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Efficiency of biological products and mineral fertilizers application on winter garlic crops in the conditions of the Right-Bank Forest-Steppe of Ukraine

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Abstract. The article presents the results of three years of research on the effectiveness of the influence of the biological product Phytohelp, mineral fertiliser Drip Fert $N_{15}P_5K_{30}$+ME and bioadhesive Liposam on the structure of the winter garlic yield of the Lyubasha variety under drip irrigation. The relevance of the research is due to the search for new approaches to the development of technological methods for growing winter garlic, taking into account the specific conditions of unstable moisture in the Forest-Steppe. The purpose of the article is to establish the optimal doses and the ratio between them to achieve an increase in the quality and yield of winter garlic. The study was conducted on the experimental field of the Department of Vegetable Growing of the National Assessed Contribution of Ukraine of the Uman National University of Horticulture on podzolised heavy loamy black soil in 2017-2019. As a result, it was proved that in the conditions of the Right-Bank Forest-Steppe of Ukraine on podzolic chernozem under drip irrigation, a higher yield was obtained in plots with the combined use of the biological product Phytohelp at a rate of 1-2 l/ha, mineral fertiliser Drip Fert $N_{15}P_5K_{30}$+ME and bioadhesive Liposam at a rate of 1 l/ha. This resulted in an increase of 9.0-10.6 t/ha compared to the control variant, respectively. Using the biopreparation Phytohelp and bioadhesive Liposam at a rate of 2/1 and 1/1 l/ha, a yield of 16.6-17.1 t/ha was obtained, where the increase to the control was 7.7-8.2 t/ha. The effect of foliar fertilisation with Drip Fert $N_{15}P_5K_{30}$+ME (4 g/2 l of water or 0.5 c/ha) on the yield of winter garlic was determined. The increase to the control was 1.6%. The results of this study may be useful for agricultural enterprises and farmers who grow garlic and other crops

Keywords: variety; growth; development; bulb; yield

INTRODUCTION

The process of growing winter garlic under unstable moisture conditions in the Forest-Steppe faces numerous challenges, as unstable moisture conditions can negatively affect the yield and quality of this crop. The development of technological methods that take into account specific conditions of unstable moisture can ensure a more stable and higher yield of garlic, and research in this area can help garlic producers to implement optimal moisture management methods and increase the efficiency of cultivation. In addition, the development of new technological techniques can have a positive impact on the sustainability and productivity of the main crops in the Right-Bank Forest-Steppe of Ukraine. The development and introduction of modern

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competitive crop cultivation technologies that contribute to the maximum realisation of their productive potential is important for the efficient use of the bioclimatic potential of natural and climatic conditions, and optimal efficiency can be achieved by combining the use of biological products and mineral fertilisers, taking into account specific growing conditions and expert recommendations.

Scientists F. Yang *et al*. (2019) believe that fertilisation is a global management strategy to improve soil quality, and that the use of chemical fertilisers is an important factor in high agricultural production to increase yields. Y. Geng *et al*. (2019) noted that global yield growth is largely dependent on large investments in chemical fertilisers. Scientists J. Zhu *et al*. (2019) and G. Brunetti *et al*. (2019) noted that in order to maintain soil productivity, farmers applied large quantities of fertiliser, often exceeding the rate required by crops. According to F. Lv *et al*. (2020), excessive chemical fertilisers in the soil can lead to deterioration of soil quality, a decrease in organic matter content and a sharp decline in soil biodiversity, including acidification. This, in turn, can cause a wide range of environmental problems in freshwater, terrestrial and marine ecosystems. Y. Lin *et al*. (2019) noted that soil organic matter plays an important role in regulating atmospheric CO_2 concentrations and maintaining soil fertility and productivity. Scientists H. Cheng *et al*. (2020) argue that the use of organic fertilisers can also have a positive impact on soil characteristics. Organic fertilisers help to improve soil structure, increase soil fertility and the content of organic decomposed material. As a result, the mineralisation and nitrogen fixation processes in the soil can be regulated and improved. The use of organic fertilisers can affect the processes of nitrification and denitrification in the soil. The research of M. Qaswar *et al*. (2020) found that the use of a combination of organic and mineral fertilisers leads to a partial replacement of chemical fertilisers and stabilisation of corn and wheat yields, providing plants with all the necessary nutrients.

Under the influence of various factors, the nutritional value of garlic undergoes significant changes. One of the methods of levelling external stresses during the growing season is the system and technology of applying biological products and mineral fertilisers. As of 2024, the impact of combined fertilisation on crop yields and quality has not been sufficiently studied. That is why the purpose of the research was to study the impact of the biological product Phytohelp, the mineral fertiliser Drip Fert NPK and the bioadhesive Liposam on the growth and development, yield and quality of bulbs on podzolic black soil under drip irrigation.

MATERIALS AND METHODS

The study complies with ethical standards and adheres to the Convention on Biological Diversity (Secretariat of the..., 2011). The research was conducted during 2017-2019 on the experimental field of the Department of Vegetable Growing of the National Assigned Contribution of Ukraine of the Uman National University of Horticulture on podzolised heavy loamy black soil. The area of the experimental plot is 12 m^2, the accounting plot is 10 m^2. Plots were systematically arranged. The experiment was repeated four times. Predecessor – early vegetables. The cloves of winter garlic variety Lyubasha were planted in the soil at the beginning of the second decade of October according to the scheme of 45x6 cm.

The experiments used the biological products Phytohelp for local fertilisation and the mineral fertiliser Drip Fert $N_{15}P_5K_{30}$+ME for foliar application (spraying on the leaf). The experiment includes the following options: without fertilisation (control); Phytohelp biological product – 1 l/ha; Phytohelp biological product – 2 l/ha; Phytohelp biological product – 1 l/ha + Drip Fert $N_{15}P_5K_{30}$+ME – 4 g/2 l of water; biological preparation Phytohelp – 2 l/ha + Drip Fert $N_{15}P_5K_{30}$+ME – 4 g/2 l of water; mineral fertiliser Drip Fert $N_{15}P_5K_{30}$+ME – 4 g/2 l of water (0.5 c/ha).

The biological product Phytohelp was applied simultaneously with watering for the first time – in the phase of three or four true leaves, the second – at the beginning of bulb formation with the appearance of inflorescences. Mineral fertiliser Drip Fert $N_{15}P_5K_{30}$+ME was applied foliarly twice (during the period of intensive bulb growth in the first half of June with an interval of 10 days). According to the recommendations of the manufacturers of the studied preparations, the bioadhesive Liposam (1 l/ha) was added to their working solutions. In the control variant, garlic was watered only with water. In order to increase the yield of underground bulbs, the flower-bearing arrow was removed manually. Weeding during the growing season was carried out three times (manually), thus destroying weeds in winter garlic crops.

RESULTS

According to the results of three years of research, the applied factors (fertilisation with the biological preparation Phytohelp, mineral fertiliser Drip Fert $N_{15}P_5K_{30}$+ME and bioadhesive Liposam) significantly influenced the biometric parameters and formation of productivity elements of winter garlic variety Lyubasha. Thus, after biometric measurements, it was found that 30 days after germination, the height of plants exceeded the control by 4.1-4.8%. In the phase of intensive growth and development, the best results were recorded

with the combined use of the biological product Phytohelp at a rate of 2 l/ha, mineral fertiliser $N_{15}P_5K_{30}$+ME – 4 g/2 l of water and bioadhesive Liposam at a rate of 1 l/ha. The height of the plants was 64.2 cm, which is 29.3% higher compared to the control variant. Reducing the rate of the biological product Phytohelp to 1 l/ha, the mineral fertiliser Drip Fert $N_{15}P_5K_{30}$+ME – 4 g/2 l of water and the bioadhesive Liposam 1 l/ha, a lower height was observed, but the plants exceeded the control by 25.9%. In the variants where Phytohelp was applied at a rate of 1 l/ha and 2 l/ha, the height of plants was 53.6-54.7 cm, which is 24.5-25.0% more than the control. When applying foliar fertilisation with mineral fertiliser $N_{15}P_5K_{30}$+ME – 4 g/2 l of water and bioadhesive Liposam, this indicator was 23.8% higher than in the control. A month after germination, the use of the biological product Phytohelp at a rate of 1 and 2 l/ha in combination with foliar feeding with Drip Fert $N_{15}P_5K_{30}$+ME mineral fertiliser – 4 g/2 l of water and Liposam bioadhesive at a rate of 1 l/ha was more effective. The height of the plants was 58.6 and 65.0 cm. The use of only the biological product Phytohelp (1 l/ha – 2 l/ha) contributed to an increase of 11.1 and 11.3 cm, respectively. The mineral fertiliser Drip Fert $N_{15}P_5K_{30}$+ME – 4 g/2 l of water and the bioadhesive Liposam 1 l/ha provided a 26.8% increase in height (Fig. 1).

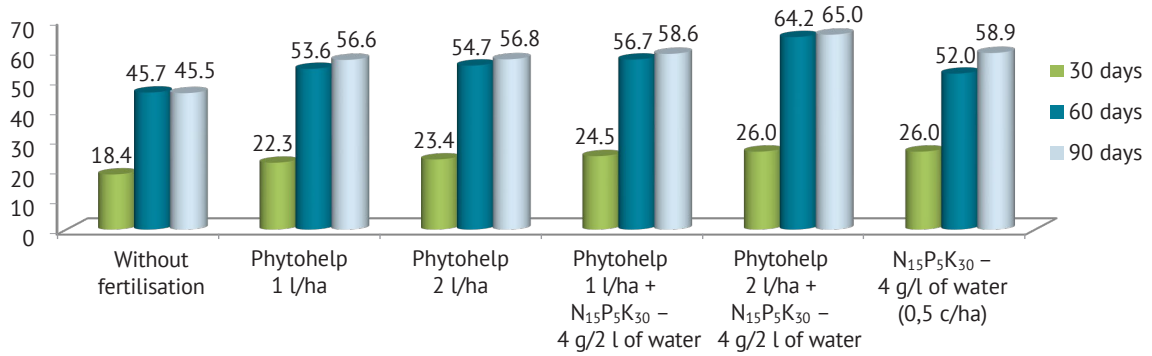

Figure 1. *Plant height depending on the method of fertilisation with a biological product and complex mineral fertiliser 30, 60, 90 days after spring regrowth*

Source: *author's development*

The use of biological products and foliar fertilisation with mineral fertiliser showed positive dynamics. Thus, the average number of leaves in 30 days after germination varied from 4.2 to 5.1 per plant. In the phase of intensive growth and development, in the control variant it was 2.2 pcs./plant lower than in the experimental variant, where the biological product Phytohelp was used at a rate of 2 l/ha and foliar fertilisation with mineral fertiliser $N_{15}P_5K_{30}$+ME – 4 g/2 l of water (bioadhesive Liposam at a rate of 1 l/ha). On the variants where the biological product Phytohelp was used at a rate of 1 and 2 l/ha, the number of leaves was 1.0-1.6 pcs./plant higher compared to the control. The use of foliar fertilisation with Drip Fert $N_{15}P_5K_{30}$+ME – 4 g/2 l of water and Liposam bioadhesive 1 l/ha, the number of leaves per plant was 7.3, which is 1.5 more than in the control. Due to the partial drying of the tops of the leaves, the height of garlic plants before harvesting was in the range of 4.6-5.3 pcs./plant (Fig. 2).

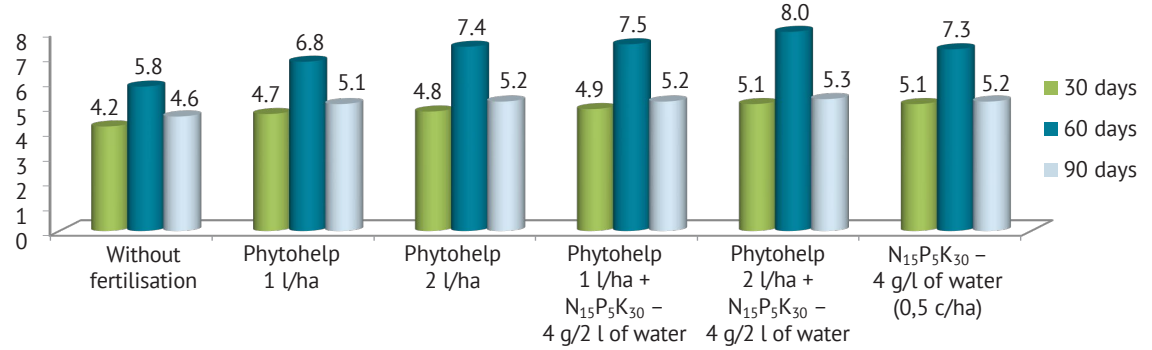

Figure 2. *Number of leaves depending on the method of fertilisation with a biological product and complex mineral fertiliser 30, 60, 90 days after spring regrowth*

Source: *author's development*

The studied plants of winter garlic differed in a complex of biometric parameters depending on fertilisation. The highest with the maximum surface area were mainly in the phase of intensive growth and development with the combined use of the biological product Phytohelp at a rate of 1 and 2 l/ha and the mineral fertiliser Drip Fert $N_{15}P_5K_{30}$+ME at a rate of 4 g/2 l of water or 0.5 c/ha, the bioadhesive Liposam at a rate of 1 l/ha was 349.2 and 404.8 cm^2/plant. A month after germination, this figure was lower, but exceeded the other experimental variant, where the biological product Phytohelp was used at a rate of 1 and 2 l/ha and the bioadhesive Liposam at a rate of 1 l/ha, respectively, by 41.7 and 63.5 cm^2/plant. The use of foliar fertilization with mineral fertilizer Drip Fert $N_{15}P_5K_{30}$+ME – 4 g/2 l of water and bioadhesive Liposam at a rate of 1 l/ha (leaf area per plant) provided an assimilation surface of 361.7 cm^2/plant, and in a month these data decreased to 180.0 cm^2/plant, but exceeded the control variant by 112.4 cm^2/plant (Fig. 3).

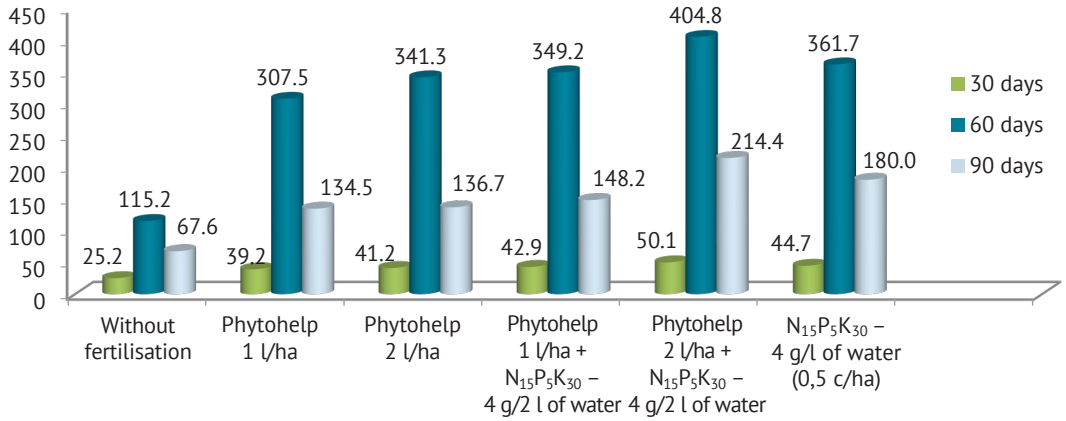

Figure 3. *Leaf blade area depending on the method of fertilisation with biological product and complex mineral fertiliser, cm2/plant after 30, 60, 90 days after spring regrowth*

Source: *author's development*

Leaf area index is a complex indicator that reflects the area of plant leaves per unit area of soil. Thus, with the combined application of the biological product Phytohelp at a rate of 1 and 2 l/ha, foliar fertilisation with Drip Fert $N_{15}P_5K_{30}$+ME mineral fertiliser at a rate of 4 g/2 l of water or 0.5 c/ha, and the bioadhesive Liposam at a rate of 1 l/ha, the increase to the control variant was 0.86-1.07 m^2. When fertilising with biological preparations Phytohelp at a rate of 1-2 l/ha and Liposam at a rate of 1 l/ha, the increase in leaf index was 0.7-0.84 m^2. This indicator exceeded the control by 0.9 m^2 in the variant where foliar fertilisation with Drip Fert $N_{15}P_5K_{30}$+ME mineral fertiliser at a rate of 4 g/2 l of water or 0.5 c/ha and Liposam bioadhesive at a rate of 1 l/ha was used (Fig. 4).

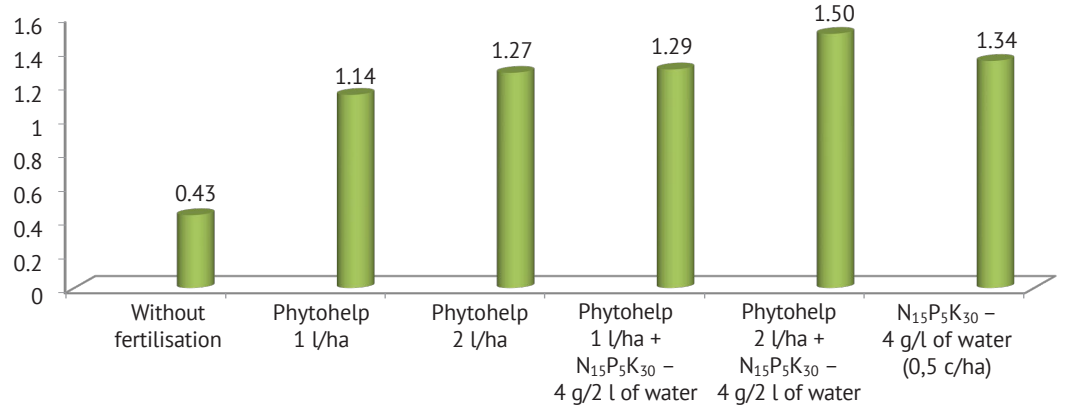

Figure 4. *Leaf surface index of winter garlic variety Lyubasha 60 days after germination depending on the method of fertilisation with biological product and complex mineral fertiliser (2017-2019), m^2*

Source: *author's development*

Analysing the results of research on the structure of the yield of winter garlic variety Lyubasha, it can be noted that the increase in bulb weight directly depends on the rate of fertilisation with biological products and mineral fertiliser. Thus, in 2017, the average bulb weight in the control variant was 20.0 g, and in the variant with the use of the biological preparation Phytohelp at a rate of 1-2 l/ha and the bioadhesive Liposam at a rate of 1 l/ha – 54.5-55.4 g, respectively. The best results were obtained with the combined application of the biological product Phytohelp at a rate of 1 and 2 l/ha, foliar fertilisation with Drip Fert $N_{15}P_5K_{30}$+ME mineral fertiliser at a rate of 4 g/2 l of water or 0.5 c/ha and Liposam bioadhesive at a rate of 1 l/ha – 5.5 g in both variants. When using foliar fertilisation with Drip Fert $N_{15}P_5K_{30}$+ME mineral fertiliser at a rate of 4 g/2 l of water and Liposam bioadhesive at a rate of 1 l/ha, this indicator exceeded the control by 35.4 g. In 2018, the weather conditions for growing winter garlic were less favourable, but the control prevailed by 9.2-9.5% in the variant with the use of the biological preparation Phytohelp at a rate of 1-2 l/ha and the bioadhesive Liposam at a rate of 1 l/ha. With the combined application of the biological preparation Phytohelp at a rate of 1 and 2 l/ha, foliar feeding with mineral fertilizer Drip Fert $N_{15}P_5K_{30}$+ME at a rate of 4 g/2 l of water, this indicator exceeded the control variant by 10.4-11.6%, and in the variant with foliar fertilisation with Drip Fert $N_{15}P_5K_{30}$+ME at a rate of 4 g/2 l of water and Liposam bioadhesive at a rate of 1 l/ha – by 9.2%. In 2019, a positive dynamics of the effect of biological products and mineral fertiliser on the weight of winter garlic bulbs of the Lyubasha variety was noted. In areas where joint fertilisation with the biological product Phytohelp was used at a rate of 1 and 2 l/ha, together with foliar fertilisation with the mineral fertiliser Drip Fert $N_{15}P_5K_{30}$+ME at a rate of 4 g/2 l of water, the bulb weight was 55.4-56.4 g, respectively. On winter garlic crops, where the biological product Phytohelp was applied at a rate of 1 and 2 l/ha with foliar application of Drip Fert $N_{15}P_5K_{30}$+ME mineral fertilizer at a rate of 4 g/2 l of water, a lower bulb weight was observed, but they exceeded the control by 25.9 and 28.4 g. In the variant with the use of foliar fertilisation with mineral fertiliser Drip Fert $N_{15}P_5K_{30}$+ME at a rate of 4 g/2 l of water and bioadhesive Liposam at a rate of 1 l/ha, the bulb weight was 56.4 g, which exceeded the variant without fertilisation by 14.2% (Fig. 5).

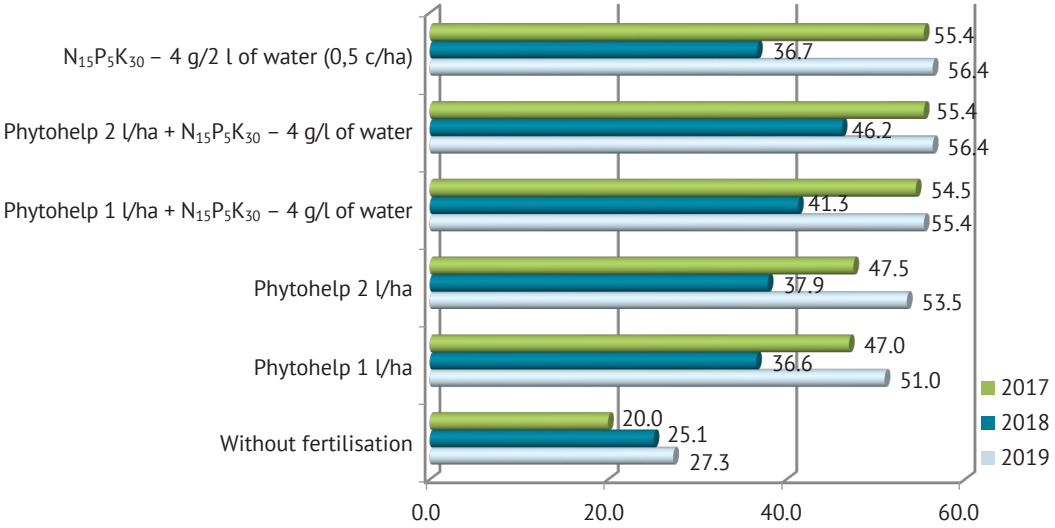

Figure 5. *Weight of winter garlic bulb of Lyubasha variety depending on the method of fertilisation with biological product and complex mineral fertiliser (2017-2019), g*

Source: *author's development*

On average, over the years of research, the highest yield of winter garlic variety Lyubasha was obtained with the combined application of the biological preparation Phytohelp at a rate of 1 and 2 l/ha, foliar fertilisation with the mineral fertiliser Drip Fert $N_{15}P_5K_{30}$+ME at a rate of 4 g/2 l of water or 0.5 c/ha and the bioadhesive Liposam at a rate of 1 l/ha – 17.9 and 19.5 t/ha, an increase over the control was 9-10.6 t/ha. Biological preparations Phytohelp at a rate of 1-2 l/ha and Liposam at a rate of 1 l/ha contributed to an increase of 7.7-8.2 t/ha of winter garlic. The use of foliar fertilisation with Drip Fert $N_{15}P_5K_{30}$+ME at a rate of 4 g/2 litres of water or 0.5 c/ha and Liposam bio-sticker at a rate of 1 l/ha resulted in an increase in yield to 18.1 t/ha, while the increase in the control plots was 9.1 t/ha.

In 2017, in the first decade of July, the commercial bulbs of winter garlic variety Lyubasha were harvested, with yields exceeding the control by 2.4 and 2.8 times. In 2018, the highest productivity indicators were obtained in the variant with the combined application of the biological product Phytohelp at a rate of 1 and 2 l/ha and the mineral fertiliser Drip Fert $N_{15}P_5K_{30}$+ME at a rate of 4 g/2 l of water or 0.5 c/ha, and the bioadhesive Liposam at a rate of 1 l/ha – 15.3 and 17.1 t/ha. In other experimental variants, the yield was 4.3-4.7 t/ha higher than in unfertilised plots. In 2019, weather conditions were more favourable for the formation of structural elements. These indicators were higher and the increase to the control ranged from 8.8 to 10.8 t/ha (Table 1).

Table 1. *Yield of winter garlic variety Lyubasha depending on the method of fertilisation with biological product and complex mineral fertiliser t/ha*

Fertilisation	Year			average	+ - control
	2017	2018	2019		
No fertilisation (control)	7.4	9.3	10.1	8.9	-
Phytohelp – 1 l/ha	17.4	13.6	18.9	16.6	7.7
Phytohelp – 2 l/ha	17.6	14.0	19.8	17.1	8.2
Phytohelp – 1 l/ha + $N_{15}P_5K_{30}$ – 4 g/2 l of water	20.2	15.3	20,5	17.9	9.0
Phytohelp – 2 l/ha + $N_{15}P_5K_{30}$ – 4 g/2 l of water	20.5	17.1	20.9	19.5	10.6
$N_{15}P_5K_{30}$ – 4 g/2 l of water (0.5 c/ha)	17.4	13,6	18.9	18.1	9.1
HIP_{05}	0.808	0.614	0.881	0.788	

Source: *author's development*

Various biochemical processes and moisture evaporation occur in the tissues of winter garlic bulbs, which leads to a decrease in their weight. According to the results of the study, it was found that the greatest weight loss was observed in the first weeks after harvesting – up to 24.8%. This is due to the loss of moisture accumulated during the growing season. Thus, with the combined application of the biological product Phytohelp at a rate of 1 and 2 l/ha, foliar feeding with the mineral fertiliser Drip Fert $N_{15}P_5K_{30}$+ME at a rate of 4 g/2 l of water and the bioadhesive Liposam at a rate of 1 l/ha, the loss of bulb weight 2 weeks after harvesting was 19.9 and 24.8%. In the variant where the biological product Phytohelp was used at a rate of 1-2 l/ha and the bioadhesive Liposam at a rate of 1 l/ha, this indicator was 15.8-16.7%. When applying foliar fertilisation with Drip Fert $N_{15}P_5K_{30}$+ME mineral fertiliser at a rate of 4 g/2 litres of water, the bulb weight decreased by 15.8%. The harvested crop from unfertilised areas also recorded a weight loss of 7.3% (Fig. 6).

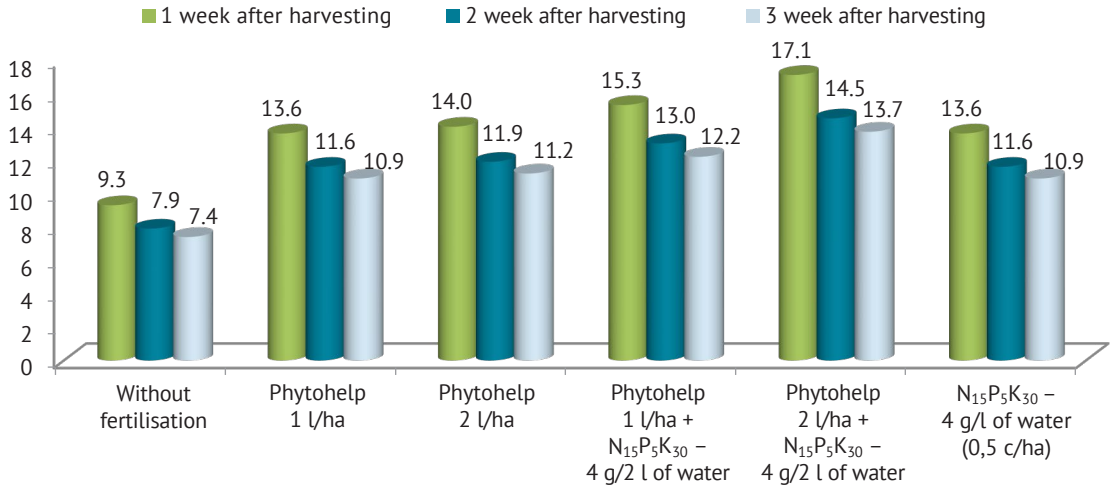

Figure 6. *Productivity of winter garlic variety Lyubasha depending on the method of fertilisation with biological product and complex mineral fertiliser 1, 2, 3 weeks after harvesting, t/ha*

Source: *author's development*

Three weeks after harvesting, a further decrease in the weight of the bulbs of winter garlic variety Lyubasha was recorded. With the combined application of the biological product Phytohelp at a rate of 1

and 2 l/ha, foliar feeding with Drip Fert $N_{15}P_5K_{30}$+ME mineral fertiliser at a rate of 4 g/2 l of water and Liposam bioadhesive at a rate of 1 l/ha, the bulbs decreased by 15.9-19.9%. When using the biopreparation Phytohelp at a rate of 1-2 l/ha and the bioadhesive Liposam at a rate of 1 l/ha, the losses were 12.6-13.3%. In the variant where foliar fertilisation with Drip Fert $N_{15}P_5K_{30}$+ME mineral fertiliser at a rate of 4 g/2 l of water was applied, the weight of garlic decreased to 12.6%, and in the control variant – by 5.8%.

DISCUSSION

The results of this study provide scientific support to scientists to create an environmentally friendly technology for growing crops by applying organic fertilisers. These technologies provide for the efficient use of resources and contribute to the sustainable development of agriculture and industrial production. The use of organic fertilisers helps to avoid negative environmental impacts and maintains biodiversity. However, crop yields depend not only on climatic conditions but also on soil fertility. Y. Ma *et al*. (2023) argue that organic fertilisers, such as composts, humus or green manure, are a natural source of nutrients that contribute to soil enrichment. They help to support healthy microorganisms in the soil, such as bacteria and fungi, which help to retain nutrients and improve soil quality, as well as increase the organic carbon content. This is in line with the study conducted, where the effect of fertiliser on the vegetative growth of garlic parameters is positive.

Scientists A. Degwale *et al*. (2016) found that in Northwestern Ethiopia, before planting garlic, local application of vermicompost to the rows at a rate of 2.5-5 t/ha allowed to obtain a yield increase of 3 to 10%. In the same region, according to scientists F.T. Kenea & F. Gedamu (2018), after applying vermicompost at a rate of 2.5-7.5 t/ha, a larger assimilation surface area of garlic was obtained (17.6-35.4%), while both bulb weight (2.8 to 5.9%) and yield (15.9-38.7%) increased. A similar situation can be observed in this study, when fertilising with the biological product Phytohelp at a rate of 1 and 2 l/ha, foliar fertilisation with mineral fertiliser Drip Fert $N_{15}P_5K_{30}$+ME at a rate of 4 g/2 l of water and bioadhesive Liposam at a rate of 1 l/ha 60 days after spring regrowth, a larger leaf area of 349.2-404.8 cm^2/plant and a yield increase (average for three years) of 9.0 and 10.6 t/ha were observed. According to the phenological observations, a direct dependence on the rate of application of biological products was established. The average number of leaves in 30 days after spring regrowth varied between 4.2-5.1 pcs./plant, providing an assimilation surface of 25.2-50.1 cm^2/plant.

According to N. Hu *et al*. (2023), garlic yield had a positive correlation with TOC (Total Organic Carbon), DOC (Dissolved Organic Carbon) and POC (Particulate Organic Carbon). The increase in garlic production was facilitated by the increase in TOC, POC and DOC content, and the treatment with 1/3OF + 2/3NF organic fertilisers increased the garlic yield by 37.2 and 15.3%, respectively, compared to N0 and NF. The study shows that fertiliser application regimes can directly affect total soil organic carbon and labile organic carbon components, thereby affecting the organic carbon associated with aggregates. Aggregates with a particle size of 0.5-2 mm played an important role and had a positive effect on garlic yield. Analysing the results, it can be said that the application of organic fertilisers has the potential to increase the organic carbon content of the soil and also the yield of garlic. These conclusions are in line with those of H. Zhao *et al.* (2018), who showed that the combined use of organic and chemical fertilisers can improve soil structure and promote the aggregation of more soil particles.

X. Zhang *et al*. (2019) found that the best choice for increasing soil carbon sequestration and maize yields based on long-term experiments is organic fertiliser, which completely replaces chemical fertilisers. However, the nitrogen in organic fertilisers is mainly in the form of organic nitrogen. The needs of crop production are not fully met because the release of organic nitrogen and the supply of effective nitrogen to plants are slow. L. Zhang *et al*. (2023) found that the use of nitrogen fertilisers increased corn yields by 50.64%, N_2O emissions by 64.39%, and NH_3 evaporation by 69.25%, respectively. Feeding winter garlic variety Lyubasha with nutrients from the biological product Phytohelp and mineral fertiliser Drip Fert $N_{15}P_5K_{30}$+ME contributed to an increase in plant vegetative mass and bulb weight, and had an impact on yield. Something similar was noted in the work of V. Palamarchuk *et al*. (2024).

Having analysed the productivity indicators of winter garlic, it was noted that favourable weather conditions in 2019 contributed to the highest yield in all variants, except for the control 10.1 t/ha. The highest yields were collected from the plots where the combined fertilisation with the biological product Phytohelp at a rate of 1 and 2 l/ha, foliar fertilisation with the mineral fertiliser Drip Fert $N_{15}P_5K_{30}$+ME at a rate of 4 g/2 l of water and the bioadhesive Liposam at a rate of 1 l/ha were applied. O. Ulianych & V. Yatsenko (2018) found that the Sofiyivskyi garlic variety (multi-clove form) requires a maximum rate of biohumus of 5 t/ha, which increased the yield by 3.6 t/ha. For the Prometheus variety (small-toothed form), by increasing the weight of the tooth and increasing their number, the

bulb weight also increases. In order to obtain a high yield, the optimal rate is considered to be 3-5 t/ha. G. Yarovyi & V. Kuzmenko (2013) noted in their work that the highest technical efficiency against tomato pathogens, namely 43.6-59.5%, was obtained in the variant where a mixture of biological products with plant growth regulators was used: Vermistim + Azotophyte and Bioglobin + Azotophyte.

In summary, most studies demonstrate the significant potential of organic fertilisers to improve soil fertility, conserve biodiversity and increase crop yields. The use of biological products and organic fertilisers is an effective strategy aimed at sustainable productivity growth and environmental sustainability in agriculture.

CONCLUSIONS

The influence of the biological product Phytohelp and its combined use with the mineral fertiliser Drip Fert $N_{15}P_5K_{30}$+ME on the growth, development, formation and quality of winter garlic variety Lyubasha under drip irrigation was studied. According to the phenological observations, it was found that the highest rates were in the variants with the combined use of the biological product Phytohelp at a rate of 1-2 l/ha, Drip Fert $N_{15}P_5K_{30}$+ME – 4 g/2 l of water and the bioadhesive Liposam at a rate of 1 l/ha. The height of plants in the phase of intensive growth and development was 56.7-64.2 cm, which is 11.0-18.5 cm higher compared to the control. There was also a greater number of leaves per plant (7.5-8.0), which made it possible to obtain a larger leaf surface area – 349.2 and 404.8 cm^2/plant. In the variant where the biological product Phytohelp and the bioadhesive Liposam were applied at 2/1 and 1/1 l/ha, the plant height exceeded the control by 24.5-25.0%, the number of leaves was 6.8-7.4 pieces, and the assimilation surface area was 307.5-341.3 cm^2/plant. The use of foliar fertilisation with Drip Fert $N_{15}P_5K_{30}$+ME mineral fertiliser at a rate of 4 g/2 l of water contributed to an increase in height by 23.8%. The number of leaves was 7.3 pcs./plant, and the leaf surface area was 361.7 cm^2/plant. The use of foliar fertilisation with Drip Fert $N_{15}P_5K_{30}$+ME mineral fertiliser contributed to the production of winter garlic (18.1 t/ha) and an increase in yield (9.1 t/ha). The introduction of the biological product Phytohelp with Liposam adhesive at a dose of 2/1 and 1/1 was ineffective, but the yield increase was 8.2 and 7.7 t/ha. The yield was maximum when the biological product Phytohelp was applied together at a dose of 2 l/ha and the mineral fertiliser Drip Fert $N_{15}P_5K_{30}$+ME (4 g/2 l of water or 0.5 c/ha) with the adhesive Liposam (1 l/ha) – 19.5 t/ha, which is 1.7% more than in the control. When fertilising with the biological product Phytohelp at a dose of 2 l/ha and the mineral fertiliser Drip Fert $N_{15}P_5K_{30}$+ME (4 g/2 l of water or 0.5 c/ha) with the adhesive Liposam (1 l/ha), the yield increase was 9.0 t/ha, which is 1.6% more than in the control variant. Thus, the use of biological products and mineral fertiliser are effective methods for fertilising winter garlic. They have a positive effect on the height, number of leaves per plant and assimilation surface area, which helps to increase yields and improve plant quality. However, many mechanisms of interaction between plants and biological products in different soil and climatic conditions have not been identified. Also, the effect of biological products of different concentrations on plants and the environment has not been studied in more detail, which may be a prospect for further research.

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CONFLICT OF INTEREST

None.

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Ефективність застосування біопрепаратів та мінеральних добрив на посівах часнику озимого в умовах Правобережного Лісостепу України

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Анотація. У статті представлено результати трирічних досліджень ефективності впливу біопрепарату Фітохелп, мінерального добрива Drip Fert $N_{15}P_5K_{30}$+ME та біоприлипач Липосам на структуру врожаю часнику озимого сорту Любаша в умовах краплинного зрошення. Актуальність досліджень обумовлена пошуком нових підходів до розробки технологічних прийомів вирощування часнику озимого із урахуванням конкретних умов нестійкого зволоження Лісостепу. Метою написання статті є встановлення оптимальних доз та співвідношення між ними для досягнення підвищення якості та врожайності часнику озимого. Дослідження було проведено на дослідному полі кафедри овочівництва національного визначеного внеску України Уманського національного університету садівництва на чорноземі опідзоленому важко суглинковому у 2017-2019 рр. В результаті було доведено, що в умовах Правобережного Лісостепу України на чорноземі опідзоленому за краплинного зрошення більшу урожайність отримано на ділянках за сумісного застосування біопрепарату Фітохелп нормою 1-2 л/га, мінеральне добриво Drip Fert $N_{15}P_5K_{30}$+ME та біоприлипач Липосам у нормі 1 л/га. Це дозволило отримати приріст до контрольного варіанту 9,0-10,6 т/га відповідно. Використовуючи біопрепарат Фітохелп та біоприлипач Липосам у нормі 2/1 та 1/1 л/га, одержано врожай 16,6-17,1 т/га, де надбавка до контролю становила 7,7-8,2 т/га. Встановлено вплив позакореневого підживлення мінеральним добривом Drip Fert $N_{15}P_5K_{30}$+ME (4 г/2 л води або 0,5 ц/га) на врожайність часнику озимого. Приріст до контролю становив 1,6 %. Результати проведеного дослідження можуть бути корисними для сільськогосподарських підприємств та фермерів, які займаються вирощуванням часнику та інших культур

Ключові слова: сорт; ріст; розвиток; цибулина; урожайність