + spraying at 3-5 leaves stage with BIO-GEL, 2 l/ha, (1.0%)	58	75.8

Soybean growth and development and, consequently, its productivity under the conditions of the northern steppe depend on weather conditions and particularly on rainfall even distribution during vegetation period. An important biological indicator which characterizes plant reaction to changes in the cultivation is plant height and the height of the lowest beans. Various ways of BIO-GEL application provided various conditions for soybean development and growth. In the control the height of the *Medeya* soybean variety was 73.3 cm. Increase in soybean height caused by BIO-GEL application was 2.4 and 0.4 cm. Spraying soybean plants at the stage of 3-5 leaves with BO-GEL (1.0 and 2.0 l/ha) caused the decrease of this characteristic by 3.1 and 1.0 cm (4.2 and 1.4 %), respectively. The highest (75.7 cm) were the plants when BIO-GEL was used for pre-sowing seed treatment, 1 l/t, 10% concentration (table 14).

For soybean mechanized harvesting in addition to a number of important features, such as high and compact branches, resistance to lodging and bean sloughing, good and even ripening, good drying at the root, a very important and decisive feature is the height of beans of the lower layer.

The analysis of the research shows that the height of the lowest beans depends on the concentration and the stage of BIO-GEL application. This is very important as a great part of the yield can be lost during harvesting. Pre-sowing seed treatment with BIO-GEL (1 l/t and 2 l/t) promoted higher layer of the lowest beans by 0.3 and 1.0 cm (2.5 and 8.3%) compared to the control (12.0 cm). Spraying plants with BIO-GEL at the 3-5 leaves stage resulted in lowest beans height of 13.1 and 13.2 cm, that is, 1.1 and 1.2 cm higher (9.2-10.0 %).

Table 14. Biometric characteristics of the *Medeya* soybean variety depending on BIO-GEL application

Variant	Plant height, cm	Height of lowest bean, cm	Number of branches, pc
1. Control (integrated plant protection)	73.3	12.0	2.2
2. IPP +seed treatment with BIO-GEL, 1 l/t, (10%)	75.7	12.3	2.6
3. IPP +seed treatment with BIO-GEL, 2 l/t, (20%)	73.7	13.0	2.5

4. IPP + spraying at 3-5 leaves stage with BIO-GEL, 1 l/ha, (0.5%)	70.2	13.1	2.4
5. IPP + spraying at 3-5 leaves stage with BIO-GEL, 2 l/ha, (1.0%)	72.3	13.2	2.6

The number of branches on soybean plants mostly depends on the variety peculiarities, as a rule early varieties form fewer number of branches whereas late-ripening varieties form greater number as they are physiologically capable of intensive tillering. The use of biologically active substances promotes tillering to some extent but it is more dependent on weather conditions at the time. The use of BIO-GEL for seed treatment and for spraying at the 3-5 leaves stage in 2015 increased the number of branches of the *Medeya* early soybean variety by 0.2-0.4 ones (9.1-18.2%). In the control the number of branches was 2.2 per plant.

The yield size is dependent on the plant organs development and its intensity. For soybeans the most important yield elements are the number of beans, grains and their weight. The yield can be higher or lower depending on these elements which in their turn depend on cultivation conditions.

The number of beans which were formed on soybean plants depended on weather conditions and application of BIO-GEL. The number of beans increased due to pre-sowing seed treatment by 2.6-8.4 pc and by 1.1-2.2 pc due to spraying plants at the 3-5 leaves stage compared to the control (25.8 pc) (4.3-32.6% increase). At the same time, the general tendency is obvious: increasing the concentration of BIO-GEL from 0.5 to 1.0% leads to a decrease in its positive effect. Greater number of soy beans (34.2 pc) was formed in the variant of pre-sowing seed treatment with BIO-GEL, 1l/t, 0.5% concentration (table 15).

Table 15. Different numbers of soy beans and grains depending on BIO-GEL application, pc/plant

Variant	Number of beans, pc	Number of grains, pc
1. Control (integrated plant protection)	25.8	43.3
2. IPP +seed treatment with BIO-GEL, 1 l/t, (10%)	34.2	49.,4
3. IPP +seed treatment with BIO-GEL, 2 l/t, (20%)	28.4	48.8
4. IPP + spraying at 3-5 leaves stage with BIO-GEL, 1 l/ha, (0.5%)	28.0	44.7
5. IPP + spraying at 3-5 leaves stage with BIO-GEL, 2 l/ha, (1.0%)	26.9	42.0

The amount of seeds that is formed on soy plants depends on the number of beans and the number of grains in them. The number of grains is quite unstable depending on weather conditions during the period of grain formation and ripening. The *Medeya* early soybean variety formed in various experiment variants from 43.3 (control) to 49.4 grains per plant (pre-sowing seed treatment with BIO-GEL, 1 l/t, 0.5%). The use of BIO-GEL for seed treatment increased the number of grains by 5.5-6.1 pc, or 12.7-14.1%, while after spraying plants – only by 1.4 pc (3.2%) in the variant where plants were sprayed with BIO-GEL, 1 l/ha (0.5%) at the 3-5 leaves stage. When the BIO-GEL concentration increased to 2 l/ha (1.0%) the number of grains decreased by 1.3 pc (3.0%).

Higher plant resistance to stresses during grain formation and ripening due to BIO-GEL biologically active product application resulted in bigger size grains which brought about its generally higher weight. In the control the grain weight per plant was 4.53 g, whereas BIO-GEL use increased it by 0.09-0.66 g (2.0-14.6%). The greatest grain weight (5.19 g) was obtained in the variant where seeds were treated with BIO-GEL (2 l/t, 1.0%) before sowing, while spraying plants with BIO-GEL at the 3-5 leaves stage yielded the least result (table 16).

The *Medeya* early soybean variety is capable of forming grains of high weight. In 2015 the weight of 1000 grains changed from 133.9 g (control) to 147.3 g (pre-sowing seed treatment with BIO-GEL, 2 l/t, 1.0%). Thus BIO-GEL biologically active product promoted the formation of bigger grains, the weight of 1000 grains was greater by 7.1-13.4 g (5.3-10.0%) compared to the control. The greatest positive effect was obtained on using BIO-GEL for pre-sowing seed treatment.

Table 16. Weight of soybean grains depending on BIO-GEL application

Variant	Grain weight per plant, g	1000 grains weight, g
1. Control (integrated plant protection)	4.53	133.9
2. IPP +seed treatment with BIO-GEL, 1 l/t, (10%)	5.04	143.7
3. IPP +seed treatment with BIO-GEL, 2 l/t, (20%)	5.19	147.3
4. IPP + spraying at 3-5 leaves stage with BIO-GEL, 1 l/ha, (0.5%)	5.03	142.9
5. IPP + spraying at 3-5 leaves stage with BIO-GEL, 2 l/ha, (1.0%)	4.62	141.0

Thus, using BIO-GEL biologically active product affected positively the formation of the *Medeya* early soybean variety productive elements. At the same time the changes in the productivity parameters and the degree of the product effect was determined by weather conditions during the grain formation and ripening.

Soybean capacity depends on both natural and agrotechnical factors. Agrotechnical factors should be aimed at ensuring the vital needs of plants when the environmental parameters change. Soybean productive capacity can be considered only in connection with weather and soil conditions.

In 2015 the *Medeya* early soybean variety yield was 2.05 t/ha in the control. The pre-sowing seed treatment with BIO-GEL (0.5% and 1.0% concentrations) promoted increase in soybean yield by 0.52 and 0.50 t/ha (25.4 and 24.4%), while spraying plants at the 3-5 leaves stage with BIO-GEL, 1 l/ha(0.5%), increased the yield by 0.29 t/ha (14.1%). Spraying plants with BIO-GEL in higher dose (2 l/ha) decreased the yield by 0.10 t/ha (4.9%) (table 17).

Table 17. *Medeya* early soybean variety yield depending on BIO-GEL application, t/ha

Variant	Yield, t/ha	+/- to control	
		t/ha	%
1. Control (integrated plant protection)	2.05	-	-
2. IPP +seed treatment with BIO-GEL, 1 l/t, (10%)	2.57	+0.52	25.4
3. IPP +seed treatment with BIO-GEL, 2 l/t, (20%)	2.55	+0.50	24.4
4. IPP + spraying at 3-5 leaves stage with BIO-GEL, 1 l/ha, (0.5%)	2.34	+0.29	14.1
5. IPP + spraying at 3-5 leaves stage with BIO-GEL, 2 l/ha, (1.0%)	1.95	-0.10	-4.9
HIP_{05}		0.12	

The highest yield (2.57 t/ha) by 0.52 t/ha (25.4%) higher than the control was obtained after pre-sowing seed treatment with BIO-GEL, 1 l/t (0.5%).

2.4 BIO-GEL effect in sunflower cultivation

Such characteristics of sunflower as the heart diameter, number and weight of 1000 seeds changed depending on BIO-GEL concentration. Thus, spraying plants at the 2-3 pairs of leaves stage with BIO-GEL, 1 l/ha (0.5% concentration) increased the heart diameter by 0.9 cm (4.5%), the number of seeds in the heart – by 54 pc (4.9%), the weight of grains – by 3.3 g (5.4%), the weight of 1000 grains – by 5.8 g (12.1%). In the control these values were 20.1 cm, 1096 pc, 61 g and 48.1 g, respectively. Higher BIO-GEL concentration (2 l/ha) increased just the number of seeds in the heart (table 20).

Table 20. BIO-GEL effect on sunflower yield structure

Variant	Heart diameter, cm	Grain number in heart, pc	Weight of grains in heart, g	Weight of 1000 grains, g
1. Control (integrated plant protection)	20.1	1096	61.0	48.1
2. IPP + spraying at 2-3 pairs of leaves stage with BIO-GEL, 1 l/ha (0.5%)	21.0	1150	64.3	53.9
3. IPP + spraying at 2-3 pairs of leaves stage with BIO-GEL, 2 l/ha (1.0%)	19.5	1128	56.5	46.3

Forward sunflower hybrid under integrated plant protection yielded in the control 2.75 t/ha. Higher yield was obtained on using BIO-GEL, 1 l/ha (1.0% concentration) at the 2-3 pairs of leaves stage, in this case the gain was 0.15 t/ha, or 5.5%. When the concentration was increased (2 l/ha) the yield decreased (table 19).

Table 19. BIO-GEL effect on *Forward* sunflower hybrid yield, t/ha

Variant	Yield	+/- to control	
		t/ha	%
1. Control (integrated plant protection)	2.75	-	-
2. IPP + spraying at 2-3 pairs of leaves stage with BIO-GEL, 1 l/ha (0.5%)	2.90	+0.15	5.5
3. IPP + spraying at 2-3 pairs of leaves stage with BIO-GEL, 2 l/ha (1.0%)	2.58	-0.17	-6.2
HIP_{05}		0.14	

CONCLUSIONS

BIO-GEL biologically active product affected positively plant growth and development, strengthened plant resistance to stresses, promoted the development of productivity elements and finally increased the yield. The effectiveness of the product in 2015 conditions depended on concentration and application period. In the broad sense BIO-GEL can be considered as an adaptogen of natural origin which has a positive effect on plants stress resistance and soil fertility.

In our opinion the positive effect of BIO-GEL on crops yield can be higher in case of using it for pre-sowing seed treatment. Experiments with soybeans showed +25% yield gain in case of seed treatment compared with +14% yield gain in case of spraying vegetating plants.

The experiments carried out by the customer on seed germination in laboratory and the positive results obtained confirm the prospects of using this method of BIO-GEL application, which is planned to be performed in the field next year.