Research Institute of Irrigated Farming, NAAS

REPORT

on BIO-GEL product effect on winter wheat grown on fallow land after treating its seeds and tops

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1. Aim

Field research aimed at establishing BIO-GEL product effectiveness in treating seeds and tops of winter wheat grown on fallow land.

2. Methods and farming techniques applied

Object of studies: BIO-GEL product on winter wheat.

Methods: field tests, laboratory analysis, data statistical treatment.

Experiment scheme is given in table 1.

The experiment was carried out on the soils which are typical of southern Ukraine: dark chestnut, medium-loamy, humus content amounting to 2.1%, humidity of wilting 7.8%.

Winter wheat was grown on fallow land, the commonly used technology of growing winter wheat on fallow land in the conditions of the southern Ukrainian steppe was applied.

Before sowing the arable soil layer contained NO_3 – 8.44 mg/100 g, P_2O_5 – 3.23 mg/100 g, K_2O – 22.4 mg/100 g soil. That is why before sowing $N_{15}P_{15}$ was applied and early in spring N_{30} was applied.

The seeds were treated with BIO-GEL and protectant on September, 21, 2016 in compliance with the experiment scheme. The *Maria* winter wheat variety was sown on September, 26, 2016, the rate being 5 million seeds per hectare with CH-16 sowing machine. Before the end of autumn vegetation (November 21, 2016), the variants No.8 and No.12 plots were sprayed with BIO-GEL (1.5 l / ha).

In variants 1-7 the crops were sprayed twice (at the end of tillering and at the beginning of earing) with fungicides at the recommended rates.

The plot area was 25 m^2, the record plot was 20.5 m^2.

The research was performed according to the methods (1985) by B.A. Bospekhov and by the Institute of Irrigated Farming (2014). Biometric analysis and determination of crop structure were made in accordance with the State variety test methods.

Table 2.1. Experiment scheme

	Variant	Seed treatment	Spraying at tillering	Spraying before earing
1	Pure seeds (water)	-	-	-
2	BIO-GEL, 1 l/t	+	-	-
3	BIO-GEL, 1.5 l/t	+	-	-
4	BIO-GEL, 2 l/t	+	-	-
5	Kinto Duo (protectant), 2 l/t	+	-	-
6	Kinto Duo (protectant), 2 l/t + BIO-GEL, 1.5 l/t	+	-	-
7	Kinto Duo (protectant), 1 l/t + BIO-GEL, 1.5 l/t	+	-	-
8	Pure seeds (water) + BIO-GEL, 1.5 l/ha	-	autumn	-
9	Pure seeds (water) + BIO-GEL, 1.5 l/ha	-	spring	-
10	Pure seeds (water) + BIO-GEL, 1.5 l/ha + fungicide, 0.5 l/ha	-	++	-
11	Pure seeds (water) + BIO-GEL, 1.5 l/ha + fungicide, 0.3 l/ha	-	++	-
12	BIO-GEL, 1.5 l/t + BIO-GEL 1.5 l/ha	+	autumn	-
13	BIO-GEL, 1.5 l/t + BIO-GEL 1.5 l/ha	+	spring	-
14	BIO-GEL, 1.5 l/t + BIO-GEL 1.5 l/ha + fungicide, 0.5 l/ha	+	spring	-
15	BIO-GEL, 1.5 l/t + BIO-GEL 1.5 l/ha + fungicide, 0.4 l/ha	+	++	-
16	Kinto Duo (protectant), 1 l/t + BIO-GEL, 1.5 l/t + BIO-GEL, 1.5 l/ha + fungicide, 0.5 l/ha + BIO-GEL, 1.5 l/ha	+	++	+
17	Kinto Duo (protectant), 1 l/t + BIO-GEL, 1.5 l/t + BIO-GEL, 1.5 l/ha + fungicide, 0.4 l/ha + BIO-GEL, 1.5 l/ha	+	++	+
18	Kinto Duo (protectant), 1 l/t + BIO-GEL, 1.5 l/t + BIO-GEL, 1.5 l/ha + fungicide, 0.5 l/ha + BIO-GEL, 1.5 l/ha + fungicide, 0.5l/ha	+	++	+
19	Kinto Duo (protectant), 1 l/t + BIO-GEL, 1.5 l/t + BIO-GEL, 1.5 l/ha + fungicide, 0.4 l/ha + BIO-GEL, 1.5 l/ha + fungicide, 0.4l/ha	+	++	+
20	Kinto Duo (protectant), 1 l/t + BIO-GEL, 1.5 l/t + BIO-GEL, 1.5 l/ha + fungicide, 0.4 l/ha + BIO-GEL, 1.5 l/ha + fungicide, 0.4l/ha + insecticide	+	++	+

3. 2016-2017 weather conditions

This year the winter crop sowing was carried out in difficult weather conditions. Thus, the first ten-day period of September was dry, with temperatures of 2-3 ° C above the climatic norm. Soil and air drought was observed in most areas of the region which kept back the beginning of sowing. Such weather conditions were during the second ten-day period of September. Only on the last days of the period it started raining which increased soil moisture reserves to start winter crops sowing.

There was enough moisture in the arable layer to ensure good and even sprouts on fallow lands.

In October the meteorological conditions varied greatly. At the beginning of the month high temperatures and no rains prolonged the soil drought. But at the end of the first ten-day period it started raining replenishing soil moisture reserves which contributed to seed germination. Later because of air temperature drop and cold weather setting there was an acute shortage of effective heat which is required for the initial development of winter crops. The average air temperatures in the second and third ten-day periods of October were by 2-4°C lower than the seasonal norm. At night the air and soil temperatures dropped to negative values which stopped plant growing.

The beginning of November was warm and wet which was good for plants development. During this period the winter wheat sown in optimal time (the second half of September) started tillering. The favorable factor of this autumn period was the rains which were sufficient in the first and second ten-day periods of October (74.4 mm). The reserves of productive moisture under winter crops on October 28 showed that they amounted to 26 and 95 mm in 0-20 cm and 1 m soil layer, respectively.

The situation was complicated by the fact that in January and at the beginning of February ice crust was formed, besides, in some lower places melt water was accumulated. The studies of the experimental variants by researchers showed that in general winter wheat plants did not die, only on plots 16-20, the third replication plant density was reduced.

All winter wheat crops wintered satisfactorily. During the winter the rainfall amounted to 74.1 mm, that is, 71.2% of the average.

Winter wheat vegetation started again on February 28, two weeks before the usual date.

Weather conditions in the 2017 spring were generally favorable for forming winter crops yield, but on certain days the temperature dropped to minus 3-5°C which did not affect the crops.

The amount of rainfall from January 1 to June 20 amounted to 159.3 mm, the norm being 199 mm: 87.9 mm in April and 24.9 mm in the first half of May. In March the average air temperature was 7.0°C, in April – 9.3°C, in May – 16.3°C, in June – 22.0°C, the long-term temperature values being 2.3°C, 10.0°C, 16.0°C and 19.9°C, respectively (table 3.3).

Moisture deficit during the winter crop vegetation period was 237.8 mm, it was by 37.1 mm, or by 18.5% higher than the average long-term data.

Table 3.3. Meteorological conditions during the 2017 vegetation period compared to the average long-term data (1976-2010)

Month	Values					
	average air temperature, °C	relative air humidity, %	amount of rainfall, mm	evaporation, mm	moisture deficit, mm	precipitation-evaporation ratio
Average rainfall, 2017						
March	7.0	73	5.1	49.8	44.7	0.10
April	9.3	72	87.9	59.3	-28.6	1.48
May	16.3	64	25.6	110.5	84.9	0.23
June	22.0	63	10.3	147.1	136.8	0.07
during I-VI	13.6	68	197.7	366.7	237.8	0.47
Average long-term, 1976-2010						
March	2.3	69	28.0	41.6	13.60	0.67
April	10.0	68	33.0	70.6	37.60	0.47
May	16.0	65	42.0	105.9	63.90	0.40
June	19.9	64	45.0	130.6	85.60	0.34
during I-VI	12.1	66	148.0	348.7	200.7	0.42

In March the potential evaporation did not exceed 49.8 mm, in April – 59.3 mm, in May – 110.5 mm, in June – 147.1 mm. All in all during the winter wheat vegetation period in 2017 the rainfall amounted to 197.7 mm which is by 49.7 mm (33.6%) more than the average long-term rate. The potential evaporation during the vegetation period in 2017 was 366.7 mm. This value depended to a great extent on average daily temperature, relative air humidity, the amount of rainfall during the winter wheat vegetation period.

Winter wheat and winter barley water supply during the spring-summer period was also determined using the precipitation-evaporation ratio. On the average this ratio in 2017 was 0.47: 0.10 in March, 1.48 in April, 0.23 in May, 0.07 in June.

Due to such weather conditions the crops developed faster as their vegetation restarted earlier (February 28) and intensive grain ripening occurred at high air temperatures (above 30°C) and soil drought.

The full ripening stage was achieved on June 26 which is a week earlier than usual. Harvesting was performed on July, 2, 2017.

4. Results of field experiments

4.1 Phenological observations and crops density

Crops coming up started on October 3-4 (table 4.1)

4.1Winter wheat development stages depending on BIO-GEL application

	Coming-up	Tillering	Stem elongation	Earing	Ripeness		
					milky	wax	full
1	3.10.2016	2.11.2016	15.04.2017	15.05.2017	8.06.2017	18.06.2017	26.062017
2	3.10.2016	2.11.2016	15.04.2017	15.05.2017	8.06.2017	18.06.2017	26.062017
3	3.10.2016	2.11.2016	15.04.2017	15.05.2017	8.06.2017	18.06.2017	26.062017
4	3.10.2016	2.11.2016	15.04.2017	15.05.2017	8.06.2017	18.06.2017	26.062017
5	4.10.2016	2.11.2016	15.04.2017	15.05.2017	8.06.2017	18.06.2017	26.062017
6	4.10.2016	2.11.2016	15.04.2017	15.05.2017	8.06.2017	18.06.2017	26.062017
7	3.10.2016	2.11.2016	15.04.2017	15.05.2017	8.06.2017	18.06.2017	26.062017
8	3.10.2016	2.11.2016	15.04.2017	15.05.2017	8.06.2017	18.06.2017	26.062017
9	3.10.2016	2.11.2016	15.04.2017	15.05.2017	8.06.2017	18.06.2017	26.062017
10	3.10.2016	2.11.2016	15.04.2017	15.05.2017	8.06.2017	18.06.2017	26.062017
11	3.10.2016	2.11.2016	15.04.2017	15.05.2017	8.06.2017	18.06.2017	26.062017
12	3.10.2016	2.11.2016	15.04.2017	15.05.2017	8.06.2017	18.06.2017	26.062017
13	3.10.2016	2.11.2016	15.04.2017	15.05.2017	8.06.2017	18.06.2017	26.062017
14	3.10.2016	2.11.2016	15.04.2017	15.05.2017	8.06.2017	18.06.2017	26.062017
15	3.10.2016	2.11.2016	15.04.2017	15.05.2017	8.06.2017	18.06.2017	26.062017
16	3.10.2016	2.11.2016	15.04.2017	15.05.2017	8.06.2017	18.06.2017	26.062017
17	3.10.2016	2.11.2016	15.04.2017	15.05.2017	8.06.2017	18.06.2017	26.062017
18	3.10.2016	2.11.2016	15.04.2017	15.05.2017	8.06.2017	18.06.2017	26.062017
19	3.10.2016	2.11.2016	15.04.2017	15.05.2017	8.06.2017	18.06.2017	26.062017
20	3.10.2016	2.11.2016	15.04.2017	15.05.2017	8.06.2017	18.06.2017	26.062017

In variants 5 and 6 where seeds were treated with Kinto Duo (2 l/t) the coming-up was observed on October 4 while the rest of crops came up on October 3, one day earlier. The other phases started practically at the same time in all variants.

As to the density of winter wheat plants, it was the smallest in variants 5 and 6 where the seeds were treated with Kinto Duo (2 l/t) and amounted to 362 pc/m^2 (table 4.2).

The greatest plant density was observed in variants 3, 9, 12, 18 where BIO-GEL product was applied, their number being 464, 489,475 and 463 pc/m^2, or 92.8, 97.8, 95.0, 92.6%.

Table 4.2. Winter wheat plants density depending on BIO-GEL application, 10.10.2016, pc/m²

Variant	On fallow land					
	I	**II**	**III**	**IV**	**per 1 m²**	**%**
1	448	478	432	470	457	91.4
2	404	384	433	459	420	84.0
3	416	456	484	500	**464**	**92.8**
4	416	446	456	450	442	88.4
5	364	378	386	320	362	72.4
6	368	374	389	320	362	72.4
7	410	430	401	371	403	80.6
8	422	472	462	464	455	91.0
9	494	394	464	504	**489**	**97.8**
10	412	402	432	454	425	85.0
11	442	412	462	480	449	89.8
12	487	457	497	459	**475**	**95.0**
13	412	402	398	436	412	82.4
14	411	421	479	493	451	90.2
15	406	396	438	424	416	83.2
16	408	411	448	449	429	85.8
17	391	410	400	411	403	80.6
18	482	442	462	466	**463**	**92.6**
19	402	412	432	382	407	81.4
20	387	400	412	470	399	79.8

4.2 Plant growth and development depending on BIO-GEL application

Morphological and biological characteristics of winter wheat before winter in the variants where BIO-GEL was applied did not differ much from the control (with no BIO-GEL) but as for tillering, in variants **2** (pre-sowing seed treatment with BIO-GEL, 1.5 l/t), **3** (pre-sowing seed treatment with BIO-GEL, 2 l/t) and **12** (pre-sowing seed treatment with BIO-GEL, 1.5 l/t) it was 3.8, 3.7 and 4.0, that is higher than in the control: 3.3 (table 4.3).

Table 4.3. Morphological and biological characteristics of winter wheat grown on fallow lands depending on BIO-GEL application

	Variant	Weight of plants, g/m²	Number of plants per m²		Height of plants, cm	Tillering of plants
			plants	stems		
Plants before wintering (28.11.2016)						
1	Variant 1	**332**	**478**	**1580**	17	3.3
2	Variant 2	264	384	**1452**	**18**	**3.8**
3	Variant 3	**314**	**456**	**1688**	17	**3.7**
4	Variant 4	230	**446**	1408	15	3.1
5	Variant 5	230	378	1008	16	2.7
6	Variant 6	224	374	1046	15	2.8
7	Variant 7	**302**	**430**	1270	17	3.0
8	Variant 8	**304**	**472**	1440	**18**	3.1
9	Variant 12	284	394	**1582**	17	**4.0**

4.3 Sugar content of winter wheat tillering nodes and their wintering

Before wintering more sugars were accumulated in the variants with BIO-GEL, their content was by 6.47-15.15% higher than in the control (no seed treatment) (table 4.4).

Table 4.4. Dynamics of sugar content in winter wheat tillering nodes depending on BIO-GEL application

	Variant	Before winter (28.11.2016)			At the end of winter (03.03.2017)		
		Sugar content in fresh, %	Dry matter, %	Sugar per dry matter, %	Sugar content in fresh, %	Dry matter, %	Sugar per dry matter, %
1	Variant 1	9.20	28.15	32.66	6.16	20.24	30.43
2	Variant 2	8.97	22.29	**40.18**	6.83	19.61	**34.83**
3	Variant 3	9.37	23.07	**40.57**	6.10	18.24	**33.43**
4	Variant 4	9.08	23.18	**39.13**	5.98	19.46	30.74
5	Variant 5	10.35	21.64	**47.81**	5.67	19.10	29.65
6	Variant 6	9.84	22.54	**43.59**	5.67	18.98	29.88
7	Variant 7	10.35	22.85	**45.22**	6.95	18.05	**38.50**
8	Variant 8	9.55	21.56	**44.21**	6.04	19.49	30.98
9	Variant 12	9.89	22.14	**44.60**	6.59	18.74	**35.19**

At the end of the winter higher content of sugar (by 3.0-8.07%) was also recorded in the variants (2, 3, 7, 12) where BIO-GEL was applied.

Practically all plants survived in all experimental variants. Only in variant 5 where the protectant was applied plant density decreased by 5% (table 4.5).

Table 4.5. Winter wheat survival depending on BIO-GEL application

Variant	Before winter, pc/m2	After winter, pc/m2	Survivors, %
1	**478**	**468**	98
2	384	**428**	100
3	**456**	452	99
4	**446**	**480**	100
5	378	360	95
6	374	**426**	100
7	**430**	420	98
8	**472**	**472**	100
12	394	444	100

4.4 Plant growth and development depending on BIO-GEL application

The analysis of plants at the stage of spring tillering showed that BIO-GEL promoted the intensity of plants vegetative mass development, especially in variants 4, 6, 8, 9 and 13 where it amounted to 1154, 1056, 1006, 1040 and 1220 g/m^2 (table 4.6).

Table 4.6. Morphological and biological characteristics of winter wheat depending on BIO-GEL application at the spring tillering stage.

Variant	Plant weight, g/m^2	Number, pc/m^2		Plant height, cm	Plant tillering
		plants	stems		
Spring tillering stage (30.03.2017)					
1	960	**468**	**2566**	**23.7**	5.5
2	970	**428**	**2914**	24.0	**6.8**
3	966	**452**	**2908**	24.1	**6.4**
4	1154	**480**	**2842**	24.0	5.9
5	960	360	2324	**24.0**	**6.4**
6	**1056**	**426**	**2858**	**24.4**	**6.7**
7	964	420	2384	23.0	5.7
8	**1006**	**472**	**2736**	22.0	5.8
9	**1040**	**468**	**2736**	**22.5**	5.8
12	1000	444	2730	22.5	**6.1**
13	**1220**	**526**	**3394**	**24.1**	**6.5**

Compared to the control variant biomass gain in these variants amounted to 194, 96, 46, 80 and260 g/m^2, respectively.

At the same time general layering capacity was the highest in variants 2, 3, 5, 6, 12 and 13 (6.1-6.7 compared to 5.5 in the control). This fact is due to the greater number of stems in the plant and to the strong root system in the variants where BIO-GEL was applied.

4.5 Structure and amount of winter wheat yield depending on BIO-GEL application

The analysis of winter wheat samples testifies to various effects of BIO-GEL on plant height and winter wheat productivity depending on BIO-GEL application (table 4.7).

Table 4.7 Plant height and winter wheat yield structure depending on BIO-GEL application

	Plant height, cm	Number of productive stems, pc/m^2	Number of grains in ear, pc	Weight of 1000 grains, g
1	100.7	790	28	29.0
2	102.1	**821**	28	29.4
3	102.3	**847**	27	29.4
4	103.8	**834**	28	29.0
5	99.0	799	30	27.0
6	100.9	800	27	**30.6**
7	101.7	810	28	29.3
8	101.5	**821**	27	**30.0**
9	101.3	802	28	28.8
10	101.0	800	28	28.5
11	102.6	808	27	28.9
12	101.0	815	26	29.0
13	105.4	819	27	29.5
14	102.5	**828**	28	29.0
15	104.5	806	27	**30.4**

16	98.3	808	27	**32.4**
17	96.6	**854**	26	**31.3**
18	96.7	**822**	25	**33.2**
19	97.4	**821**	27	**32.1**
20	97.4	**826**	27	**31.1**

BIO-GEL application promotes plants growth. Thus, in the control the plant height was 100.7 cm while in the variants with BIO-GEL it was 100.9-105.4 cm. But application of the Kinto Duo protectant and other chemicals decreased plant height to 96.6-99.0 cm.

The highest plants (105.4 cm) were in variant 13 where only BIO-GEL was used for seed treatment (1.5 l/t) and for spraying crops (1.5 l/ha) at the beginning of spring.

The greatest number of productive stems was formed in variants 2, 3, 4, 8, 14, 17, 18, 19 and 20 where it was 821, 847, 834, 828,854, 822, 821 and 826 pc/m^2. The smallest number of ears per unit area was formed in the control variant (pure seed) and in the variants where seeds were treated with Kinto Duo protectant (2 l/t), these are variants 1 and 5, the ear number being 790 and 799 pc/m^2, respectively.

In different variants the number of grains in the ear varied from 25 to 30. In most cases it equaled 27-28 grains per ear.

This year because of soil and air drought the grains were not completely formed, their weight being low, and varied from 27.0 to 33.2 g. The largest grains (the weight of 1000 grains being 31.1-33.2 g), were formed in variants 16-20 where BIO-GEL was used together with chemicals. The weight of 1000 grains equaled 30.0-30.6 g in variants 8 and 15 where BIO-GEL was used without Kinto Duo protectant.

Such difference in the yield characteristics affected the amount of yield. Thus, wheat threshing showed that when winter wheat was grown on fallow lands and various combinations of BIO-GEL with protectants and without them was applied the yield was from 6.22 to 7.06 t/ha (table 4.8).

Table 4.8 Winter wheat yield depending on BIO-GEL application

	Replication			Average yield, t/ha	+/- to control	
	I	II	III		t/ha	%
1	6.54	6.17	6.51	6.41	-	-
2	6.94	6.13	6.90	6.66	0.249	3.9
3	6.68	6.36	7.18	**6.74**	**0.334**	5.2
4	6.94	6.62	7.01	**6.85**	**0.447**	7.0
5	6.70	6.09	6.87	6.55	0.148	2.3
6	6.81	6.50	6.78	**6.70**	0.291	4.5
7	6.63	6.67	6.86	**6.72**	0.312	4.9
8	6.91	6.88	6.49	**6.76**	**0.351**	5.5
9	6.47	6.49	6.54	6.50	0.092	1.4
10	6.61	6.16	6.17	6.32	-0.091	-1.4
11	6.25	6.23	6.59	6.36	-0.052	-0.8
12	6.20	6.16	6.30	6.22	-0.191	-3.0
13	6.75	6.35	6.71	6.60	0.195	3.0
14	6.74	6.89	6.53	**6.72**	0.315	4.9
15	6.63	6.31	6.90	6.61	0.203	3.2
16	7.13	6.29	7.46	**6.96**	**0.551**	8.6
17	6.84	6.49	7.21	**6.85**	**0.441**	6.9
18	7.25	6.71	6.72	**6.89**	**0.488**	7.6
19	6.91	6.91	7.23	**7.02**	**0.608**	9.5
20	7.30	6.92	6.97	**7.06**	**0.653**	10.2

HIP_{05}, t/ha 0.330

In the control variant the grain weight was 6.41 t/ha. Significant gains from 0.334 to 0.653 t / ha were obtained on variants Nos. 3, 4, 8, 16, 17, 18, 19 and 20, where the yield was 6.74, 6.85, 6.76, 6.96, 6.8, 6.89, 7.02 and 7.06 t / ha. The highest yield (7.02-7.06 t/ha) was in variants 19 and 20 where BIO-GEL was applied three times and Kinto Duo (1 l/t) was used as a protectant and Rex Duo fungicide rate was reduced by 20%. In these variants yield gains were 0.608 and 0.653 t/ha, or 9.5 and 10.2%.

A high yield gain (0.551 t/ha, or 8.6%) was obtained in variant 16 where reduced rate of Kinto Duo protectant (1 l/t) together with BIO-GEL (1.5 l/t) was used for seed treatment, at the tillering stage BIO-GEL (1.5 l/ha) with fungicide (0.5 l/ha) was used for spraying and at the beginning of earing just BIO-GEL (1.5 l/ha) was applied.

4.6 Economic efficiency of BIO-GEL application

Calculations of economic efficiency have shown that in agrometeorological conditions in 2017 winter wheat cultivation was economically justified. In all experiment variants winter wheat provided a fairly high contingent net profit, which depended on the use of BIO-GEL and plant protectants and ranged from 18007 to 20936 UAH / ha (Table 4.9). In the control the contingent net profit was smaller and amounted to 17737 UAH/ha.

The best combination of all economic efficiency indicators was noted when BIO-GEL was used during the autumn tillering phase, in this case the contingent net profit obtained was the highest (20936 UAH/ha), the profitability rate was 281% and the cost was the lowest (1103.0 UAH/t).

The best economic efficiency indicators were obtained on seed treatment with ½ rate of Kinto Duo protectant (1 l/t) in combination with BIO-GEL (1.5 l/t) followed by spraying crops with BIO-GEL (1.5 l/ha) and Rex Duo fungicide (0.5 l/ha) at the end of tillering phase and only with BIO-GEL (1.5 l/ha) at the beginning of earing. In this case the contingent net profit was 20319 UAH/ha, grain cost was 128.06 UAH/t, profitability – 228%.

Reducing the rate of chemical fungicides by 20% is conducive to better economic indicators. Thus, when seeds were treated with ½ rate of Kinto Duo (1 l/t) in combination with BIO-GEL (1.5 l/t) and later at the tillering stage the plants were sprayed with BIO-GEL (1.5 l/ha) in combination with Rex Duo fungicide (0.5 l/ha) the contingent net profit amounted to 19403 UAH/ha, grain cost was 1383.9 UAH/t, the profitability was 203%. In the similar variant but with the Rex Duo fungicide rate reduced to 0.4 l/ha the values were as follows: 20185 UAH/ha, 1324.7 UAH/t, 217%.

Table 4.9 Economic efficiency of cultivating winter wheat on fallow land applying BIO-GEL product and plant protectants

	Variant	Expenses, UAH/ha	Contingent net profit, UAH/ha	Grain cost, UAH/t	Profitability, %
1	Pure seeds (water)	9184.79	17737	1432.9	193
2	BIO-GEL, 1 l/t	9276.51	18695	1392.9	202
3	BIO-GEL, 1.5 l/t	9305.88	**19002**	1380.7	**204**
4	BIO-GEL, 2 l/t	9356.88	**19413**	1366.0	**207**
5	Kinto Duo (protectant), 2 l/t	9503.14	18007	1450.9	189
6	Kinto Duo (protectant), 2 l/t + BIO-GEL, 1.5 l/t	9534.41	18606	1423.0	195
7	Kinto Duo (protectant), 1 l/t + BIO-GEL, 1.5 l/t	9368.24	18856	1394.1	201
8	Pure seeds (water)+ BIO-GEL, 1.5 l/ha in autumn	7456.10	**20936**	1103.0	**281**
9	Pure seeds (water)+ BIO-GEL, 1.5 l/ha in spring	7423.36	19877	1142.1	**268**
10	Pure seeds (water)+ BIO-GEL, 1.5 l/ha + fungicide, 0.5 l/ha	8476.40	18068	1341.2	213
11	Pure seeds (water)+ BIO-GEL, 1.5 l/ha + fungicide, 0.3 l/ha	8293.15	18377	1306.0	222
12	BIO-GEL, 1.5 l/t + BIO-GEL, 1.5 l/ha in autumn	7595.38	18529	1221.1	244
13	BIO-GEL, 1.5 l/t + BIO-GEL, 1.5 l/ha in spring	7635.83	**20084**	1156.9	263

14	BIO-GEL, 1.5 l/t + BIO-GEL, 1.5 l/ha + fungicide, 0.5 l/ha	8605.40	**19619**	1280.6	228
15	BIO-GEL, 1.5 l/t + BIO-GEL, 1.5 l/ha + fungicide, 0.4 l/ha	8310.47	**19452**	1257.3	234
16	Kinto Duo protectant, 1 l/t + BIO-GEL, 1.5 l/t + BIO-GEL, 1.5 l/ha + fungicide, 0.5 l/ha + BIO-GEL, 1.5 l/ha	8913.27	**20319**	1280.6	**228**
17	Kinto Duo protectant, 1 l/t + BIO-GEL, 1.5 l/t + BIO-GEL, 1.5 l/ha + fungicide, 0.4 l/ha + BIO-GEL, 1.5 l/ha	8716.19	**20054**	1272.4	230
18	Kinto Duo protectant, 1 l/t + BIO-GEL, 1.5 l/t + BIO-GEL, 1.5 l/ha + fungicide, 0.5 l/ha + BIO-GEL, 1.5 l/ha + fungicide , 0.5 l/ha	9535.06	**19403**	1383.9	203
19	Kinto Duo protectant, 1 l/t + BIO-GEL, 1.5 l/t + BIO-GEL, 1.5 l/ha + fungicide, 0.4 l/ha + BIO-GEL, 1.5 l/ha + fungicide , 0.4 l/ha	9299.48	**20185**	1324.7	**217**
20	Kinto Duo protectant, 1 l/t + BIO-GEL, 1.5 l/t + BIO-GEL, 1.5 l/ha + fungicide, 0.4 l/ha + BIO-GEL, 1.5 l/ha + fungicide , 0.4 l/ha + insecticide	9597.56	**20054**	1359.4	209

Thus, on reducing the fungicide rate by 20% the economic efficiency indicators are higher. This testifies to the fact that when applying BIO-GEL in winter wheat cultivation fungicide load should be reduced by 20% which does not affect the yield.

The lowest economic values were obtained in the control variant with no BIO-GEL used, the contingent net profit in this case was 17737 UAH/ha, the grain cost was 1432.9 UAH/t, the profitability was 193%.

CONCLUSIONS:

- when treating seeds only with BIO-GEL fertilizer, its rate should be 1.5 – 2 l/ha;
- when treating seeds with the combination of BIO-GEL (1.5 l/ha) and a protectant, the rate of the latter can be reduced twice;
- seed treatment or crops spraying in the autumn tillering phase with BIO-GEL increases carbohydrate accumulation in tillering zones thus increasing plant winter hardiness;
- BIO-GEL use for seed treatment or in autumn or early spring vegetation periods promotes plant overall tillering which increases to 6.1-6.7 compared to 5.5 in the control (no BIO-GEL);
- BIO-GEL application has a positive effect on yield structure, especially great increase is registered in the number of productive stems – up to 821-854 stems/m^2, whereas the control gives only 790 stems/m^2;
- BIO-GEL provides a reliable increase in grain yields – from 0.334 to 0.653 t/ha (5.2 – 10.2%);
- the best combination of all economic efficiency indicators has been registered when applying BIO-GEL in the autumn tillering phase, the highest contingent net profit amounting to 20936 UAH/ha and the profitability rate making 281% at the lowest net cost of 1103.0 UAH/t;
- when using BIO-GEL, it is expedient to reduce the chemical fungicide rate by 20%, which ensures better economic results.