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Effect of Biohumus on Agrochemical Properties of Soil, Fertility and Plant Productivity in Greenhouse Conditions

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A B S T R A C T

In this research work, the effect of biohumus on the agrochemical properties of the soil, fertility and productivity of cucumbers in greenhouse conditions is studied.Since biohumus stores a large amount of nutrients, when added to the soil, it changes the amount of nutrients in the soil. Since biohumus contains trace elements and humic acids, it has an effect of enhancing plant development in cucumber cultivation. Greenhouse soil treated with mineral fertilizer was used as a control option in the experiment. The amount of mineral fertilizer applied to the soil in different years was determined based on the level of nutrient supply of the greenhouse soil as a result of agrochemical analysis. For all options, the plant was fed with the specified amount of mineral and organic fertilizer every 30 days. Application of mineral fertilizers was carried out in two stages. The amount of mineral fertilizers calculated on the basis of the chemical analysis of the soil carried out in the first stage was added. In the second stage, a certain amount of organic fertilizer-biohumus was added according to different options. The mineral fertilizer used in feeding is the same in all options: nitrogen 29 mg/kg (or 7.5 g/m2), phosphorus (P_2O_5) 19.5 mg/kg (or 5.0 g/m^2) and potassium (in terms of K_2O) was equal to 23.5 mg/kg (or 6.0 g/m^2). Mineral fertilizers were given in the form of ammonium nitrate (22.0 kg/ha), double superphosphate (25 kg/ha) and potassium chloride (11 kg/ha). Comparing the amount of NPK determined after feeding for each option with the amount of NPK before feeding in these options shows the increase in the amount of nutrients in 2019-2021: N-1.2-1.7; P-1.2-2.0; It shows that K–1.2-2.3 times. This mainly corresponded to options 5-8, where feeding with biohumus in the amount of 1.0 kg/m2 was carried out in several stages. According to option 5, the amount of nitrogen in the soil increased from 50 mg/kg to 90 mg/kg, the amount of phosphorus from 53 mg/kg to 101 mg/kg, and the amount of potassium from 49 mg/kg to 66 mg/kg was observed in the 3rd year. In option 9, where 4.0 kg/m^2 of biohumus was used under the plow, at the end of the experiment, the amount of NPK in the soil of the experimental plot decreased from the optimum. At the end of the experiment, a significant decrease in NPK was observed in the soil of the site where manure was used at the rate of 2 kg/m2 for feeding. As a result of intensive use of the soil in greenhouse conditions, it was observed that the amount of mineral substances necessary for the development of the plant, especially micro- and macroelements in the mobile form, in the soil of the control option, where only mineral fertilizer was used, was significantly reduced. Usually, in such cases, it is required to use high-quality mineral fertilizers and other chemical compounds in order to obtain a high yield under closed soil conditions. As a result, an excess amount of harmful chemicals accumulates in the crop. The use of biohumus during feeding prevents such unpleasant situations.

Introduction

Cucumber is the largest cultivated vegetable in the world and has become one of the main agricultural crops in recent years as a result of the reduction of fertile land and the increase of soil and water salinity (Liu *et al.,* 2020; Naglaa Taha *et al.,* 2020). Cucumber (*Cucumis sativus* L.) is an important vegetable crop belonging to the *Cucurbitaceace* family and has a chromosome number of 2n=14 (Janapriya *et al.,* 2010; Krug *et al.,* 2002; Kubota *et al.,* 2013).

Cucumber is grown in large quantities in South Asia, especially in the hot and humid climate of the Himalayas in Northwest India, and in countries located in North Africa. The climatic conditions of these countries correspond to the productivity requirements of cultivation with high temperature, humidity and light intensity with sufficient amount of water and nutrients. Cucumber cultivation in India dates back to 3000 BC, and in China 100 BC (Arunabha Pal *et al.,* 2020).

Cucumber is considered the most cultivated plant in greenhouses in the world (Sharma *et al.,* 2018; Singh, 2005; Bairagi *et al.,* 2013; Egel, 2015; Fernandes *et al.,* 2002), the growth and development of cucumber in the process of cultivation in greenhouses, its physiology, It is characterized by the fact that a lot of scientific and research work has been carried out on the biochemistry and factors affecting productivity (Sharma *et al.,* 2018; Savvas *et al.,* 2013).

However, in scientific sources, there are insufficient research studies on the effect of biohumus on the migration of heavy metals during the cultivation of cucumbers in greenhouses and the mobility of nitrates in cucumber fruits (Khujamshukurov *et al.,* 2022 a,b).

Purpose of work

Therefore, in this research work, the effect of biohumus on the agrochemical properties of the soil, fertility and productivity of cucumbers in greenhouse conditions is studied.

Materials and Methods

At this stage of the work, the effect of organic fertilizer, biohumus on the agrochemical indicators of the substrate in closed soil conditions, the growth and development of cucumber seedlings was determined during the cultivation of "Avitsena" F_1 cucumber seedlings in greenhouse conditions. The existing technology, which is widely used in practice, was used in the research, differing in the experimental scheme. In experiments conducted on this technology, adding mineral fertilizers to the substrate was carried out two weeks before placing it in the pens. The addition of the appropriate amount of biohumus was done before putting it in the pond. Cucumber seeds to be planted were washed for 1 hour in 1% KMnO4 solution in cold running water and kept in diluted (1:50) Na_3PO_4 solution for 1 day. By the time of planting, most of the seeds that had sprouted were planted in pots with a volume of 500 ml. The density of planting seedlings is 45 per square meter, they were covered with transparent polyethylene film until they germinated. During seedling germination, the temperature was kept in the range of 25-28°C. At the beginning of seedling germination, the film was removed and the temperature was lowered to 22-24°C. During the first three days, the place where the seedling stood was additionally illuminated (this stage of the technology is necessary in conditions of low solar radiation in winter). On the remaining days, it was illuminated for 12-16 hours, and the illumination level of the experimental area was 4-5 thousand lux. During the dark period of the day, the air temperature was kept at 19-20°C. Transplanting the seedling to its permanent place in the greenhouse was carried out after 30 days.

As a control option, a 1:1 mixture of soil and wood chips was used, which contained enough nutrients in mineral form and is now widely used in most large greenhouses. Mineral fertilizers (ammonium nitrate, double superphosphate and potassium sulfate) were used in order to ensure optimal values of nutrients in the initial mixture of the control option. In the experiments, 600 g of ammonium nitrate, 125 g of granulated double superphosphate, 455 g of potassium chloride and 115 g of magnesium sulfate salts were added to 1 m^3 of the initial mixture. The effect of the amount of biohumus on the development of seedlings was determined with the help of phenological observations and biometric studies carried out together with agrochemical analyzes (Dospekhov, 1985).

The quality of a cucumber seedling has a dramatic effect on its subsequent productivity. Geisler T. *et al.,* (1979), its indicators should have the size of an average sheep before planting: height 20-25 cm, number of real leaves 4-5, length of joints up to 3-5 cm, total weight up to 20-30 grams. Veins should be white, free from various diseases.

Results and Discussion

Effect of biohumus on soil agrochemical properties and fertility

Cucumber plant is distinguished by its demand for the composition of the soil due to its fast growth and intensive absorption of nutrients. It grows well in soil with sufficient organic and mineral fertilizers. Nitrogen is necessary for the growth of the vegetative mass of the cucumber and the formation of the crop, phosphorus accelerates its flowering and the appearance of the crop, and potassium increases the quality of the product.

When growing cucumbers in greenhouse conditions, the amount of available nitrogen and potassium in the soil is estimated in relation to the amount of nitrogen and potassium determined by the above equations as follows: the amount of available nitrogen and potassium in the soil is less than 1/3 A (or K) - the level of nitrogen and potassium supply to the soil is low; From 1/3 A (or K) - to 2/3 A (or K) - below the norm; 2/3 A (or K)-standard; 1.33 A (or K) - more than the norm; Greater than 1.33 A (or K) – very high.

When evaluating the amount of phosphorus in all types of soil during the cultivation of cucumbers in greenhouse conditions, the following indicators (mg) per 1 kg of absolute dry soil were adopted: low 0-20 mg, less than the norm 20-40 mg, normal 40-60 mg, more than the norm 60-80 mg, very higher than 80 milligrams.

According to the results of the volumetric analysis of wet soil, the level of nutrient supply of greenhouse soil (mg/l) is presented in table-1.

The necessity of continuous feeding of the cucumber plant during all periods of its development in greenhouse conditions is related to a number of factors. First, cucumber continuously absorbs nutrients from the soil for 7-9 months to form a plant stem and crop.

2.64 g of nitrogen, 1.55 g of phosphorus, 6.60 g of potassium, 2.19 g of calcium and 0.57 g of magnesium are required for the formation of 1 kg of cucumber crop. On average, 1 cucumber plant contains 23 g of nitrogen, 14 g of phosphorus, 58 g of potassium, 19 g of calcium and 5 g of magnesium. Therefore, in order to ensure a high yield throughout the year, the starting soil must have a large amount of nutrients, but cucumbers cannot tolerate a large concentration of nutrients in the soil. It is negatively affected by a large concentration of soil solution and a high value of pN (normal values of pN for cucumbers are in the range of 6.0-7.2).

In this case, it is appropriate to use biohumus and use the required total nutrients in parts.

Since cucumber is a plant that is watered a lot, when mineral fertilizers are used, some of the nutrients (potassium and nitrogen) are washed away during the irrigation process. In addition, most nutrients combine with the soil and pass into a hard-to-dissolve form (this mainly applies to phosphorus). At different stages of plant development, cucumber needs different elements. In addition to the above, a limited amount of greenhouse soil can never retain the nutrients required to grow a cucumber crop of

30-40 kg/m2. For this reason, using the amount of fertilizer required for growing cucumbers in greenhouse conditions in phased feeding will further increase its effectiveness.

In order to determine the amount of fertilizer used under the plow and in feeding, the composition of the soil of the greenhouse was analyzed before the start of the experiment and once a month during the entire development period of the plant.

Agrochemical indicators of greenhouse soil without mineral and organic fertilizers during the years of the experiment are presented in Table 2.

From Table 2, the 3-year average amount of nitrogen, phosphorus and potassium in the soil of the experimental plot before plowing (control option) where mineral and organic fertilizers were not applied is 77, respectively; We see that it is 39 and 280 mg/kg.

Currently, in the cultivation of cucumbers in greenhouse conditions, in addition to providing the soil with the optimal amount of micro- and macroelements necessary for the development of cucumbers, great attention is paid to the use of physiologically active substances that enhance the nutrition of the plant from the soil. Biohumus is one such substance. The results of determining the main parameters of manure and biohumus used in the experiments are presented in Table 3.

From Table 3, the amount of nutrients contained in biohumus of different years differs partially from each other in some parameters, depending on the composition of the initial product (manure) in its preparation. However, in all cases, the amount of NPK contained in biohumus is much higher than the amount of nutrients contained in manure and the soil of the experimental area. For example, the results of the agrochemical analysis showed that the amount of nitrogen, phosphorus, and potassium in the prepared biohumus was different from the amount of nitrogen, phosphorus, and potassium in the experimental area: N-5.2; P- was 3.0 and K-1.8 times higher than nitrogen, phosphorus and potassium content of manure, respectively, N-2.6, P-2.0 and K-4.8 times higher.

Since biohumus stores a large amount of nutrients, when added to the soil, it changes the amount of nutrients in the soil. Since biohumus contains trace elements and humic acids, it has an effect of enhancing plant development in cucumber cultivation.

Greenhouse soil treated with mineral fertilizer was used as a control option in the experiment. The amount of mineral fertilizer applied to the soil in different years was determined based on the level of nutrient supply of the greenhouse soil as a result of agrochemical analysis. For all options, the plant was fed with the specified amount of mineral and organic fertilizer every 30 days.

Application of mineral fertilizers was carried out in two stages. The amount of mineral fertilizers calculated on the basis of the chemical analysis of the soil carried out in the first stage was added. In the second stage, a certain amount of organic fertilizer-biohumus was added according to different options.

The mineral fertilizer used in feeding is the same in all options: nitrogen 29 mg/kg (or 7.5 g/m2), phosphorus (P_2O_5) 19.5 mg/kg (or 5.0 g/m^2) and potassium (in terms of K_2O) was equal to 23.5 mg/kg (or 6.0 g/m^2). Mineral fertilizers were given in the form of ammonium nitrate (22.0 kg/ha), double superphosphate (25 kg/ha) and potassium chloride (11 kg/ha).

Before and after all feedings, a sample was taken from the soil for agrochemical analysis, and with the help of commonly used agrochemical analysis methods, the amount of nitrogen, phosphorus, potassium in the soil was determined and its pH value was monitored. In the experiment, feeding was carried out from one to four times according to the scheme established in the experimental area in different variants.

Table 4 shows the agrochemical parameters of the greenhouse soil with mineral and organic fertilizers before planting.

From the above results, the amount of nutrients contained in the soil of the field prepared for planting seedlings in a wide range according to the type and rate of the applied fertilizer (nitrogen 98.5-198.5 mg/kg, phosphorus 60.7-117.0 mg/kg, potassium 321, 5-430.7 mg/kg).

The amount of nutrients in the soil of the control option area is equal to: N-98.5 mg/kg, P-60.7 mg/kg and K-321.5 mg/kg. This shows that even without the use of biohumus, the field is provided with sufficient amount of nutrients according to generally accepted gradations in cucumber cultivation.

In all options, the same amount of biohumus - 1.0 kg/m2 - put under the plow had a positive effect on the physico-chemical parameters of the soil. The amount of nutrients in the mobile form in the soil of different years of the experiment was different in accordance with their content in the used biohumus of these years. In all years, the amount of nutrients in the control option was not lower than the optimal indicators (Appendix 1.).

It was noted that manure and biohumus applied to the soil had no significant effect on its pN value. The pH value of the greenhouse soil in different options where biohumus was applied was in the range of 6.30-6.60.

The salt concentration was close to the optimal value and varied in the range of 0.58 - 0.72%. The use of biohumus led to a significant increase in the amount of nitrogen, phosphorus and potassium in mobile form in the soil in all variants. An increase in the amount of nutrients was observed from the first option, where biohumus was used. Agrochemical analyzes showed that biohumus increases the amount of nutrients in the soil in accordance with the biohumus standard (Table 4). Determination of the level of phosphorus supply of the soil was based on the amount of P_2O_5 available in mg of 1 kg of dry soil under greenhouse conditions. If the amount of phosphorus in the soil is higher than 60 mg, then this is a sufficient amount for most plants. However, the excess amount of phosphorus in the soil does not have a negative effect on the growth and development of the plant (Gluntsov, 1989).

Table 4 shows that the use of biohumus at the rate of 1.0 kg/m^2 is enough to significantly increase the amount of phosphorus in the soil, which increases the amount of P_2O_5 in the soil by an average of 12.2-15.0 mg/kg or 17-20% in different years (Appendix 1). However, 1 kg/m^2 of biohumus added to the soil when applied in moderation did not cause a dramatic change in potassium content. 1kg/m^2 of biohumus increases the amount of potassium by 3-5%. The maximum accumulation of phosphorus in the soil (117.0 mg/kg) was observed in the 9th option, where biohumus was applied under the plow in the amount of 4.0 kg/m^2. In the 10th option, where 3.0 kg/m^2 of manure was used, and the 8th option, where 3.0 kg/m^2 of biohumus was used, compared to the control option, the increase of total nitrogen was 1.30 and 1.60 times, respectively, and the increase of mobile phosphorus was 1.1 and 1, It was found that 4 times and the increase in potassium content was equal to 1.1 and 1.2 times.

In options 2-5, where 1.0 kg of biohumus was added to each square meter of the experimental area, it was determined that the amount of nutrients was 1.25 times more than the control option, 1.25 times more potassium and 1.10 and 1.23 times more phosphorus, respectively. In variants 7-9 of the experiment, an increase in the amount of nutrients in the soil was observed in accordance with the increase in the amount of biohumus (Table 4).

The highest indicator of the average amount of nutrients in the soil (N-195.8; P-117.0 and K-430.7 mg/kg) corresponds to the 9th option with the addition of biohumus in the amount of 4 kg per square meter of the greenhouse area during plowing. The average amount of NPK in the 10th option, in which 3 kg of half-rotted manure was used under the plow for each square meter: N-129.9; P-68.3 and K-

334.2 mg/kg, which is close to the amount of nutrients in options 2-6, where 1.0 kg/m2 of biohumus was used.

The analysis of the 3rd option, which was carried out to determine the amount of nutrients from the greenhouse soil, was carried out 1 month after planting, corresponding to the period of full flowering of the cucumber plant (the period of picking the first crop). The results of this analysis are presented in Table 5. From the results of the soil analysis of the experimental area presented in Table 5, we can see that the main part of the total nutrients accumulated in the soil was absorbed by the plant during the period before flowering.

During the period before the first feeding (before flowering) in the experiments, it was observed that the plant absorbed 22-27% of the total nitrogen, 19-23% of phosphorus, and 29-33% of potassium. The total nutrient absorption coefficient is 1.25-1.35 for nitrogen, 1.25-1.30 for phosphorus and 1.42-1.56 for potassium in different options (Table 5 and Appendix 2).

During the experiments, one to four feedings were carried out according to the scheme. The results of the analysis of the soil after the first feeding corresponding to the period of plant development are presented in Table 6.

From the results of the soil composition test presented in Table 6, we can see that the amount of nutrients in the soil of all options increased significantly after the first feeding. This change was more significant in variants 3-9, where feeding with biohumus was carried out, and the amount of NPK in the soil increased in accordance with the amount of applied biohumus. The increase in the amount of NPK in all the variants using biohumus at the rate of 1.0 kg/m^2 compared to the control was 1.41-1.70 times for nitrogen, 1.47-1.68 times for phosphorus, and 1.17-1.22 times for potassium. was found to be equal (Appendix 3). Tables 7-8 show the results of greenhouse soil analysis before feeding (Table 7, Appendix 4) and after feeding (Table 8, Appendix 5) carried out by the period of gross ripening of cucumbers.

From the results presented in Table 7, it can be observed that the amount of nutrients in all variants drastically decreases during the ripening period of the gross crop. The lowest amount of nitrogen before feeding 2 (35.4 mg/kg) was observed in the control variant. As a result of feeding only with mineral fertilizer, the amount of nitrogen in the soil of the field corresponding to this control option increased to 66.1 mg/kg (Table 8).

During the mass crop ripening period before the 2nd feeding, the amount of nitrogen in the soil of the 2nd-7th variants was in the range of 60-80 mg/kg. A sharp decrease in the amount of phosphorus during the full ripening of the cucumber crop was observed in options 1 and 7 and option 10, where manure was used. The lowest level of phosphorus in these options was 32-42 mg/kg.

A comparison of the results of the soil analysis of the same options area in the period of the formation of the gross crop of the plant in 2020-2021 showed that the amount of nutrients in the soil in 2021 has higher values than in 2020. From the given tables 7-8, we can see that the amount of potassium in the soil decreased by 1.6-1.8 times during 1 month by the time of maturity of the gross harvest. As a result of the 2nd feeding, it was noted that the amount of nutrients in the soil of options 4-6, which used biohumus, increased significantly (Appendix 5).

The highest amount of nitrogen in the field soil in the options where biohumus was used was 232.6 mg/kg in the 8th option, and the lowest amount was 149.5 mg/kg in the 2nd option. In the second feeding, it was observed that the amount of phosphorus was in the range of 105-140 mg/kg, and the amount of potassium was in the range of 248-385 mg/kg, except for options 1-3, where only mineral fertilizers were used.

Thus, a sufficiently high amount of nutrients was observed in all variants during the growth period.

The third and fourth feedings of the cucumber plant were carried out according to the plan by the time of ripening of the gross crop.

Tables 9-10 show the results of the greenhouse soil composition analysis of the soil of the experimental field in different variants of the 3rd stage of feeding before and after feeding the plant.

The analysis of these tables shows that the amount of nitrogen accumulated after the second feeding of the plant during the period of gross productivity before the 3rd feeding according to different options is 39.8-70.7%, phosphorus is 23.4-52.1%, and potassium is 39.51- Up to 59.8% absorption was noted. A sharp decrease of the nutrient element was observed in options 1 and 3 for nitrogen, in options 1 and 7 for phosphorus, and in options 1 and 5 for potassium.

Another advantage of feeding with biohumus when growing cucumbers in greenhouse conditions, compared to feeding only with mineral fertilizers, is that biohumus can retain nutrients in its content without immediately transferring them to the soil solution and release them in the amount needed by the plant. This can be clearly seen in Annex 6 and Table 9, where the results of soil analysis before 3rd feeding are presented.

Comparing the amount of NPK in the soil of the control option fed only with mineral fertilizer and options 8 and 9 without mineral fertilizer fed only with biohumus in the table, we can see that the nutrient elements in the option with mineral fertilizer were sharply reduced in the period before the next fertilization compared to the options where biohumus was used. In variants 8 and 9, where biohumus was used, high values of NPK remained stable throughout the entire development period of the plant.
At this stage of the experiment, it was found that the nutrient content of the greenhouse soil in options 5-8, where feeding with biohumus was carried out, compared to options treated only with mineral fertilizers without biohumus.

After the third feeding, it was noted that the amount of nutrients in the soil of options 5-8, where biohumus and mineral fertilizers were used, was significantly higher than in options 3 and 4, where only mineral fertilizers were used without biohumus.

From Appendix 7 and Table 10, in options 5-8, where biohumus was used, after the last feeding, compared to options 1-4, where feeding was carried out only with mineral fertilizers, nitrogen was 20-65 mg/kg or 16-82%, phosphorus was 20-50 mg/kg kg or 20-71%, and potassium 43-84 mg/kg or 26-67% can be seen.

A similar situation is observed in the option where manure is used. After each feeding, depending on the amount of manure used, an increase in nitrogen, phosphorus and potassium content was observed compared to the control option.

In the experiment, the amount of NPK in the soil of the greenhouse corresponding to the options 1-4, where feeding with biohumus was carried out up to two times, increases in accordance with the number of feedings with biohumus. For example, in the control variant where biohumus was not used at all, the amount of nitrogen is 61% of the amount of nitrogen in variant 2, where biohumus was used 1 time.

Of the options where feeding with biohumus was stopped, only 2 times biohumus was treated in the soil of option 4, which retained a high nitrogen content of 120.5 mg/kg.

The changes in the above laws can be observed in P and K as well. After the 3rd feeding, the amount of P and K in the soil of options 5 and 6 treated with mineral fertilizer and biohumus was 12-20 mg/kg in terms of phosphorus compared to the amount in the 4th option, where biohumus was used in the previous two feedings and only mineral fertilizer was used in the 3rd feeding, and potassium was higher by 22-43 mg/kg.

It was found that the amount of nutrients in the soil of the biohumus-applied option was higher in the 3rd year of the experiment than in the first year. For example, in the first year, in the 5th option, after the 3rd feeding, the amount of NPK accumulated in the soil of the greenhouse is 129.9; At 91.5 and 165.7 mg/kg, these indicators were N-165.6, P-126.6 and K-205.8 mg/kg in the 3rd year of the experiment (Appendix 6).

Table.1 Level of nutrient supply of greenhouse soil in cucumber cultivation

No	Availability level	Amount of nutrients, mg/l					Electrical conductivity at 25°C
		N_{common}	P_2O_5	K_2O	MgO	CaO	
1	Low	0-30	0-3,5	0-38	0-18	0-36	**0-0,5**
2	Less than normal	31-60	3,6-7,0	39-76	10-36	37-72	**0,6-1,0**
3	Normal	61-90	7,1-10,5	77-115	37-54	73-108	**1,1-2,0**
4	High from normal	91-120	10,6-14,0	116-154	55-72	109-144	**2,1-3,0**
5	**Veryhigh**	**121-150**	**14,1-17,5**	**155-190**	**73-90**	**145-180**	**3,1-4,0**

Table.2 Agrochemical parameters of unfertilized greenhouse soil

Years	pH	Humus, %	Gross amount of NPK , %			Amount of nutrients, mg/kg					CaO, %	MgO, %	Salt concentration, % soil to the mass relatively
			N	P	K	N_{common}	NO_3^-	NH_4^+	P_2O_5	K_2O			
2019	7,2	2,64	0,23	0,26	2,2	74	57,5	16,5	39,5	280,0	4,8	0,6	**0,18**
2020	7,3	3,05	0,28	0,29	2,1	79	61,4	17,6	39,0	277,0	4,3	0,9	**0,17**
2021	7,4	2,86	0,24	0,26	2,0	78	61,1	16,9	38,5	283,0	4,1	0,9	**0,19**
3 years average	**7,3**	**2,85**	**0,25**	**0,27**	**2,1**	**77**	**60,0**	**17,0**	**39,0**	**280,0**	**4,4**	**0,8**	**0,18**

Table.3 Some indicators of manure and biohumus used in greenhouse conditions

No	Determined indicator 3 years average	2019 years	2020 years	2021 years	3 years average
Chemical composition of manure					
1	Moisture%	69,0	67,8	65,7	**70,8**
2	Organic substances%	21,8	23,3	26,9	**24**
3	N,%	0,53	0,48	0,45	**0,49**
4	P_2O_5, %	0,41	0,37	0,42	**0,40**
5	$К_2O$,%	0,62	0,80	0,96	**0,79**
6	CaO,%	1,47	1,35	1,34	**1,39**
7	MgO,%	0,17	0,14	0,12	**0,14**
Chemical composition of biohumus					
8	pH saltymilk	7,3	7,0	7,3	**7,2**
9	Moisture %	62,0	60,6	60,8	**61,1**
10	Relative weight, g/cm3	0,71	0,73	0,72	**0,72**
11	Amount of humus, %	28,3	29,9	30,1	**29,4**
12	N, %	1,21	1,24	1,42	**1,29**
13	P_2O_5, %	0,83	0,77	0,83	**0,81**
14	$К_2O$, %	3,82	3,70	3,94	**3,82**
15	CaO, %	1,70	1,46	1,4	**1,52**
16	MgO, %	1,20	1,40	1,04	**1,21**
17	Cu, mg/kg	3,8	3,8	4,1	**3,90**
18	Zn, mg/kg	54,2	48,4	50,4	**51,0**
19	Co, mg/kg	0,3	0,4	0,2	**0,3**
20	Mn, mg/kg	61,8	64,0	63,8	**63,2**
21	**Fe, mg/kg**	**258,0**	**277,0**	**266,0**	**267,0**

Table.4 Pre-planting agrochemical analysis of greenhouse soil plowed with different amounts of mineral and organic fertilizers (biohumus, manure) (average 2019-2021)

No	Options	pH	Amount of mobile NPK in the soil before transplanting, mg/kg		
			N	P_2O_5	**K_2O**
1	$N_{350}P_{250}K_{170}$	6,67	98,5	60,7	**321,5**
2	$N_{350}P_{250}K_{170}$+$Б_{10}$(1)	6,73	120,8	74,4	**344,2**
3	$N_{350}P_{250}K_{170}$+$Б_{20}$(1+1)	6,90	124,8	75,1	**335,0**
4	$N_{350}P_{250}K_{170}$+$Б_{30}$(1+1+1)	6,83	125,1	80,0	**332,5**
5	$N_{350}P_{250}K_{170}$+$Б_{40}$(1+1+1+1)	6,90	123,2	75,0	**330,2**
6	$N_{350}P_{250}K_{170}$+$Б_{50}$) (1+1+1+1+1)	6,90	124,8	73,0	**336,8**
7	$Б_{50}$(2+1+1+1)	7,03	127,2	78,1	**346,2**
8	$Б_{80}$(3+2+1+1+1)	7,13	156,5	83,8	**376,0**
9	$N_{350}P_{250}K_{170}$+$Б_{40}$(40)	7,10	198,5	117,0	**430,7**
10	**$N_{350}P_{250}K_{170}$+H_{90}(3+2+2+2)**	**6,63**	**129,9**	**68,3**	**334,2**

Table.5 The result of pre-harvest agrochemical analysis of greenhouse soil (average amount of NPK, 2019-2021, mg/kg)

No	Options	pH	NPK available in greenhouse soil before first feeding, mg/kg		
			N	P_2O_5	K_2O
1	$N_{350}P_{250}K_{170}$	6,70	72,2	43,7	**210,2**
2	$N_{350}P_{250}K_{170}$+$Б_{10}$(1)	6,77	92,1	56,0	**233,2**
3	$N_{350}P_{250}K_{170}$+$Б_{20}$(1+1)	6,87	88,1	59,8	**230,1**
4	$N_{350}P_{250}K_{170}$+$Б_{30}$(1+1+1)	6,83	90,5	56,3	**224,9**
5	$N_{350}P_{250}K_{170}$+$Б_{40}$(1+1+1+1)	6,90	86,9	60,5	**230,6**
6	$N_{350}P_{250}K_{170}$+$Б_{50}$) (1+1+1+1+1)	6,90	95,0	55,2	**232,8**
7	$Б_{50}$(2+1+1+1)	7,00	89,4	54,2	**243,1**
8	$Б_{80}$(3+2+1+1+1)	7,10	116,0	63,6	**260,5**
9	$N_{350}P_{250}K_{170}$+$Б_{40}$(40)	7,00	148,8	101,8	**274,9**
10	**$N_{350}P_{250}K_{170}$+H_{90}(3+2+2+2)**	**6,73**	**102,2**	**54,5**	**218,4**

Table.6 The amount of nutrients accumulated in greenhouse soil after the first feeding (average, 2019-2021)

No	Options	pH	Amount of total NPK accumulated in greenhouse soil after first feeding, mg/kg		
			N	P_2O_5	K_2O
1	$N_{350}P_{250}K_{170}$	6,80	101,2	66,0	**233,2**
2	$N_{350}P_{250}K_{170}$+$Б_{10}$(1)	6,80	138,1	87,0	**281,1**
3	$N_{350}P_{250}K_{170}$+$Б_{20}$(1+1)	6,87	156,2	98,2	**296,1**
4	$N_{350}P_{250}K_{170}$+$Б_{30}$(1+1+1)	6,97	158,3	97,6	**294,4**
5	$N_{350}P_{250}K_{170}$+$Б_{40}$(1+1+1+1)	6,90	165,9	100,6	**295,6**
6	$N_{350}P_{250}K_{170}$+$Б_{50}$) (1+1+1+1+1)	6,90	162,2	110,1	**299,6**
7	$Б_{50}$(2+1+1+1)	7,10	154,7	87,1	**312,0**
8	$Б_{80}$(3+2+1+1+1)	7,10	215,2	125,0	**378,3**
9	$N_{350}P_{250}K_{170}$+$Б_{40}$(40)	7,07	241,3	151,8	**397,8**
10	**$N_{350}P_{250}K_{170}$+H_{90}(3+2+2+2)**	**6,53**	**164,4**	**84,8**	**292,5**

Table.7 The amount of NPK available in the greenhouse soil before the 2nd feeding of the plant during the period of gross productivity (average, 2019-2021)

No	Options	pH	NPK content in greenhouse soil before second feeding, mg/kg		
			N	P_2O_5	K_2O
1	$N_{350}P_{250}K_{170}$	6,80	35,4	32,5	**113,4**
2	$N_{350}P_{250}K_{170}$+$Б_{10}$(1)	6,67	59,7	49,0	**152,2**
3	$N_{350}P_{250}K_{170}$+$Б_{20}$(1+1)	6,83	77,5	55,5	**160,6**
4	$N_{350}P_{250}K_{170}$+$Б_{30}$(1+1+1)	6,80	79,7	57,5	**165,2**
5	$N_{350}P_{250}K_{170}$+$Б_{40}$(1+1+1+1)	6,90	83,3	57,1	**168,0**
6	$N_{350}P_{250}K_{170}$+$Б_{50}$)(1+1+1+1+1)	6,90	79,1	66,2	**174,5**
7	$Б_{50}$(2+1+1+1)	7,00	71,3	42,6	**167,1**
8	$Б_{80}$(3+2+1+1+1)	7,07	121,7	75,6	**237,5**
9	$N_{350}P_{250}K_{170}$+$Б_{40}$(40)	6,97	163,0	104,0	**230,0**
10	**$N_{350}P_{250}K_{170}$+H_{90}(3+2+2+2)**	**6,67**	**82,1**	**36,1**	**142,4**

Table.8 Amount of total nutrients accumulated in greenhouse soil after 2nd feeding (average, 2019-2021)

No	Options	pH	Amount of NPK after the second feeding, mg/kg		
			N	P_2O_5	K_2O
1	$N_{350}P_{250}K_{170}$	6,73	66,1	51,7	**150,0**
2	$N_{350}P_{250}K_{170}$+$Б_{10}$(1)	6,83	105,2	75,1	**195,9**
3	$N_{350}P_{250}K_{170}$+$Б_{20}$(1+1)	6,90	136,3	89,4	**229,1**
4	$N_{350}P_{250}K_{170}$+$Б_{30}$(1+1+1)	6,80	149,5	109,6	**260,5**
5	$N_{350}P_{250}K_{170}$+$Б_{40}$(1+1+1+1)	6,97	162,5	105,7	**257,7**
6	$N_{350}P_{250}K_{170}$+$Б_{50}$) (1+1+1+1+1)	6,93	155,3	113,2	**265,7**
7	$Б_{50}$(2+1+1+1)	7,00	122,1	78,7	**248,1**
8	$Б_{80}$(3+2+1+1+1)	7,10	232,6	129,0	**385,3**
9	$N_{350}P_{250}K_{170}$+$Б_{40}$(40)	6,97	213,4	140,8	**327,6**
10	**$N_{350}P_{250}K_{170}$+H_{90}(3+2+2+2)**	**6,60**	**155,1**	**70,8**	**229,8**

Table.9 The amount of NPK in the soil of the greenhouse before the 3rd feeding during the period of gross plant production (average, 2019-2021)

№	Options	pH	NPK content in greenhouse soil before the third feeding, mg/kg		
			N	P_2O_5	K_2O
1	$N_{350}P_{250}K_{170}$	6,80	19,7	25,0	**63,7**
2	$N_{350}P_{250}K_{170}$+$Б_{10}$(1)	6,83	41,4	45,0	**116,6**
3	$N_{350}P_{250}K_{170}$+$Б_{20}$(1+1)	6,87	39,9	47,8	**120,0**
4	$N_{350}P_{250}K_{170}$+$Б_{30}$(1+1+1)	6,80	69,9	58,7	**107,1**
5	$N_{350}P_{250}K_{170}$+$Б_{40}$(1+1+1+1)	6,93	68,0	58,3	**103,6**
6	$N_{350}P_{250}K_{170}$+$Б_{50}$) (1+1+1+1+1)	6,90	64,5	69,6	**114,8**
7	$Б_{50}$(2+1+1+1)	6,97	39,8	37,7	**104,7**
8	$Б_{80}$(3+2+1+1+1)	7,10	140,0	98,8	**233,2**
9	$N_{350}P_{250}K_{170}$+$Б_{40}$(40)	7,00	112,0	96,9	**168,2**
10	**$N_{350}P_{250}K_{170}$+H_{90}(3+2+2+2)**	**6,60**	**82,4**	**34,2**	**95,1**

Table.10 The amount of total NPK accumulated in the soil after the 3rd feeding during the gross production period of the plant (on average 2019-2021)

№	Options	pH	Amount of NPK in the soil after the third feeding, mg/kg		
			N	P_2O_5	K_2O
1	$N_{350}P_{250}K_{170}$	6,73	42,0	44,4	**83,6**
2	$N_{350}P_{250}K_{170}$+$Б_{10}$(1)	6,77	79,6	66,9	**110,1**
3	$N_{350}P_{250}K_{170}$+$Б_{20}$(1+1)	6,80	82,2	70,2	**123,9**
4	$N_{350}P_{250}K_{170}$+$Б_{30}$(1+1+1)	6,83	120,5	99,8	**170,2**
5	$N_{350}P_{250}K_{170}$+$Б_{40}$(1+1+1+1)	6,87	147,1	112,5	**186,6**
6	$N_{350}P_{250}K_{170}$+$Б_{50}$) (1+1+1+1+1)	6,90	143,6	121,0	**207,7**
7	$Б_{50}$(2+1+1+1)	6,93	87,0	68,7	**184,5**
8	$Б_{80}$(3+2+1+1+1)	7,07	210,5	144,0	**324,5**
9	$N_{350}P_{250}K_{170}$+$Б_{40}$(40)	6,93	145,6	122,6	**198,6**
10	**$N_{350}P_{250}K_{170}$+H_{90}(3+2+2+2)**	**6,63**	**165,4**	**68,1**	**177,0**

Table.11 The content of NPK in the soil of the greenhouse before the 4th feeding of the plant during the period of gross productivity (average, 2019-2021)

№	Options	pH	Amount of NPK in the soil before fourth feeding, mg/kg		
			N	P_2O_5	K_2O
1	$N_{350}P_{250}K_{170}$	6,73	16,2	25,4	**20,6**
2	$N_{350}P_{250}K_{170}$+$Б_{10}$(1)	6,73	33,4	49,9	**58,3**
3	$N_{350}P_{250}K_{170}$+$Б_{20}$(1+1)	6,77	34,8	45,3	**43,8**
4	$N_{350}P_{250}K_{170}$+$Б_{30}$(1+1+1)	6,80	60,3	65,2	**55,8**
5	$N_{350}P_{250}K_{170}$+$Б_{40}$(1+1+1+1)	6,87	58,7	69,1	**52,9**
6	$N_{350}P_{250}K_{170}$+$Б_{50}$) (1+1+1+1+1)	6,87	62,2	86,2	**64,6**
7	$Б_{50}$(2+1+1+1)	6,90	40,6	43,0	**88,7**
8	$Б_{80}$(3+2+1+1+1)	6,97	153,7	115,3	**223,8**
9	$N_{350}P_{250}K_{170}$+$Б_{40}$(40)	6,97	98,7	95,0	**108,8**
10	**$N_{350}P_{250}K_{170}$+H_{90}(3+2+2+2)**	**6,63**	**97,7**	**36,3**	**68,9**

Table.12 The content of NPK in the soil after the 4th feeding during the gross yield period of the plant (average, 2019-2021)

№	Options	pH	NPK content in greenhouse soil after 4-feeding, mg/kg		
			N	P_2O_5	K_2O
1	$N_{350}P_{250}K_{170}$	6,70	45,3	46,1	**43,2**
2	$N_{350}P_{250}K_{170}$+$Б_{10}$(1)	6,70	63,4	66,3	**81,6**
3	$N_{350}P_{250}K_{170}$+$Б_{20}$(1+1)	6,80	58,8	66,3	**70,6**
4	$N_{350}P_{250}K_{170}$+$Б_{30}$(1+1+1)	6,80	89,9	91,1	**92,9**
5	$N_{350}P_{250}K_{170}$+$Б_{40}$(1+1+1+1)	6,90	107,7	103,3	**99,7**
6	$N_{350}P_{250}K_{170}$+$Б_{50}$) (1+1+1+1+1)	6,90	123,7	122,5	**157,6**
7	$Б_{50}$(2+1+1+1)	7,00	65,6	62,7	**133,6**
8	$Б_{80}$(3+2+1+1+1)	7,10	188,9	137,3	**267,1**
9	$N_{350}P_{250}K_{170}$+$Б_{40}$(40)	7,00	126,4	114,3	**148,8**
10	**$N_{350}P_{250}K_{170}$+H_{90}(3+2+2+2)**	**6,67**	**127,0**	**59,3**	**108,3**

Table.13 The results of the analysis of soil composition after harvesting the entire crop (average 2019-2021)

№	Options	pH	Amount of NPK in the soil at the end of the growing season, mg/kg		
			N	P_2O_5	K_2O
1	$N_{350}P_{250}K_{170}$	6,73	18,9	32,8	**26,6**
2	$N_{350}P_{250}K_{170}$+$Б_{10}$(1)	6,77	27,9	51,7	**49,1**
3	$N_{350}P_{250}K_{170}$+$Б_{20}$(1+1)	6,87	34,9	49,8	**29,0**
4	$N_{350}P_{250}K_{170}$+$Б_{30}$(1+1+1)	6,80	45,5	73,8	**38,1**
5	$N_{350}P_{250}K_{170}$+$Б_{40}$(1+1+1+1)	6,90	50,8	80,3	**50,6**
6	$N_{350}P_{250}K_{170}$+$Б_{50}$) (1+1+1+1+1)	6,93	64,0	101,4	**100,4**
7	$Б_{50}$(2+1+1+1)	6,97	27,9	45,2	**92,9**
8	$Б_{80}$(3+2+1+1+1)	7,03	110,0	119,3	**221,0**
9	$N_{350}P_{250}K_{170}$+$Б_{40}$(40)	7,00	93,0	101,1	**92,5**
10	**$N_{350}P_{250}K_{170}$+H_{90}(3+2+2+2)**	**6,77**	**91,0**	**48,7**	**69,0**

Appendix.1 Pre-planting agrochemical analysis of greenhouse soil plowed with mineral and organic fertilizers (biohumus, gunk)

№	Options	pH	Amount of NPK in the soil before transplanting, mg/kg		
			Nм	P_2O_5	K_2O
		2019 years			
1	$N_{350}P_{250}K_{170}$	6,8	96,5	58,5	**323,5**
2	$N_{350}P_{250}K_{170}$+$Б_{10}$(1)	6,7	114,1	70,7	**331,8**
3	$N_{350}P_{250}K_{170}$+$Б_{20}$(1+1)	6,9	120,5	71,1	**327,0**
4	$N_{350}P_{250}K_{170}$+$Б_{30}$(1+1+1)	6,8	121,1	73,0	**322,8**
5	$N_{350}P_{250}K_{170}$+$Б_{40}$(1+1+1+1)	6,9	120,2	71,7	**319,9**
6	$N_{350}P_{250}K_{170}$+$Б_{50}$) (1+1+1+1+1)	6,9	121,1	70,7	**327,8**
7	$Б_{50}$(2+1+1+1)	7,0	122,2	70,4	**339,5**
8	$Б_{80}$(3+2+1+1+1)	7,1	150,3	80,1	**364,0**
9	$N_{350}P_{250}K_{170}$+$Б_{40}$(40)	7,0	194,4	108,0	**422,0**
10	$N_{350}P_{250}K_{170}$+H_{90}(3+2+2+2)	6,6	130,1	70,6	**340,1**
		2020years			
1	$N_{350}P_{250}K_{170}$	6,7	104,5	60,0	**322,5**
2	$N_{350}P_{250}K_{170}$+$Б_{10}$(1)	6,8	120,1	73,9	**344,8**
3	$N_{350}P_{250}K_{170}$+$Б_{20}$(1+1)	6,9	123,5	76,1	**337,0**
4	$N_{350}P_{250}K_{170}$+$Б_{30}$(1+1+1)	6,9	125,1	78,0	**332,8**
5	$N_{350}P_{250}K_{170}$+$Б_{40}$(1+1+1+1)	6,9	123,2	75,7	**329,9**
6	$N_{350}P_{250}K_{170}$+$Б_{50}$) (1+1+1+1+1)	6,9	124,1	72,7	**337,8**
7	$Б_{50}$(2+1+1+1)	7,0	126,2	77,4	**348,5**
8	$Б_{80}$(3+2+1+1+1)	7,1	156,6	83,1	**378,1**
9	$N_{350}P_{250}K_{170}$+$Б_{40}$(40)	7,2	197,0	119,8	**432,0**
10	$N_{350}P_{250}K_{170}$+H_{90}(3+2+2+2)	6,7	135,1	68,6	**334,1**
		2021years			
1	$N_{350}P_{250}K_{170}$	6,5	94,5	63,7	**318,5**
2	$N_{350}P_{250}K_{170}$+$Б_{10}$(1)	6,7	128,1	78,7	**356,1**
3	$N_{350}P_{250}K_{170}$+$Б_{20}$(1+1)	6,9	130,5	78,1	**341,0**
4	$N_{350}P_{250}K_{170}$+$Б_{30}$(1+1+1)	6,8	129,1	89,0	**341,8**
5	$N_{350}P_{250}K_{170}$+$Б_{40}$(1+1+1+1)	6,9	126,2	77,7	**340,9**
6	$N_{350}P_{250}K_{170}$+$Б_{50}$) (1+1+1+1+1)	6,9	129,1	75,7	**344,8**
7	$Б_{50}$(2+1+1+1)	7,1	133,2	86,4	**350,5**
8	$Б_{80}$(3+2+1+1+1)	7,2	162,6	88,1	**386,0**
9	$N_{350}P_{250}K_{170}$+$Б_{40}$(40)	7,1	204,0	121,8	**438,0**
10	**$N_{350}P_{250}K_{170}$+H_{90}(3+2+2+2)**	**6,6**	**124,5**	**65,7**	**328,5**

Appendix.2 The result of soil analysis before picking the first crop (NPK amount, mg/kg)

№	Options	pH	NPK available in greenhouse soil before first feeding, mg/kg		
			N	P_2O_5	K_2O
2019 years					
1	$N_{350}P_{250}K_{170}$	6,6	72,4	43,4	**198,0**
2	$N_{350}P_{250}K_{170}$+Б$_{10}$(1)	6,9	87,1	52,1	**226,8**
3	$N_{350}P_{250}K_{170}$+Б$_{20}$(1+1)	6,9	84,5	55,7	**219,5**
4	$N_{350}P_{250}K_{170}$+Б$_{30}$(1+1+1)	6,7	85,1	52,7	**209,7**
5	$N_{350}P_{250}K_{170}$+Б$_{40}$(1+1+1+1)	6,9	82,3	55,1	**222,8**
6	$N_{350}P_{250}K_{170}$+Б$_{50}$) (1+1+1+1+1)	6,9	91,1	51,9	**212,3**
7	Б$_{50}$(2+1+1+1)	6,9	83,2	50,4	**229,5**
8	Б$_{80}$(3+2+1+1+1)	7,1	108,3	61,1	**249,0**
9	$N_{350}P_{250}K_{170}$+Б$_{40}$(40)	7,0	142,4	95,8	**227,3**
10	$N_{350}P_{250}K_{170}$+H_{90}(3+2+2+2)	6,7	111,2	52,6	**225,1**
2020 years					
1	$N_{350}P_{250}K_{170}$	6,7	73,2	46,6	**209,6**
2	$N_{350}P_{250}K_{170}$+Б$_{10}$(1)	6,7	92,9	56,9	**230,6**
3	$N_{350}P_{250}K_{170}$+Б$_{20}$(1+1)	6,8	86,5	58,6	**232,1**
4	$N_{350}P_{250}K_{170}$+Б$_{30}$(1+1+1)	6,9	89,6	57,0	**222,8**
5	$N_{350}P_{250}K_{170}$+Б$_{40}$(1+1+1+1)	6,9	86,2	59,3	**230,4**
6	$N_{350}P_{250}K_{170}$+Б$_{50}$) (1+1+1+1+1)	6,9	94,8	55,2	**235,1**
7	Б$_{50}$(2+1+1+1)	7,0	88,3	54,2	**236,5**
8	Б$_{80}$(3+2+1+1+1)	7,1	117,0	64,0	**259,3**
9	$N_{350}P_{250}K_{170}$+Б$_{40}$(40)	7,0	148,0	102,2	**290,8**
10	$N_{350}P_{250}K_{170}$+H_{90}(3+2+2+2)	6,7	94,6	56,8	**217,2**
2021 years					
1	$N_{350}P_{250}K_{170}$	6,8	70,9	41,0	**223,0**
2	$N_{350}P_{250}K_{170}$+Б$_{10}$(1)	6,7	97,3	59,0	**242,3**
3	$N_{350}P_{250}K_{170}$+Б$_{20}$(1+1)	6,9	93,4	65,1	**238,7**
4	$N_{350}P_{250}K_{170}$+Б$_{30}$(1+1+1)	6,9	96,8	59,2	**242,3**
5	$N_{350}P_{250}K_{170}$+Б$_{40}$(1+1+1+1)	6,9	92,4	67,2	**238,6**
6	$N_{350}P_{250}K_{170}$+Б$_{50}$) (1+1+1+1+1)	6,9	99,3	58,4	**250,9**
7	Б$_{50}$(2+1+1+1)	7,1	96,9	58,1	**263,4**
8	Б$_{80}$(3+2+1+1+1)	7,1	124,0	65,7	**273,2**
9	$N_{350}P_{250}K_{170}$+Б$_{40}$(40)	7,0	156,0	107,4	**306,6**
10	**$N_{350}P_{250}K_{170}$+H_{90}(3+2+2+2)**	**6,8**	**100,9**	**54,0**	**213,0**

Appendix.3 The Amount of Nutrients Accumulated in Greenhouse Soil After the First Feeding

№	Options	pH	Amount of NPK in greenhouse soil after the first feeding, mg/kg		
			Nм	P_2O_5	K_2O
			2019 years		
1	$N_{350}P_{250}K_{170}$	6,8	101,4	62,4	**221,0**
2	$N_{350}P_{250}K_{170}$+$Б_{10}$(1)	6,9	131,1	81,1	**270,7**
3	$N_{350}P_{250}K_{170}$+$Б_{20}$(1+1)	6,9	151,2	94,8	**288,5**
4	$N_{350}P_{250}K_{170}$+$Б_{30}$(1+1+1)	7,0	150,2	92,0	**291,5**
5	$N_{350}P_{250}K_{170}$+$Б_{40}$(1+1+1+1)	6,9	161,2	92,8	**296,5**
6	$N_{350}P_{250}K_{170}$+$Б_{50}$) (1+1+1+1+1)	6,9	158,2	102,8	**286,5**
7	$Б_{50}$(2+1+1+1)	7,2	148,4	82,9	**301,0**
8	$Б_{80}$(3+2+1+1+1)	7,1	203,7	120,8	**361,1**
9	$N_{350}P_{250}K_{170}$+$Б_{40}$(40)	7,2	241,6	152,5	**383,5**
10	$N_{350}P_{250}K_{170}$+H_{90}(3+2+2+2)	6,5	183,4	87,3	**302,5**
			2020 years		
1	$N_{350}P_{250}K_{170}$	6,8	102,2	65,6	**232,6**
2	$N_{350}P_{250}K_{170}$+$Б_{10}$(1)	6,7	136,9	88,9	**280,5**
3	$N_{350}P_{250}K_{170}$+$Б_{20}$(1+1)	6,8	159,2	96,7	**295,1**
4	$N_{350}P_{250}K_{170}$+$Б_{30}$(1+1+1)	6,9	155,7	99,3	**289,6**
5	$N_{350}P_{250}K_{170}$+$Б_{40}$(1+1+1+1)	6,9	166,1	100,0	**293,1**
6	$N_{350}P_{250}K_{170}$+$Б_{50}$) (1+1+1+1+1)	6,9	161,9	109,1	**297,3**
7	$Б_{50}$(2+1+1+1)	7,0	153,5	88,7	**313,0**
8	$Б_{80}$(3+2+1+1+1)	7,1	212,4	123,7	**378,4**
9	$N_{350}P_{250}K_{170}$+$Б_{40}$(40)	7,0	237,2	148,9	**397,0**
10	$N_{350}P_{250}K_{170}$+H_{90}(3+2+2+2)	6,5	166,8	84,5	**284,6**
			2021 years		
1	$N_{350}P_{250}K_{170}$	6,8	99,9	70,0	**246,0**
2	$N_{350}P_{250}K_{170}$+$Б_{10}$(1)	6,8	146,3	91,0	**292,2**
3	$N_{350}P_{250}K_{170}$+$Б_{20}$(1+1)	6,9	158,1	103,2	**304,7**
4	$N_{350}P_{250}K_{170}$+$Б_{30}$(1+1+1)	7,0	168,9	101,5	**302,1**
5	$N_{350}P_{250}K_{170}$+$Б_{40}$(1+1+1+1)	6,9	170,3	108,9	**297,3**
6	$N_{350}P_{250}K_{170}$+$Б_{50}$) (1+1+1+1+1)	6,9	166,4	118,3	**315,1**
7	$Б_{50}$(2+1+1+1)	7,1	162,1	89,6	**321,9**
8	$Б_{80}$(3+2+1+1+1)	7,1	229,4	130,4	**395,3**
9	$N_{350}P_{250}K_{170}$+$Б_{40}$(40)	7,0	245,2	154,1	**412,8**
10	**$N_{350}P_{250}K_{170}$+H_{90}(3+2+2+2)**	**6,6**	**143,1**	**82,7**	**290,4**

Appendix.4 The amount of NPK present in the greenhouse soil before the 2nd feeding of the plant during the period of gross productivity

№	Options	pH	Amount of NPK present in greenhouse soil before second feeding, mg/kg		
			Nм	P_2O_5	K_2O
2019 years					
1	$N_{350}P_{250}K_{170}$	6,9	35,7	25,6	**113,6**
2	$N_{350}P_{250}K_{170}$+Б$_{10}$(1)	6,7	49,3	41,9	**123,8**
3	$N_{350}P_{250}K_{170}$+Б$_{20}$(1+1)	6,9	64,4	49,2	**140,5**
4	$N_{350}P_{250}K_{170}$+Б$_{30}$(1+1+1)	6,8	68,3	50,1	**148,2**
5	$N_{350}P_{250}K_{170}$+Б$_{40}$(1+1+1+1)	6,9	76,4	45,4	**143,6**
6	$N_{350}P_{250}K_{170}$+Б$_{50}$) (1+1+1+1+1)	6,9	71,4	54,3	**150,2**
7	Б$_{50}$(2+1+1+1)	7,0	65,5	38,0	**149,0**
8	Б$_{80}$(3+2+1+1+1)	7,1	105,0	66,4	**230,8**
9	$N_{350}P_{250}K_{170}$+Б$_{40}$(40)	7,0	153,0	98,0	**262,9**
10	$N_{350}P_{250}K_{170}+H_{90}$(3+2+2+2)	6,6	91,1	36,0	**132,3**
2020 years					
1	$N_{350}P_{250}K_{170}$	6,7	32,9	21,3	**103,1**
2	$N_{350}P_{250}K_{170}$+Б$_{10}$(1)	6,6	58,8	47,6	**150,6**
3	$N_{350}P_{250}K_{170}$+Б$_{20}$(1+1)	6,7	73,9	52,2	**146,7**
4	$N_{350}P_{250}K_{170}$+Б$_{30}$(1+1+1)	6,8	77,4	54,6	**159,0**
5	$N_{350}P_{250}K_{170}$+Б$_{40}$(1+1+1+1)	6,9	72,8	55,7	**158,7**
6	$N_{350}P_{250}K_{170}$+Б$_{50}$) (1+1+1+1+1)	6,9	74,7	64,7	**168,8**
7	Б$_{50}$(2+1+1+1)	7,0	68,8	40,6	**152,6**
8	Б$_{80}$(3+2+1+1+1)	7,0	121,1	70,9	**237,2**
9	$N_{350}P_{250}K_{170}$+Б$_{40}$(40)	6,9	161,0	104,1	**217,7**
10	$N_{350}P_{250}K_{170}+H_{90}$(3+2+2+2)	6,7	74,0	27,5	**127,4**
2021 years					
1	$N_{350}P_{250}K_{170}$	6,8	37,6	50,6	**123,6**
2	$N_{350}P_{250}K_{170}$+Б$_{10}$(1)	6,7	71,0	57,4	**182,3**
3	$N_{350}P_{250}K_{170}$+Б$_{20}$(1+1)	6,9	94,1	65,2	**194,7**
4	$N_{350}P_{250}K_{170}$+Б$_{30}$(1+1+1)	6,8	93,5	67,8	**188,5**
5	$N_{350}P_{250}K_{170}$+Б$_{40}$(1+1+1+1)	6,9	100,8	70,1	**201,6**
6	$N_{350}P_{250}K_{170}$+Б$_{50}$) (1+1+1+1+1)	6,9	91,3	79,5	**204,4**
7	Б$_{50}$(2+1+1+1)	7,0	79,5	49,3	**199,8**
8	Б$_{80}$(3+2+1+1+1)	7,1	139,0	89,4	**244,6**
9	$N_{350}P_{250}K_{170}$+Б$_{40}$(40)	7,0	175,0	110,0	**209,3**
10	**$N_{350}P_{250}K_{170}+H_{90}$(3+2+2+2)**	**6,7**	**81,2**	**44,7**	**167,6**

Appendix.5 Amount of total nutrients accumulated in greenhouse soil after second feeding

№	Options	pH	Amount of total NPK accumulated after the second feeding, mg/kg		
			Nм	P_2O_5	K_2O
2019 years					
1	$N_{350}P_{250}K_{170}$	6,8	63,9	44,6	**146,8**
2	$N_{350}P_{250}K_{170}$+Б$_{10}$(1)	6,9	95,8	62,1	**177,3**
3	$N_{350}P_{250}K_{170}$+Б$_{20}$(1+1)	6,9	128,0	75,9	**216,8**
4	$N_{350}P_{250}K_{170}$+Б$_{30}$(1+1+1)	6,8	134,5	103,0	**245,1**
5	$N_{350}P_{250}K_{170}$+Б$_{40}$(1+1+1+1)	6,9	150,7	93,0	**248,1**
6	$N_{350}P_{250}K_{170}$+Б$_{50}$) (1+1+1+1+1)	7,0	146,7	102,0	**245,0**
7	Б$_{50}$(2+1+1+1)	7,0	107,4	63,3	**228,8**
8	Б$_{80}$(3+2+1+1+1)	7,1	221,8	118,0	**366,0**
9	$N_{350}P_{250}K_{170}$+Б$_{40}$(40)	7,0	205,9	142,0	**315,7**
10	$N_{350}P_{250}K_{170}+H_{90}$(3+2+2+2)	6,5	164,0	72,5	**235,7**
2020 years					
1	$N_{350}P_{250}K_{170}$	6,8	51,9	40,7	**126,4**
2	$N_{350}P_{250}K_{170}$+Б$_{10}$(1)	6,7	102,3	71,7	**194,3**
3	$N_{350}P_{250}K_{170}$+Б$_{20}$(1+1)	6,9	135,4	91,7	**221,3**
4	$N_{350}P_{250}K_{170}$+Б$_{30}$(1+1+1)	6,8	144,0	108,8	**258,4**
5	$N_{350}P_{250}K_{170}$+Б$_{40}$(1+1+1+1)	6,9	159,4	104,9	**254,1**
6	$N_{350}P_{250}K_{170}$+Б$_{50}$) (1+1+1+1+1)	6,9	151,3	108,9	**268,2**
7	Б$_{50}$(2+1+1+1)	7,0	114,1	76,1	**239,1**
8	Б$_{80}$(3+2+1+1+1)	7,1	228,1	125,2	**381,2**
9	$N_{350}P_{250}K_{170}$+Б$_{40}$(40)	7,0	210,1	132,3	**322,8**
10	$N_{350}P_{250}K_{170}+H_{90}$(3+2+2+2)	6,7	142,0	61,4	**191,7**
2021 years					
1	$N_{350}P_{250}K_{170}$	6,6	82,6	70,0	**176,9**
2	$N_{350}P_{250}K_{170}$+Б$_{10}$(1)	6,9	117,5	91,5	**216,0**
3	$N_{350}P_{250}K_{170}$+Б$_{20}$(1+1)	6,9	145,6	100,7	**249,3**
4	$N_{350}P_{250}K_{170}$+Б$_{30}$(1+1+1)	6,8	170,1	117,0	**277,9**
5	$N_{350}P_{250}K_{170}$+Б$_{40}$(1+1+1+1)	7,1	177,4	119,3	**271,0**
6	$N_{350}P_{250}K_{170}$+Б$_{50}$) (1+1+1+1+1)	6,9	167,9	128,7	**283,8**
7	Б$_{50}$(2+1+1+1)	7,0	144,8	94,8	**276,3**
8	Б$_{80}$(3+2+1+1+1)	7,1	248,0	143,7	**408,6**
9	$N_{350}P_{250}K_{170}$+Б$_{40}$(40)	6,9	224,1	148,2	**344,4**
10	**$N_{350}P_{250}K_{170}+H_{90}$(3+2+2+2)**	**6,6**	**159,2**	**78,6**	**261,9**

Appendix.6 The amount of NPK in the soil of the greenhouse before the 3rd feeding during the period of gross plant productivity

№	Options	pH	Amount of NPK present in the greenhouse soil before the third feeding, mg/kg		
			Nм	P_2O_5	**K_2O**
			2019 years		
1	$N_{350}P_{250}K_{170}$	6,8	19,7	20,9	**76,9**
2	$N_{350}P_{250}K_{170}$+Б$_{10}$(1)	6,9	36,5	36,6	**102,7**
3	$N_{350}P_{250}K_{170}$+Б$_{20}$(1+1)	6,9	33,0	41,8	**107,1**
4	$N_{350}P_{250}K_{170}$+Б$_{30}$(1+1+1)	6,8	55,5	51,2	**93,2**
5	$N_{350}P_{250}K_{170}$+Б$_{40}$(1+1+1+1)	6,9	50,8	50,7	**92,2**
6	$N_{350}P_{250}K_{170}$+Б$_{50}$) (1+1+1+1+1)	6,8	52,7	61,9	**95,3**
7	Б$_{50}$(2+1+1+1)	7,0	32,9	32,5	**93,9**
8	Б$_{80}$(3+2+1+1+1)	7,1	135,0	86,0	**216,5**
9	$N_{350}P_{250}K_{170}$+Б$_{40}$(40)	7,0	100,0	83,7	**150,6**
10	$N_{350}P_{250}K_{170}$+Н$_{90}$(3+2+2+2)	6,6	90,7	22,5	**102,3**
			2020 years		
1	$N_{350}P_{250}K_{170}$	6,8	16,6	24,1	**44,0**
2	$N_{350}P_{250}K_{170}$+Б$_{10}$(1)	6,7	38,2	44,4	**111,9**
3	$N_{350}P_{250}K_{170}$+Б$_{20}$(1+1)	6,8	40,1	45,5	**118,6**
4	$N_{350}P_{250}K_{170}$+Б$_{30}$(1+1+1)	6,8	72,3	58,2	**103,6**
5	$N_{350}P_{250}K_{170}$+Б$_{40}$(1+1+1+1)	7,0	66,6	58,5	**105,8**
6	$N_{350}P_{250}K_{170}$+Б$_{50}$) (1+1+1+1+1)	6,9	61,9	70,7	**120,3**
7	Б$_{50}$(2+1+1+1)	7,0	38,9	37,6	**105,9**
8	Б$_{80}$(3+2+1+1+1)	7,1	139,0	93,6	**225,0**
9	$N_{350}P_{250}K_{170}$+Б$_{40}$(40)	7,0	109,9	96,1	**160,0**
10	$N_{350}P_{250}K_{170}$+Н$_{90}$(3+2+2+2)	6,7	77,5	29,8	**72,9**
			2021 years		
1	$N_{350}P_{250}K_{170}$	6,8	22,8	30,1	**70,1**
2	$N_{350}P_{250}K_{170}$+Б$_{10}$(1)	6,9	49,6	53,8	**135,2**
3	$N_{350}P_{250}K_{170}$+Б$_{20}$(1+1)	6,9	46,5	56,1	**134,3**
4	$N_{350}P_{250}K_{170}$+Б$_{30}$(1+1+1)	6,8	81,8	64,8	**124,4**
5	$N_{350}P_{250}K_{170}$+Б$_{40}$(1+1+1+1)	6,9	86,5	65,8	**112,9**
6	$N_{350}P_{250}K_{170}$+Б$_{50}$) (1+1+1+1+1)	7,0	78,8	76,1	**128,8**
7	Б$_{50}$(2+1+1+1)	6,9	47,5	43,0	**114,4**
8	Б$_{80}$(3+2+1+1+1)	7,1	146,0	117,0	**258,1**
9	$N_{350}P_{250}K_{170}$+Б$_{40}$(40)	7,0	126,0	111,0	**193,9**
10	**$N_{350}P_{250}K_{170}$+Н$_{90}$(3+2+2+2)**	**6,5**	**79,0**	**50,2**	**110,1**

Appendix.7 Amount of NPK contained in the soil of the greenhouse before the 4th feeding during the period of gross plant productivity

№	Options	pH	the amount of NPK contained in the soil before fourth feeding, mg/kg		
			Nм	P_2O_5	K_2O
			2019 years		
1	$N_{350}P_{250}K_{170}$	6,8	14,3	23,2	**19,3**
2	$N_{350}P_{250}K_{170}$+$Б_{10}$(1)	6,7	29,2	44,3	**47,5**
3	$N_{350}P_{250}K_{170}$+$Б_{20}$(1+1)	6,7	24,7	36,1	**30,6**
4	$N_{350}P_{250}K_{170}$+$Б_{30}$(1+1+1)	6,7	51,7	55,6	**42,8**
5	$N_{350}P_{250}K_{170}$+$Б_{40}$(1+1+1+1)	6,8	37,8	56,3	**37,9**
6	$N_{350}P_{250}K_{170}$+$Б_{50}$) (1+1+1+1+1)	6,8	51,7	68,6	**44,1**
7	$Б_{50}$(2+1+1+1)	7,0	37,1	36,4	**79,5**
8	$Б_{80}$(3+2+1+1+1)	7,1	149,0	102,0	**208,0**
9	$N_{350}P_{250}K_{170}$+$Б_{40}$(40)	7,0	90,0	78,6	**96,0**
10	$N_{350}P_{250}K_{170}$+H_{90}(3+2+2+2)	6,7	107,0	36,3	**73,1**
			2020 years		
1	$N_{350}P_{250}K_{170}$	6,6	10,9	22,7	**15,8**
2	$N_{350}P_{250}K_{170}$+$Б_{10}$(1)	6,7	33,1	49,9	**55,1**
3	$N_{350}P_{250}K_{170}$+$Б_{20}$(1+1)	6,7	34,9	42,4	**47,6**
4	$N_{350}P_{250}K_{170}$+$Б_{30}$(1+1+1)	6,9	59,1	66,4	**54,0**
5	$N_{350}P_{250}K_{170}$+$Б_{40}$(1+1+1+1)	6,9	64,6	73,5	**47,6**
6	$N_{350}P_{250}K_{170}$+$Б_{50}$) (1+1+1+1+1)	6,9	60,8	83,1	**63,7**
7	$Б_{50}$(2+1+1+1)	6,9	38,7	40,1	**84,6**
8	$Б_{80}$(3+2+1+1+1)	6,9	152,0	116,0	**228,0**
9	$N_{350}P_{250}K_{170}$+$Б_{40}$(40)	7,0	98,1	87,5	**108,7**
10	$N_{350}P_{250}K_{170}$+H_{90}(3+2+2+2)	6,6	94,5	32,1	**56,0**
			2021 years		
1	$N_{350}P_{250}K_{170}$	6,8	23,5	30,2	**26,7**
2	$N_{350}P_{250}K_{170}$+$Б_{10}$(1)	6,8	38,0	55,6	**72,2**
3	$N_{350}P_{250}K_{170}$+$Б_{20}$(1+1)	6,9	44,7	57,5	**53,1**
4	$N_{350}P_{250}K_{170}$+$Б_{30}$(1+1+1)	6,8	70,0	73,7	**70,7**
5	$N_{350}P_{250}K_{170}$+$Б_{40}$(1+1+1+1)	6,9	73,6	77,4	**73,1**
6	$N_{350}P_{250}K_{170}$+$Б_{50}$) (1+1+1+1+1)	6,9	74,1	107,0	**86,0**
7	$Б_{50}$(2+1+1+1)	6,8	46,1	52,6	**102,2**
8	$Б_{80}$(3+2+1+1+1)	6,9	160,0	128,0	**235,3**
9	$N_{350}P_{250}K_{170}$+$Б_{40}$(40)	6,9	108,0	119,0	**121,8**
10	**$N_{350}P_{250}K_{170}$+H_{90}(3+2+2+2)**	**6,6**	**91,6**	**40,4**	**77,7**

Appendix.8 The amount of NPK accumulated in the soil of the greenhouse after the 4th feeding of the plant during the period of gross productivity

№	**Options**	**pH**	**Amount of NPK accumulated in greenhouse soil after 4-feeding, mg/kg**		
			Nм	P_2O_5	K_2O
		2019 years			
1	$N_{350}P_{250}K_{170}$	6,7	43,3	27,6	**34,6**
2	$N_{350}P_{250}K_{170}$+Б$_{10}$(1)	6,7	58,2	53,7	**60,8**
3	$N_{350}P_{250}K_{170}$+Б$_{20}$(1+1)	6,8	46,2	50,1	**57,4**
4	$N_{350}P_{250}K_{170}$+Б$_{30}$(1+1+1)	6,8	80,7	81,3	**70,0**
5	$N_{350}P_{250}K_{170}$+Б$_{40}$(1+1+1+1)	6,9	91,8	91,4	**86,0**
6	$N_{350}P_{250}K_{170}$+Б$_{50}$) (1+1+1+1+1)	6,9	111,0	89,4	**137,2**
7	Б$_{50}$(2+1+1+1)	7,0	52,1	47,1	**124,3**
8	Б$_{80}$(3+2+1+1+1)	7,1	185,0	124,0	**276,7**
9	$N_{350}P_{250}K_{170}$+Б$_{40}$(40)	7,0	116,0	98,0	**179,3**
10	$N_{350}P_{250}K_{170}$+H$_{90}$(3+2+2+2)	6,6	134,0	42,7	**112,4**
		2020 years			
1	$N_{350}P_{250}K_{170}$	6,7	39,9	44,1	**45,1**
2	$N_{350}P_{250}K_{170}$+Б$_{10}$(1)	6,7	62,1	65,3	**88,4**
3	$N_{350}P_{250}K_{170}$+Б$_{20}$(1+1)	6,7	53,9	63,4	**74,4**
4	$N_{350}P_{250}K_{170}$+Б$_{30}$(1+1+1)	6,8	89,1	92,1	**101,2**
5	$N_{350}P_{250}K_{170}$+Б$_{40}$(1+1+1+1)	6,9	103,6	105,6	**91,7**
6	$N_{350}P_{250}K_{170}$+Б$_{50}$) (1+1+1+1+1)	6,9	119,8	130,0	**156,8**
7	Б$_{50}$(2+1+1+1)	7,0	68,7	60,8	**129,4**
8	Б$_{80}$(3+2+1+1+1)	7,1	186,0	138,0	**250,7**
9	$N_{350}P_{250}K_{170}$+Б$_{40}$(40)	7,0	123,1	116,9	**122,0**
10	$N_{350}P_{250}K_{170}$+H$_{90}$(3+2+2+2)	6,7	119,0	58,5	**85,3**
		2021 years			
1	$N_{350}P_{250}K_{170}$	6,7	52,5	66,6	**49,9**
2	$N_{350}P_{250}K_{170}$+Б$_{10}$(1)	6,7	70,0	80,0	**95,5**
3	$N_{350}P_{250}K_{170}$+Б$_{20}$(1+1)	6,9	76,2	85,5	**79,9**
4	$N_{350}P_{250}K_{170}$+Б$_{30}$(1+1+1)	6,8	100,0	100,0	**107,7**
5	$N_{350}P_{250}K_{170}$+Б$_{40}$(1+1+1+1)	6,9	127,6	113,0	**121,4**
6	$N_{350}P_{250}K_{170}$+Б$_{50}$) (1+1+1+1+1)	6,9	140,2	148,0	**178,9**
7	Б$_{50}$(2+1+1+1)	7,0	76,1	78,3	**147,0**
8	Б$_{80}$(3+2+1+1+1)	7,1	195,6	150,0	**273,9**
9	$N_{350}P_{250}K_{170}$+Б$_{40}$(40)	7,0	140,0	128,0	**145,2**
10	**$N_{350}P_{250}K_{170}$+H$_{90}$(3+2+2+2)**	**6,7**	**128,0**	**76,8**	**127,2**

Appendix.9 The results of the analysis of soil composition after harvesting the entire crop

№	Options	pH	Amount of NPK in harvested soil, mg/kg		
			Nм	P_2O_5	K_2O
		2019 years			
1	$N_{350}P_{250}K_{170}$	6,7	18,9	23,0	**25,6**
2	$N_{350}P_{250}K_{170}$+Б$_{10}$(1)	6,7	27,9	41,5	**30,2**
3	$N_{350}P_{250}K_{170}$+Б$_{20}$(1+1)	6,8	34,9	34,3	**20,3**
4	$N_{350}P_{250}K_{170}$+Б$_{30}$(1+1+1)	6,8	45,5	56,2	**29,7**
5	$N_{350}P_{250}K_{170}$+Б$_{40}$(1+1+1+1)	6,9	50,8	52,8	**36,4**
6	$N_{350}P_{250}K_{170}$+Б$_{50}$) (1+1+1+1+1)	6,9	64,0	67,3	**78,3**
7	Б$_{50}$(2+1+1+1)	7,0	27,9	27,6	**75,5**
8	Б$_{80}$(3+2+1+1+1)	7,1	110,0	108,0	**203,0**
9	$N_{350}P_{250}K_{170}$+Б$_{40}$(40)	7,0	93,0	78,2	**75,0**
10	$N_{350}P_{250}K_{170}$+H_{90}(3+2+2+2)	6,8	91,0	39,9	**78,3**
		2020 years			
1	$N_{350}P_{250}K_{170}$	6,7	16,3	29,5	**22,9**
2	$N_{350}P_{250}K_{170}$+Б$_{10}$(1)	6,7	40,4	50,5	**45,0**
3	$N_{350}P_{250}K_{170}$+Б$_{20}$(1+1)	6,9	35,4	49,8	**24,8**
4	$N_{350}P_{250}K_{170}$+Б$_{30}$(1+1+1)	6,8	63,4	75,0	**35,9**
5	$N_{350}P_{250}K_{170}$+Б$_{40}$(1+1+1+1)	6,9	76,2	87,0	**49,0**
6	$N_{350}P_{250}K_{170}$+Б$_{50}$) (1+1+1+1+1)	7,0	79,7	107,0	**97,0**
7	Б$_{50}$(2+1+1+1)	6,9	35,1	42,6	**91,3**
8	Б$_{80}$(3+2+1+1+1)	6,9	137,5	114,0	**221,0**
9	$N_{350}P_{250}K_{170}$+Б$_{40}$(40)	7,0	107,1	95,0	**88,6**
10	$N_{350}P_{250}K_{170}$+H_{90}(3+2+2+2)	6,8	90,1	44,4	**34,1**
		2021 years			
1	$N_{350}P_{250}K_{170}$	6,8	20,2	45,9	**31,2**
2	$N_{350}P_{250}K_{170}$+Б$_{10}$(1)	6,9	50,0	63,1	**72,1**
3	$N_{350}P_{250}K_{170}$+Б$_{20}$(1+1)	6,9	48,6	65,3	**41,9**
4	$N_{350}P_{250}K_{170}$+Б$_{30}$(1+1+1)	6,8	75,1	90,2	**48,8**
5	$N_{350}P_{250}K_{170}$+Б$_{40}$(1+1+1+1)	6,9	90,0	101,0	**66,3**
6	$N_{350}P_{250}K_{170}$+Б$_{50}$) (1+1+1+1+1)	6,9	101,0	130,0	**126,0**
7	Б$_{50}$(2+1+1+1)	7,0	49,4	65,5	**112,0**
8	Б$_{80}$(3+2+1+1+1)	7,1	146,0	136,0	**239,0**
9	$N_{350}P_{250}K_{170}$+Б$_{40}$(40)	7,0	116,0	130,0	**114,0**
10	**$N_{350}P_{250}K_{170}$+H_{90}(3+2+2+2)**	**6,7**	**100,0**	**61,8**	**94,6**

Despite the fact that the amount of manure used in the options with manure was higher than the amount of biohumus, the increase in the amount of nutrients in the soil was lower than in the options where biohumus was used.

Soil analysis in options where feeding with biohumus was stopped during the period of gross yield of cucumbers showed a significant decrease in the amount of nutrients in the soil at the later stages of plant development.

From the third feeding to the fourth feeding, nitrogen in the control variant was from 42.0 mg/kg to 16.2 mg/kg; phosphorus decreased from 44.4 mg/kg to 25.4 mg/kg and potassium decreased from 83.6 mg/kg to 20.6 mg/kg. By this period (that is, before the 4th feeding), the amount of NPK in options 1-3 was on average 25-40% of the total amount of NPK accumulated after the 3rd feeding.

After the 3rd feeding, the highest rate of absorbed nitrogen (61%) corresponded to the first control variant, and the lowest absorption (27%) corresponded to the 8th variant. It was found that the amount of total available phosphorus absorbed by plants of different variants was from 25 to 43%, and the absorbed amount of potassium was from 31 to 75%.

4th feeding with mineral fertilizer and biohumus according to the experimental plan implemented only in option 6.

From Table 12, the amount of mobile nitrogen, phosphorus and potassium in the soil of option 6, where biohumus was used at the rate of 1 kg/m2 in the fourth feeding, is 2.0, respectively, compared to their initial amounts before feeding (Table 11 and Appendix 7); It can be seen that it has increased by 1.4 and 2.4 times.

Thus, repeated feeding with biohumus significantly increased the amount of nutrients in the soil. In options 1-3, where biohumus was not used in subsequent feeding, significantly lower NPK content was observed. In all the years of the study, the amount of NPK in the soil of the experimental field decreased significantly by the time of harvest. At this time, the advantage of NPK in biohumus-fed variants was preserved compared to the control variant.

In all options, the amount of mineral nitrogen in the soil increased in accordance with the number of feedings. In some cases, the results of determination of nitrogen content obtained in different years under the same option are not repeated (Appendix 8).

But in most cases, the difference between the results of the experiment in the same variant is not big. A similar situation was observed for phosphorus and potassium.

When growing cucumbers in greenhouse conditions, potassium in the soil increases the yield of the plant and improves the quality of the product. Generally, when cucumbers are grown in soil with low potassium content, the proportion of non-standard crops increases. In all years of the study, there was a tendency to decrease K_2O in the soil with harvest. A relatively high amount of exchangeable potassium was preserved in the variants where biohumus was used a lot.

Thus, from the results of the agrochemical analysis of the soil corresponding to different stages of plant development, in the studies conducted on the cultivation of cucumbers in greenhouse conditions, it was noted that the amount of nutrients in the soil was significantly reduced due to the formation of the amount of biomass corresponding to the dose of biohumus by the time of the harvest. It should be noted that the use of biohumus in combination with mineral fertilizer during the cultivation of cucumbers in greenhouse conditions made it possible to maintain the amount of nitrogen in the experimental plot at the same level as it was before planting seedlings at different stages of plant development. The above trend was also maintained in the amount of P_2O_5 and K_2O in greenhouse soil after harvesting.

During the three-year research, after harvesting and ending the experiment, the amount of nutrients in the plow layer of the soil of the experimental plot was monitored. Table 13 shows the three-year average of the amount of nutrients in the soil after the experiment was completed in 2019-2021.

From the results of the analysis of the fully harvested soil, it was observed that in the third year of the experiment in greenhouse conditions, the amount of NRC in the soil was 1.8-2.0 times higher than the amount of residual NRC in the first year of the experiment (Appendix 9). In the control variant where biohumus was not used, such an increase in the amount of nutrients was not observed in the following years of the experiment.

Comparing the amount of NPK determined after feeding for each option with the amount of NPK before feeding in these options shows the increase in the amount of nutrients in 2019-2021: N-1.2-1.7; P-1.2-2.0; It shows that K–1.2-2.3 times. This mainly corresponded to options 5-8, where feeding with biohumus in the amount of 1.0 kg/m2 was carried out in several stages. According to option 5, the amount of nitrogen in the soil increased from 50 mg/kg to 90 mg/kg, the amount of phosphorus from 53 mg/kg to 101 mg/kg, and the amount of potassium from 49 mg/kg to 66 mg/kg was observed in the 3rd year.

In option 9, where 4.0 kg/m^2 of biohumus was used under the plow, at the end of the experiment, the amount of NPK in the soil of the experimental plot decreased from the optimum. At the end of the experiment, a significant decrease in NPK was observed in the soil of the site where manure was used at the rate of 2 kg/m2 for feeding. As a result of intensive use of the soil in greenhouse conditions, it was observed that the amount of mineral substances necessary for the development of the plant, especially micro- and macroelements in the mobile form, in the soil of the control option, where only mineral fertilizer was used, was significantly reduced. Usually, in such cases, it is required to use high-quality mineral fertilizers and other chemical compounds in order to obtain a high yield under closed soil conditions. As a result, an excess amount of harmful chemicals accumulates in the crop. The use of biohumus during feeding prevents such unpleasant situations.

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