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Influence of the fertiliser system on the soil nutrient regime and onion productivity

Abstract. Modern approaches to optimising the nutrition of vegetable plants often have low efficiency and negatively affect various components of the agrobiocoenosis (soil, microbiota). In this regard, the purpose of the study was to determine the influence of various fertiliser systems on the yield and quality of onions in irrigated vegetable-fodder crop rotation, changes in the main agrochemical and microbiological parameters of the soil. The study was conducted in the laboratory of agrochemical research and quality of products of the Institute of Vegetable and Melon Growing of NAAS of Ukraine. Research methods: long-term stationary field experiment; laboratory determination of agrochemical and microbiological parameters of soil and biochemical composition of bulbs; statistical data processing. It is determined that a significant increase in the content of nitrate nitrogen in the arable soil layer is provided by the use of mineral fertilisers, mobile compounds of phosphorus and potassium – mineral and systems. The use of mineral fertilisers leads to an increase in the number of fungi in the soil rhizosphere and a decrease in the potential activity of nitrogen fixation, which worsens the microbiological activity of the soil. The application of organic fertilisers in combination with mineral fertilisers leads to an increase in the number of nitrogen-fixing microorganisms and potential nitrogen-fixing activity, which improves soil fertility. The use of organo-mineral and mineral fertiliser systems leads to an increase in the yield of onions by 6.6-8.6 t/ha or 41.3-53.8%. When using biologised nutrition optimisation systems, the yield increases by

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19.4-23.8%. The maximum level of onion yield is indicated for the introduction of organo-mineral fertiliser systems (63 t/ha of humus + randomly $N_{45}P_{45}K_{45}$; 36 t/ha of humus + locally $N_{45}P_{45}K_{45}$); causing an increase in yield by 8.2-8.6 t/ha. There is a certain pattern of a decrease in the dry matter content in bulbs and an increase in the nitrate content under various fertiliser systems. The research materials are of practical value for the implementation of nutrition optimisation systems aimed at both sustainable growth in the yield of vegetable products and maintaining the level of soil fertility of vegetable agrobiocoenoses

Keywords: nutrition optimisation, vegetable and fodder crop rotation, yield, quality composition of the bulb

INTRODUCTION

Onions are a valuable vegetable plant that ranks first among other vegetable crops in terms of world production. Increasing gross production without expanding the area of sowing crops is possible only through the use of intensive cultivation technologies, where the key aspect is the system of nutrition optimisation (fertilisation). At the same time, the use of high fertiliser rates often has a number of negative consequences: deterioration of product quality, accumulation of nitrates in bulbs, and negative impact on the microbiota and soil fertility parameters (Horodniy & Bykina, 2000).

There are many opinions of researchers regarding the mechanisms of improving the nutrient regime of the soil and the efficiency of applying various types of fertilisers (Armstrong *et al*., 2000; Kuts *et al*., 2017 Novikova, 2020;). Some researchers suggest that the most effective factor in increasing the availability of mobile forms of nitrogen, phosphorus and potassium in the arable soil layer is the use of mineral fertilisers, especially the localisation of their application (Backes *et al*., 2018; Bezabih & Girmay, 2020). A number of agricultural chemists point to a decrease in the mobility of nutrients at the end of the growing season of agricultural crops for the use of mineral fertilisers, and a more prolonged positive effect on the soil nutrient regime for the use of organic fertilisers (Diaz-Perez *et al*., 2018). According to the results of a number of studies, it was found that the most effective way to improve the nutrient regime of the soil during the entire growing season of plants is to use the organo-mineral fertiliser system (Colla *et al*., 2018; Moraes *et al*., 2018; Moraiet & Ansari, 2022). The level of soil fertility also depends on the fertiliser system, since fertilisers affect many parameters of fertility: nutrient regime, absorption capacity, structure and water-physical properties, microbiological activity, etc.

Different fertiliser systems have different effects on crop rotation productivity and soil fertility indicators (Moraes *et al*., 2018; Bezabih & Girmay, 2020;). It is established that the effectiveness of fertilisers varies depending on the level of soil fertility, doses and methods of fertilisation, balance in nutrition elements, and distribution of fertilisers between crop rotations (Kuts *et al*., 2017; Novikova, 2020;). Many studies have found that the use of a mineral fertiliser system contributes to an increase in soil degradation processes and a gradual decrease in crop rotation productivity. Thus, in studies on acidic forest soils of the Western Forest-Steppe, long-term use of mineral fertilisers caused a decrease in crop rotation productivity relative to the option without fertilisers (Backes *et al*., 2018;). Whereas systematic joint application of the organo-mineral fertiliser system on the liming background (10 t/ha of manure + $N_{65}P_{68}K_{68}$) contributes to the development of high crop rotation productivity at the level of 6.15-6.78 t/ha of grain units (Kaminsky *et al*., 2012). Many researchers have proven that a combination of organic and mineral fertilisers plays an important role in optimising crop nutrition in crop rotation (Backes *et al*., 2018; Colla *et al*., 2018). But for the combination of applying organic and mineral fertilisers, the dose of the latter should be optimised considering the amount of nutrients in the composition of organic fertilisers, the availability of soil, and the crop rotation system (Backes *et al*., 2018). The use of manure combined with mineral fertilisers increases the efficiency of the latter, promotes the growth of yield and product quality, increases the recycling of nutrients and carbon in agrocoenoses, ensures the preservation and reproduction of soil fertility (Backes *et al*., 2018; Colla *et al*., 2018; Erkalo *et al*., 2022).

The efficiency of using mineral fertiliser systems in technological schemes for growing onions depends on the type of soil, technological growing conditions, and irrigation conditions. For each soil, climatic and technological growing conditions, a certain range of fertiliser rates can be distinguished, which is economically feasible. Thus, according to Ethiopian researchers, in irrigation conditions, it is economically feasible to apply the fertiliser for growing onions at a rate $N_{200}P_{220}S_{40}$, which provides a yield of 47.4 t/ha, causes an increase in the height of the plant, the length of leaves, the diameter and length of the bulb, its average weight, the content of dry soluble substances in the bulbs (Shura *et al*., 2022). According to Iraqi researchers, by using conditionally suitable water for irrigation, an increase in the efficiency of fertilisers depends on the norm of potassium, which is economically feasible in the range of 60-80 kg/ha (Khalefah *et al*., 2022).

Localisation of the use of mineral fertilisers is also a source of increasing their efficiency, which is especially important for nitrogen fertilisers. In the research by Mexican scientists, local application of nitrogen fertilisers provided a significant increase in bulb weight and

yield, but often created conditions for excessive supply of nitrogen to plants, which caused the appearance of a thick neck, germination and rotting of bulbs during storage (Kitila *et al*., 2022).

In conditions of a shortage of organic fertilisers, a combination of green manure and microbiological fertilisers can be used as an alternative. Thus, the use of microbiological fertilisers (Azotovit, Phosphatovit) for growing onions contributes to an increase in the leaf surface area by 27-80 cm^2, increase in yield by 0.9-3.9 /ha or by 6.0-26.3% (Kanevskaya, 2022). The range of microbiological preparations for optimising nutrition and enhancing plant growth processes is constantly growing, which allows introducing comprehensive solutions to the problem of mineral nutrition of plants.

Currently, the problem of studying the influence of various fertiliser systems on soil fertility, its agrochemical and microbiological state in vegetable agrobiocoenoses remains neglected. The solution of this problem would allow creating or correcting fertiliser systems for vegetable plants, which, in addition to increasing yields, will ensure the preservation or reproduction of soil fertility, reduce the chemical load on plant communities, and increase the economic efficiency of using fertilisers, especially mineral fertilisers.

The purpose of the study – to investigate the dynamics of agrochemical and microbiological parameters of the arable soil layer, the level of yield and qualitative composition of onion products under various fertiliser systems in the irrigated vegetable-fodder crop rotation of the Left-Bank Forest-Steppe of Ukraine.

MATERIALS AND METHODS

Scientific research was conducted at the Institute of Vegetable and Melon Growing of the National Academy of Agrarian Sciences of Ukraine in the laboratory of agrochemical research and quality of products, during 2018-2020. The soil of the experimental site is represented by typical low-humus heavy loamy chernozem on loessial soil (humus content – 4.3%; hydrolysed nitrogen – 139; mobile phosphorus – 135-352, and exchange potassium – 66-177 mg/kg of soil, pH of salt extract – 5.7).

The study is a continuation of the long-term stationary experiment that was started in 1968. Determination of the effectiveness of various fertiliser systems was carried out in an irrigated 9-field vegetable-fodder crop rotation: barley with the sowing of perennial grasses – alfalfa of the first and second years of use – cucumber – winter wheat – onion – tomato – white cabbage – table beet.

Field studies were conducted according to the experiment scheme:

1. No fertiliser (control)
2. Humus 36 t/ha (scattered)
3. $N_{90}P_{90}K_{90}$ (randomly)
4. $N_{320}P_{200}K_{130}$ (randomly) + foliar top dressing with Reakom–SO in three terms.
5. Humus 36 t/ha +$N_{45}P_{45}K_{45}$ (randomly)
6. Humus 63 t/ha +$N_{45}P_{45}K_{45}$ (randomly)
7. Humus 36 t/ha +$N_{45}P_{45}K_{45}$ (locally)
8. Humus 63 t / ha +$N_{22.5}P_{22.5}K_{22.5}$ (locally)
9. Green manure system of onions includes ploughing 3 t/ha of straw with the addition of Ecostern stubble biodestructor (1 l/ha) + soaking seeds in a solution of Azotofit-r biological preparation (1 l/t) + foliar top dressing with a solution of Organik balans biological preparation (1 l/ha) in three terms

Biologised fertiliser system includes an aftereffect of 40 t/ha (applied to the predecessor – cucumber) + ploughing of 3 t/ha of straw with the addition of Ecostern stubble biodestructor (1 l/ha) + soaking of seeds in a solution of Azotofit-r biological preparation (1 l/r) + foliar top dressing with a solution of Organik balans biological preparation (1 l/ha) in three terms

Foliar top dressing was carried out in three periods: phase 3-4 of true leaves, phase 6-8 of true leaves, and the beginning of bulb formation.

Total plot area 58.3 m^2, accounting area – 19.6 m^2, repetition – four-fold, systematic placement of plots in two tiers (Bondarenko & Yakovenko, 2001).

In soil samples, the content of nitrate nitrogen was determined: in fresh – the content of nitrate nitrogen (DSTU 4729:2007, 2008) colourimetrically with disulfophenolic acid, in air-dry – mobile phosphorus compounds and exchange potassium according to the modified Chirikov method, followed by determination of phosphorus – photometrically, potassium – on a flame photometer (DSTU 4115-2002, 2003).

Determination of soil microbiological activity included determination of:

– the number of fungi using the cup method on an acidified Czapek medium (Zvyagintseva, 1980);

– the number of nitrogen-fixing microorganisms using the method of limit dilutions using acetylene test on Ashby semi-liquid media (Villemin *et al*., 1974);

– potential activity of nitrogen fixation (activity that is noted for the formation of optimal carbon, temperature and water regimes for nitrogen-fixing microorganisms) for the use of the acetylene method in rhizospheric soil with the addition of glucose solution (Umarov, 1976; Bilay, 1982);

– the mineralisation coefficient (an indicator of the intensity of the processes of mineralisation and assimilation of nitrogen compounds in the soil, expressed by the ratio of the number of bacteria and streptomycetes that absorb mineral forms of nitrogen (cultivated on starch-ammonia agar), to the number of bacteria that consume nitrogen of organic compounds (cultivated on meat-peptone agar) (Zvyagintseva, 1980).

The quality of onion products was determined using the following methods: dry matter – (DSTU 7804:2015, 2016), total sugar – (DSTU 4954:2008, 2009), ascorbic acid – (DSTU 7803:2015, 2016), nitrates – (DSTU 4948:2008, 2009).

Onions of the Tkachenkivska variety were grown according to the technology recommended for the zone (DSTU 8072:2015, 2017): cultivation – ploughing for 22-25 cm with continuous cultivation in autumn and early spring harrowing; sowing seeds in the third 10 days of March – first 10 days of April with a norm of 650 thousand units/ha; irrigation – sprinkling in 4 terms with a rate of 250-35 m^3/ha; plant protection – a complex of recommended herbicides, fungicides, and insecticides; harvesting with mechanical digging and drying of bulbs in the field.

RESULTS AND DISCUSSION

The results of studies show that the content of mobile forms of basic nutrients in 0-30 cm soil layer during the cultivation of onions significantly varied depending on fertiliser systems. Thus, in the control option, the amount of nitrate nitrogen was the lowest and ranged from 23.6-26.5 mg/100 g of soil. Application of high doses of mineral fertilisers ($N_{320}P_{200}K_{130}$ + top dressing "Reakom-SO") caused the highest accumulation of nitrate nitrogen in 0-30 cm soil layer during all periods of soil analysis from 111.9 in June to 45.9 mg/kg before harvesting (Fig. 1).

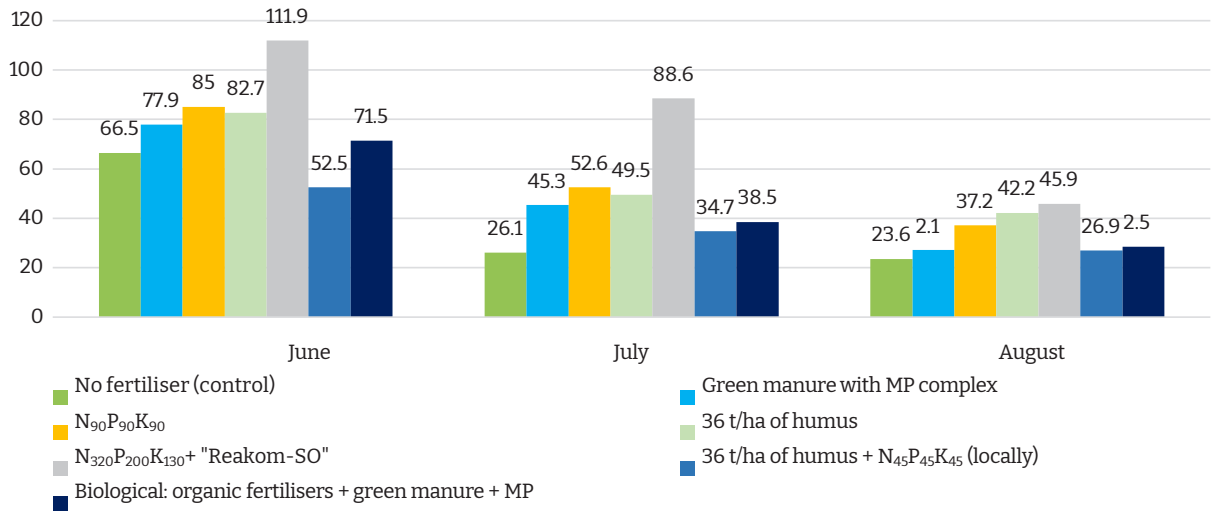

Figure 1. Content of nitrate nitrogen in the 0-30 cm soil layer, depending on the fertiliser system (average for 2018-2020)

A high level of soil supply with nitrogen compounds is also noted during the period of maximum increase in the vegetative mass of the bulb (June – July) according to the nutrition optimisation system for the use of straw as green manure in combination with microbial preparations (45.3-77.9 mg/kg), for the introduction of $N_{90}P_{90}K_{90}$ (52.6-85.0 mg/kg) and 36 t/ha of humus (49.5-82.7 mg/kg).

During the period of physiological ripeness, the amount of nitrate nitrogen sharply decreases to the level of 26.8-45.9 mg/kg of soil according to the fertiliser systems under study. The explanation for this phenomenon is, firstly, the active accumulation of nitrogenous substances by plants, and secondly, the migration of soil nitrogen compounds to the suborder layer of the soil. However, the pattern characteristic of previous periods is also noted in the future: the combined use of mineral and organic fertilisers causes high values of the indicator (37.2-45.9 mg/kg of dry soil); the use of straw ploughing in combination with microbial preparations provides a lower level of nitrogen regime in the soil (27.1-28.5 mg/kg of dry soil).

Thus, it is noted that the improvement of the nitrogen regime of the soil provides, in addition to the use of high doses of nitrogen fertilisers (N_{320}), also the use of organic fertilisers (humus). At the same time, there is no peak increase in the provision of the arable soil layer with nitrate nitrogen in the initial periods of vegetation of the crop, as with the use of $N_{320}P_{200}K_{130}$, but this parameter increases with the introduction of organic and organo-mineral fertiliser systems relative to control (by 105-120%). Such data are noted in the research of South Korean scientists (Lee, 2010).

It is indicated that the joint application of organic and mineral fertilisers (locally $N_{45}P_{45}K_{45}$) creates the best conditions for phosphorous nutrition for onion plants (Fig. 2). Under such conditions, the content of mobile phosphorus compounds in the soil increases to 316-352 mg/kg of dry soil, depending on the development phases of onion plants.

Application of $N_{90}P_{90}K_{90}$ and $N_{320}P_{200}K_{130}$ in combination with microfertilisers Reakom-SO contributes to a high level of provision of the arable soil layer with mobile phosphorus compounds – 252-320 mg/kg of dry soil.

When using organic fertilisers and ploughing straw with microbial preparations, the content of mobile phosphorus was almost at the same level and amounted to 239-252 mg/kg for organic systems and 241-281 mg/kg for biological fertiliser systems, which significantly exceeded the control (142-156 mg/kg of dry soil). It is also noted that if the mineral and organic fertiliser systems of onions provide the soil with mobile phosphorus compounds during the growing season does not change, then

with the use of a biological fertiliser system (organic fertilisers + straw + microbial preparations) there is a certain tendency to reduce the content of mobile phosphorus compounds at the end of the growing season of the crop.

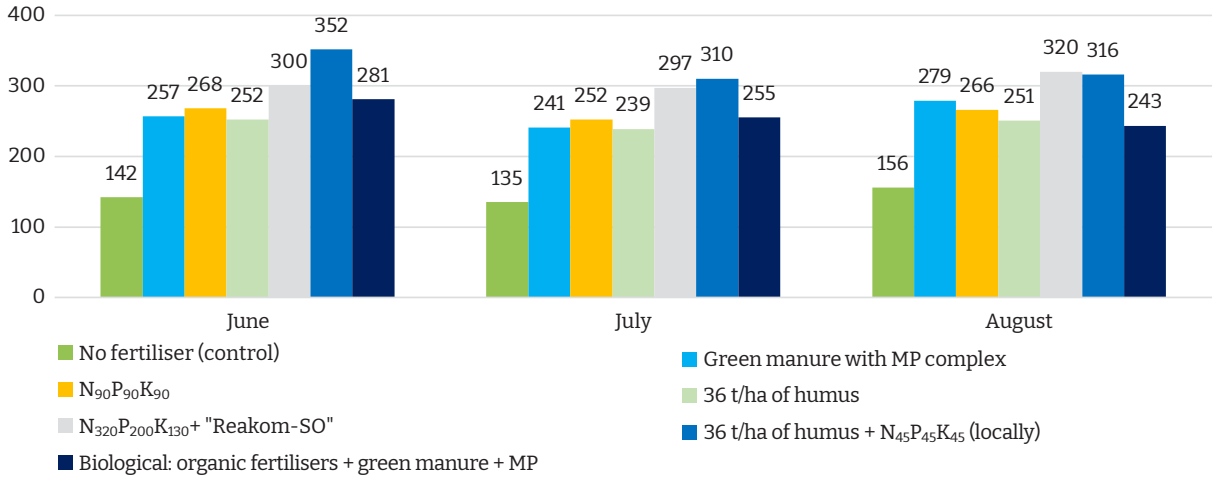

Figure 2. Dynamics of mobile phosphorus in 0-30 cm soil layer depending on the fertiliser system of Tkachenkivska onion variety (average for 2018-2020)

Similar patterns are also inherent in the supply of potassium (Figure 3). During the growing season, a high level of soil supply with potassium mobile compounds is indicated for organo-mineral (36 t/ha humus + locally $N_{45}P_{45}K_{45}$) and biologised systems for optimising plant nutrition (with the content of exchange potassium in 0-30 cm soil layer at the level of 148-177 mg/kg of soil). For the green manure fertiliser system with a complex of microbial preparations, the content of exchange potassium in the soil significantly exceeded the control – 66-79 mg/kg of dry soil, although it was less than for the biological fertiliser system (98-106 mg/kg).

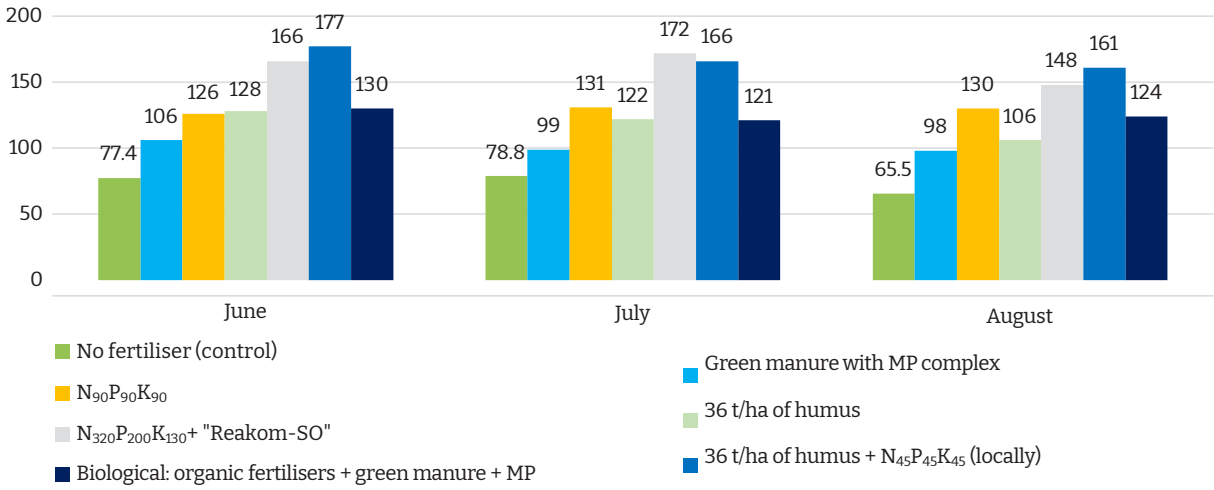

Figure 3. Content of exchange potassium in 0-30 cm soil layer, depending on the onion fertilisation system (average for 2018-2020)

Thus, the introduction of biologised and green manurefertiliser systems with a complex of microbial preparations that can be actively involved in the systems of growing agricultural plants according to the principles of organic farming, determine the optimal level of supply of plants with mobile compounds of phosphorus (241-281 mg/kg) and potassium (121-130 mg/kg) with an excess of 69-75% of the corresponding indicators on the control variant. The effectiveness of a complex of microbial preparations in combination with organic and green manure fertilisers has also been proven by studies conducted in Venezuela (Blanco *et al.*, 2021), in IndiaParray *et al.*, (2016), Spain-Barea *et al.*, (2013).

Analysing the influence of onion fertilisation systems on the microbiological activity of the soil, the dependence of the content of nitrate nitrogen in the soil on the number of nitrogen-fixing microorganisms is indicated. A certain increase in the number of nitrogen-fixing microorganisms (46-71 thousand colony-forming units (CFU)/g of dry soil) and potential

nitrogen-fixing activity (28.6-34.2 nmol C_2N_2/ g of dry soil per hour) according to the green manure, biological, and organo-mineral fertiliser system (Table 1). An increase in the number of nitrogen-fixing microorganisms was also noted when using an organic fertiliser system with the introduction of humus under the culture; the number of microorganisms was 68.4 thousand. CFU/g of dry soil.

Table 1. Changes in soil microbiological activity, onion growth and development phase of 6-8 true leaves, average for 2018-2019

Fertilisation system	Number of microorganisms, thous. CFU/g of dry soil		Potential nitrogen fixation activity, nmol C_2N_2/g of dry soil per hour	Mineralisation coefficient
	Fungi	Nitrogen-fixing microorganisms		
Without fertilisers (control)	18.8	38.8	21.8	0.38
Green manure: straw 3 t/ha + stubble biodestructor (1 l/ha) + seed treatment with Azotophyte-r (1l/t) + foliar top dressing with Organik balans (1 l/ha)	23.6	46.3	28.6	0.52
36 t/ha of humus (scattered)	20.7	68.4	30.5	0.41
$N_{90}P_{90}K_{90}$ (randomly)	22.3	42.5	24.1	0.47
36 t/ha of humus +$N_{45}P_{45}K_{45}$ (randomly)	19.3	52.3	28.6	0.41
Biological: aftereffect 40 t/ha of manure + straw 3 t/ha + stubble biodestructor (1 l/ha) + seed treatment with Azotophyte-r (1l/t) + foliar top dressing with Organik balans (1 l/ha)	21.1	71.5	34.2	0.44
Least significant difference $(LSD)_{0.95}$	1.32	5.12	4.55	-

The use of mineral fertilisers causes a certain decrease in the potential activity of nitrogen fixation relative to other fertiliser systems to the level of 24.1 nmol C_2N_2/g of dry soil per hour.

It is indicated that the number of soil fungi for the use of humus both separately and in combination with mineral fertilisers (19.3-20.7 thous. CFU/g of dry soil) is significantly reduced relative to other fertiliser systems and is within the values in the control variant (18.8 thous. CFU/g of dry soil). According to the green manure, biological, and mineral fertiliser systems, the number of soil fungi increases. This does not correspond to the results of studies obtained by Serbian researchers, where for the use of microbial preparations (*Azotobacter chroococcum, Pseudomonas fluorescens*) there is a decrease in the number of soil fungi (Čolo *et al*., 2014).

Improvement of agrochemical and microbiological parameters of the soil with the use of organic and mineral fertilisers provides an increase in the yield of onions and an improvement in the biochemical composition of products (Table 2).

Table 2. Influence of fertiliser systems on the yield and quality of onions of the Tkachenkivska variety (average for 2018-2020)

Onion fertiliser system	Yield		Biochemical parameters of bulbs			
	t/ha	increment	dry substance, %	total sugar, %	ascorbic acid, mg/100 g	nitrates, (MS[1] 80 mg/kg)
Without fertilisers (control)	16.0	-	12.8	9.6	7.5	35.5
Organic system						
36 t/ha of humus (scattered)	22.3	6.3	13.1	9.8	7.5	66.0
Mineral system						
$N_{90}P_{90}K_{90}$ (randomly)	22.6	6.6	11.5	9.4	7.2	124.4
$N_{300}P_{200}K_{130}$ (randomly) + Reakom-SO	23.6	7.6	11.4	11.2	7.5	136.0

Table 2, Continued

Onion fertiliser system	Yield		Biochemical parameters of bulbs			
	t/ha	increment	dry substance, %	total sugar, %	ascorbic acid, mg/100 g	nitrates, (MS[1] 80 mg/kg)
Organo-mineral system						
36 t/ha of humus +$N_{45}P_{45}K_{45}$ (randomly)	22.8	6.8	13.3	9.5	7.4	60.1
63 t/ha of humus + $N_{45}P_{45}K_{45}$ (randomly)	24.6	8.6	12.5	9.4	7.3	59.0
36 t/ha of humus + $N_{45}P_{45}K_{45}$ (locally)	24.2	8.2	11.8	10.6	7.7	72.1
63 t/ha of humus + $N_{22.5}P_{22.5}K_{22.5}$ (locally)	22.8	6.8	11.9	10.1	7.5	111.7
Biological fertiliser system						
Green manure (straw 3 t/ha + stubble biodestructor (1 l/ha) + seed treatment with Azotophyte-r (1l/t) + foliar top dressing with Organik balans (1 l/ha)	19.8	3.8	12.8	10.2	7.6	57.0
Biologised (aftereffect 40 t/ha of manure + straw 3 t/ha + stubble biodestructor (1 l/ha) + seed treatment with Azotophyte-r (1l/t) + foliar top dressing with Organik balans (1 l/ha)	19.1	3.1	13.1	10.0	7.8	59.1
$LSD_{0,95}$	2.17		0.94	1.25	0.76	15.8

Note: [1] MS – molar solution

A high level of yield is noted for organo-mineral fertiliser systems. Thus, for the introduction of 63 t/ha of humus with $N_{45}P_{45}K_{45}$ randomly or less than the humus rate (36 t/ha), but with the use of mineral fertilisers locally, the yield of onions increases by 8.2-8.6 t/ha or 51.3-53.8%.

Using only mineral fertilisers at a rate $N_{90}P_{90}K_{90}$ randomly provides a yield increase of 41.3%. Increasing the norm to $N_{300}P_{200}K_{130}$ (to ensure a yield of 30 t/ha) does not significantly increase the yield of onions.

The use of a system for optimising plant nutrition with the involvement of green manure fertilisers and microbial preparations causes the smallest increase in yield at the level of 3.1-3.8 t/ha or 19.4-23.8%. The corresponding results were obtained by other researchers. Thus, in the conditions of Ethiopia, inoculation of seeds with preparations containing bacteria from genera *Pseudomonas, Bacillus, Azotobacter, Enterobacter* and *Azospirillum* was effective for growing onions (Mekonnen & Kibret, 2021). According to Indian researchers, the use of a consortium of microorganisms *Azotobacter* sp. + *Sphingobacterium* sp. + *Burkholderia* sp. provides an increase in crop yield by 12.0% (Tinna *et al.*, 2020). The combination of microbial preparations with mineral fertilisers is also effective, which reduces the amount of the latter (Devi & Ado, 2005; Rafique *et al.*, 2019).

On average, over the years of research, there was a certain pattern of reducing the dry matter content in bulbs under different fertiliser systems. The dry matter content was significantly reduced for mineral fertiliser systems, as well as for the use of 36 t/ha of humus + locally $N_{45}P_{45}K_{4}$; the indicator was 11.4-11.8%. At the same time, using only organic fertilisers (36 t/ha of humus) and with the joint application of 36 t/ha of humus and randomly $N_{45}P_{45}K_{45}$ or according to the biological fertiliser system, there is a tendency to increase this biochemical parameter (13.1-13.3%).

According to the effect on the total sugar content in bulbs, a variant with an estimated dose of mineral fertilisers is distinguished, which provides a significant increase in this indicator to the level of 11.2% relative to the control with a sugar content of 9.6%. According to other fertiliser systems, the total sugar content in bulbs ranged from 9.4-10.6%.

The content of ascorbic acid (vitamin C) in bulbs was not significantly affected by the fertiliser system. At the same time, the value of the indicator ranged from 7.2-7.8 mg/100 g with a vitamin content of 7.5 mg/100 g in the control.

The use of different types and rates of fertilisers leads to an increase in the content of nitrates in bulbs. There are quite high values of this parameter for the use of mineral fertiliser systems, as well as for organo-mineral fertiliser systems, where mineral fertilisers are applied locally. At the same time, the nitrate content in the bulbs increases to the level of 72.1-136.0 mg/kg of raw weight. For organo-mineral fertiliser systems, where mineral fertilisers are used randomly, as well as for green manure and biologised fertiliser systems, the nitrate content increases significantly relative to the control, but within smaller limits (up to the level of 57.0-60.1 mg/kg

of raw weight), which does not exceed the maximum allowable level (80 mg/kg of raw weight).

CONCLUSIONS

The maximum growth of the main parameters of the soil nutrient regime is provided by the use of mineral and organo-mineral fertiliser systems, as well as a biologised system, which includes the use of a complex of microbial preparations for the aftereffect of organic fertilisers in crop rotation.

Deterioration of some parameters of soil microbiological activity causes the use of mineral fertilisers (the number of fungi in the rhizospheric soil increases, the potential activity of nitrogen fixation decreases). The introduction of organic and organo-mineral systems for optimising the nutrition of onion plants provides an increase in the number of nitrogen-fixing microorganisms (52.3-71.5 thousand CFU/g of dry soil) and potential nitrogen fixation activity (46.3-71.5 nmol S_2N_2/g of dry soil per hour).

The maximum level of onion yield was noted for the introduction of organo-mineral fertiliser systems (63 t/ha of humus + randomly $N_{45}P_{45}K_{45}$; 36 t/ha of humus + locally $N_{45}P_{45}K_{45}$); which contribute to an increase in yield in the range of 8.2-8.6 t/ha or 51.3-53.8%.

The use of organo-mineral fertiliser systems with the introduction of mineral fertilisers randomly, and the use of green manure and biologised fertiliser systems ensure the production of vegetable products with a high content of biologically active substances.

The continuation of these studies is aimed at solving two problems: 1) investigation of the transformation of the main parameters of chernozem soils of the forest-steppe of Ukraine under various fertiliser systems in vegetable agrobiocoenoses; 2) development of systems for optimising the nutrition of vegetable plants with a shortage of organic fertilisers and high cost of mineral fertilisers.

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Вплив системи удобрення на поживний режим ґрунту та продуктивність цибулі ріпчастої

Анотація. Сучасні підходи щодо оптимізації живлення овочевих рослин часто мають низьку ефективність та негативно впливають на різні компоненти агробіоценозу (ґрунт, мікробіоту). У зв'язку з цим метою досліджень було визначення впливу різних систем удобрення на формування врожайності та якості цибулі ріпчастої в зрошуваній овоче-кормовій сівозміні, зміну основних агрохімічних та мікробіологічних параметрів ґрунту. Дослідження проведено в лабораторії агрохімічних досліджень та якості продукції Інституту овочівництва і баштанництва НААН України. Методи досліджень: довготривалий стаціонарний польовий дослід, лабораторне визначення агрохімічних та мікробіологічних параметрів ґрунту, біохімчного складу цибулин, статистична обробка даних. Визначено, що істотне підвищення вмісту нітратного азоту в орному шарі ґрунту забезпечує використання мінеральних добрив, рухомих сполук фосфору та калію – мінеральна та органо-мінеральна системи удобрення. Використання мінеральних добрив зумовлює збільшення чисельності грибів у ризосфері ґрунту і зменшення потенційної активності азотфіксації, що погіршує мікробіологічну активність ґрунту. Внесення органічних добрив в поєднанні з мінеральними добривами, призводить до зростання кількості азотфіксувальних мікроорганізмів та потенційної активності азотфіксації, що покращує родючість ґрунту. Використання органо-мінеральних та мінеральних систем удобрення зумовлює підвищення урожайності цибулі ріпчастої на 6,6-8,6 т/га або 41,3-53,8%. За використання біологізованих систем оптимізації живлення урожайність зростає на 19,4-23,8%. Максимальний рівень урожайності цибулі ріпчастої зазначено за впровадження органо-мінеральних систем удобрення (63 т/га перегною + врозкид$N_{45}P_{45}K_{45}$; 36 т/га перегною + локально$N_{45}P_{45}K_{45}$); зумовлюючи підвищення урожайності на 8,2-8,6 т/га. Відмічена певна закономірність зниження в цибулинах вмісту сухої речовини та підвищення умісту нітратів за різних систем удобрення. Матеріали досліджень становлять практичну цінність для впровадження систем оптимізації живлення, що спрямовані як на стале зростання урожайності овочевої продукції, так і збереження рівня родючості ґрунтів овочевих агробіоценозів

Ключові слова: оптимізація живлення, овоче-кормова сівозміна,врожайність, якісний склад цибулини