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USING BIOPREPARATIONS TO OPTIMIZE POTATO NUTRITION IN THE SOUTHERN STEPPE OF UKRAINE

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Abstract

Potatoes in Ukraine belong to the main food crops, it is used for food throughout the year for the high nutritional quality of tubers. However, despite the significant demand for potatoes, its yield remains low and there is a need to improve the technological methods of the crop growing, which contribute to both increasing the production of tubers and improving the main indicators of their quality. The article presents the results of research conducted in 2017-2019 years on improving the nutrition of potato varieties by drip irrigation on southern Chernozem. It was determined the positive influence of mineral fertilizers and foliar nutrition on the background of application of modern biopreparations in the main periods of vegetation of plants on the level of yield of tubers and their quality. It was found that the yield of tubers under the influence of nutrition in the potato variety Minerva grew in the range of 3.0 up to 13.2 t/ha, and in the Riviera variety the yield of tuber grew from 3.2 up to 12.6 t/ha, or respectively by 18.0-79.0% and 16.4-64.6% depending on the variant. In addition to the increase in the yield level, the main properties of tubers were improved by optimizing nutrition - they increased the content of dry substance, vitamin C and starch, the conditional yield of starch per unit area increased, and, if the tubers were processed, the yield of alcohol and bioethanol increased.

Key words*: potato, variety, fertilizers, biopreparations, foliar nutrition, yield of tubers, the main indicators of quality.*

INTRODUCTION

For the population of Ukraine, potatoes are the second bread and product that is consumed throughout the year. In modern agriculture, potatoes are one of the most productive crops. In recent years (2016 yr) Ukraine is one of the five world leaders in potato production - 22 million tons of tubers on an area of 1.5 million hectares. In some countries and specialized farms where potatoes are grown on the basis of advanced technologies, about 100 t/ha of tubers are obtained. In Ukraine, the average yield of potato tubers is 10-14 t/ha, which requires the development of modern technology elements and the selection of productive varieties and hybrids of this crop.

Research previously conducted by authors (Gamajunova and Iskakova, 2015), and other scientists of our country (Bunchak, 2010; Kravchenko and Sharapa, 2010; Mialkovsky, 2017) and other States (Singh et al., 2015; Fernandes and Soratto, 2016; Gondwe et al., 2020) determined that the processes of growth and development of potato plants, their formation of productivity were closely dependent on the type of soil, the availability of its basic elements of nutrition, the use of irrigation, and so on. According to indicators of soil fertility, gradations of nutrients researchers determined the dose of nitrogen, phosphorus and potash fertilizers. Researchers found that the reaction of potato plants to the use of mineral fertilizers was closely related to the type of soil, its density and other elements of its level of fertility. The amount of watering during the growing season of potatoes also depended on the state of the soil.

Our research on changes in soil fertility indicators under the influence of long-term irrigation and fertilizer application (Gamajunova, 2017) determined that the main components of fertility, in particular water-holding capacity, were formed by the combined use of organic and mineral fertilizers. This is also extremely important when growing potatoes, the root system and tubers of which are concentrated in the soil layer up to 40 cm. For this reason, a high efficiency of mulching were established - the sealing of crop residues from previous crops, after which potatoes were planted in the conditions of Indian Punjabi. According to the research (Singh et al., 2015) mulching helps to ensure a favorable thermal regime, it reduces heat, mulching increases irrigation efficiency and productivity of

potatoes and along with the recommended doses of phosphorus and potassium fertilizers it leads to increased yields of potato tubers at 22-31% depending on soil type. The authors found significant savings in irrigation water under the influence of mulching, that is, for enriching the upper layers of the soil with organic matter.

In the conditions of Japan (Hokkaido), it was also established that the use of fertilizers should be variety depending on the availability of available forms of nitrogen, phosphorus, and even calcium in the soil (Gondwe et al., 2020). The authors determined the influence of soil type and variety characteristics on the yield level, which, depending on the management of technology elements, ranged from 21.9 up to 68.2 t/ha. The authors attributed a significant increase in the yield of tubers to the parameters of growth processes - the number of stems and tubers formed, the mass of tubers, and so on to optimize the nutrition of potato plants, which also improved the main indicators of the quality of tubers, which was important.

Nitrogen nutrition plays an outstanding role in enhancing plant growth processes, photosynthetic activity, and increasing chlorophyll in leaves (Wilkinson et al., 2019). At the same time, as established by the authors, it was affected even the form of application of nitrogen fertilizer - ammonium or nitrate, and especially when carrying out foliar nutrition's of plants for growing two yields of potatoes in greenhouses.

Research conducted over 5 years in France (Cohan et al., 2018) found that the effectiveness of nitrogen fertilizers significantly depended on the ratio between the content of mobile forms of nitrogen in the soil and a certain dose of fertilizer to obtain an optimal level of potato productivity. Under these conditions, a high return on the unit of applied fertilizer was provided and the ecological environment was preserved from clogging. In addition, the authors determined the different degree of nitrogen use by plants (removal by harvest), depending on the varietal characteristics of potatoes, which should be taken into account in the recommendations for the use of nitrogen for farmers.

In addition, when nitrogen fertilizers were applied and irrigation was carried out, nitrates were redistributed to the lower layers of the soil (Meise et al., 2019). For this reason, the authors suggested to adhere to the optimal ratio of doses of nitrogen fertilizer and irrigation standards, noting that this significantly affected and changed both the level of yield and the starch content in potato tubers.

Research (Shehata et al., 2019) established changes in the growth processes of potato plants and crop formation under the influence of plastic mulching and crop clogging. The authors determined that the yield of commercial potato tubers decreased by 57.8% in heavily polluted areas compared to clean fields.

The set of measures for the protection of potatoes for the use of pesticides, insecticides and fungicides in combination with organic and mineral fertilizers and microbial preparation Extrasol in the studies of Russian scientists carried out in the Nizhny Novgorod region on podzolized Chernozem for 2015-2017 yrs (Titova and Chudokvasoff, 2019), allowed to determine the influence of these factors on the yields of potato tubers and their quality, in particular on the starch content and its conventional crop. The authors found one of the three potato varieties as more productive and plastic in all years of research such as Labella variety (38.0-47.9 t/ha), and the highest starch yield per unit area was provided by the variety Granada (8.71 t/ha).

It was determined the difference in potato yield levels, starch content in tubers and conditional yield of it per hectare by earlier studies on southern Chernozem for growing three varieties of potatoes Tiras, Zabava and Slavyanka (Gamajunova and Iskakova, 2015).

A significant difference in the main quality indicators of potato tubers was found by researchers from Bolivia (Tejela et al., 2020) when analyzing 52 varieties of tubers. Thus, the moisture content of tubers ranged from 63 up to 81%, content of protein ranged from 3 up to 11%, content of carbohydrates ranged from 9 up to 35%, the total content of flavonoids was from 2 up to 19 mmol EQ. catechin/g of dry substances. Similarly, other important indicators of the quality of potato tubers in the context of varieties were changed, which allowed the authors to determine the most valuable varieties that can be recommended for dietary nutrition.

The content and yield of starch depending on the characteristics of the variety and fertilizer was established in the vegetation experiment (Meise et al., 2019).

In the arid conditions of the southern Steppe of Ukraine, vegetable crops and potatoes are grown on irrigation, where due to the level of optimal moisture of plants, their nutrition becomes of paramount importance. Due to fertilizers in irrigation conditions, crop yield increases by 50-75% or more, and without irrigation, but for creating optimal nutrition conditions for them, insignificant reserves of soil moisture and precipitation of the growing season, plants bee grown without irrigation used moisture and precipitation much more effectively than on impoverished NPK plots. This was defined on many crops, including vegetables, legumes, and grains. In addition, this increases the payback of fertilizers, especially when combined with mineral fertilizers with trace elements or biopreparations (Gamajunova, 2018; Gamajunova and Panfilova, 2019). The payback of a unit of fertilizer increases significantly due to their use and when growing potatoes, which is confirmed by our research (Gamajunova et al., 2019) and research by other scientists (Khmylevskyi, 2006; Balashova and Yuziuk, 2016).

In general, as already mentioned above, plant nutrition is a crucial factor in influencing on the productivity of agricultural crops, including potatoes. There is a close correlation between the level of mineral nutrition and structural elements and the yield of tubers in a number of potato hybrids (Dudar et al., 2019).

In recent years, for reducing the cost of plant nutrition and reducing the impact of fertilizers on the environment, biopreparations and growth stimulants are widely used, which include trace elements, organic components, and the like. Many studies conducted with various agricultural crops determined their impact on the yield and quality of grown products (Makukha, 2020). At the same time, they are environmentally friendly, low-cost and recommended for use for the purpose of resource conservation and environmental friendliness. Modern biopreparations quickly enter plant cells through the leaf surface, they are easily accessible and, regardless of the content of nutrients in the soil, they can increase the yield level by up to 15% and improve the quality of agricultural crops, in particular potatoes (Vlasenko et al., 2002). They increase the plant's resistance to drought and adverse environmental conditions. Our research established the positive effect of growth-regulating substances on the yield and quality of potato tubers (Gamajunova et al., 2019). The use of trace elements and growth-regulators contributed to a significant improvement in the main quality indicators of tubers of the studied potato varieties in the conditions of the right-Bank forest-Steppe of Ukraine (Mialkovski, 2018) and in the zone of the Southern Steppe of Ukraine (Balashova and Boiarkina, 2019).

The purpose of our work was to investigate the impact of nutrition optimization on the yield and quality of potato tubers and to develop a resource-saving nutrition system for growing them on drip irrigation in the South of Ukraine.

MATERIALS AND METHODS

Field experiments with potatoes were conducted in the educational, scientific and practical center of the Mykolaiv National Agrarian University during 2017-2019 yrs. Soil was South heavily clayed residual-solonetzic chernozem.

The soil layer 0-30 cm contains humus (for Tyurin) - 2.9-3.2%, light hydrolyzed nitrogen 60-62%; nitrates (for Grandval - Liagou) 20-25 mg/kg; mobile phosphorus (for Machigin) 35-49 mg/kg; exchange potassium (on the flame photometer) 320-370 mg/kg of soil; pH is 6.8-7.2. Weather conditions in the years of research differed somewhat, especially in the amount of precipitation, but they were generally characteristic of the Southern Steppe zone of Ukraine. The predecessor was black steam. Potatoes were grown on drip irrigation. Before the appearance of sprouts on tubers in the 0-20 cm soil layer, humidity was maintained at the level of 70-75% HB, and in the subsequent vegetation period humidity was maintained at the level of 80-85% HB. Studies were conducted with two zoned potato varieties such as Minerva and Riviera. The repeatability of experiments was fourfold. The area of the landing area was 90 m^2, the accounting area

was 50 m^2. The experience scheme was shown in the tables. Mineral fertilizers were introduced in the form of compound NPK fertilizer ($N_{16}P_{16}K_{16}$), ammonium nitrate (33% N) and growth-regulating preparations were used. Twice during the growing season - during the formation of 3-4 leaves and in the budding phase, foliar nutrition's were performed with modern biopreparations Plantafol, Organic D2-M and Regoplant at the appropriate cost per nutrition of 3 kg; rates 1 l/ha and 50 ml/ha, using 200 l/ha solution. The structure of the crop during harvesting in the phase of full ripeness of tubers was determined by the weight method. Data of research and accounting of yield were processed by the method of dispersion analysis (Dospehov, 1985).

Technological analysis of the quality of potato tubers was carried out according to generally accepted methods and STATE STANDARDS. The starch content was determined by the Evers method, ascorbic acid content was determined by the Murri method, and dry substance content was determined by weight-thermostatic method.

RESULTS AND DISCUSSIONS

The results of the research determined that both varieties reacted positively to the use of mineral fertilizers and especially for the use of the studied biopreparations according to their background (Table 1). Thus, the yield of commercial potato tubers of the Minerva variety with the introduction of only mineral fertilizers, depending on the dose, increased on average over three years up to 19.7-25.5 t/ha, and the yield of tubers of the Riviera variety increased up to 22.7-27.5 t/ha at its level as in the non-fertilized control the yield was 16.7 and 19.5 t/ha, respectively. After the two foliar nutrition's, the yield of tubers continued to grow and fluctuated in varieties up to 28.7-29.9 and 31.0-32.1 t/ha depending on the biopreparation.

Both in some years of research, and on average for three years, the highest yield was formed by the Riviera variety compared to the Minerva variety.

Table 1. Influence of nutrition optimization and varietal characteristics on the yield of commercial potato tubers, t/ha

Background of nutrition (factor B)	Variety (factor A)							
	2017 yr		2018 yr		2019 yr		2017-2019 yrs	
	M*)	R	M	R	M	R	M	R
Without fertilizers (control)	15.8	20.3	18.2	21.0	16.1	17.2	16.7	19.5
$N_{32}P_{32}K_{32}$ in autumn – background	18.6	22.5	21.3	24.3	19.2	21.4	19.7	22.7
Background + $N_{32}P_{32}K_{32}$+ N_{33} in spring before sowing	22.6	25.7	28.5	29.9	24.5	26.8	25.2	27.5
Background+$N_{32}P_{32}K_{32}$+ N_{33} (in spring) + Plantafol, 6 kg/ha	25.8	25.8	32.8	33.6	28.2	30.7	28.7	31.0
Background + $N_{32}P_{32}K_{32}$ + N_{33} (in spring) + Organic D2-M, 2 kg/ha	26.6	30.1	33.9	35.0	29.2	31.1	29.9	32.1
Background+$N_{32}P_{32}K_{32}$+ N_{33} (in spring)+ Regoplant, 100 ml/ha	25.9	29.2	32.7	34.3	29.0	30.9	29.3	31.5
HIP_{05}, t/ha on factor A	1.1		0.9		1.0			
on factor B	1.3		1.2		1.4			
on factors AB	1.6		1.5		1.9			

Note: M*) - variety Minerva; R - variety Riviera.

However, slightly higher increase in the yield of commercial tubers compared to non-fertilized control provided by less productive variety, which can be seen in the illustration of Figure 1.

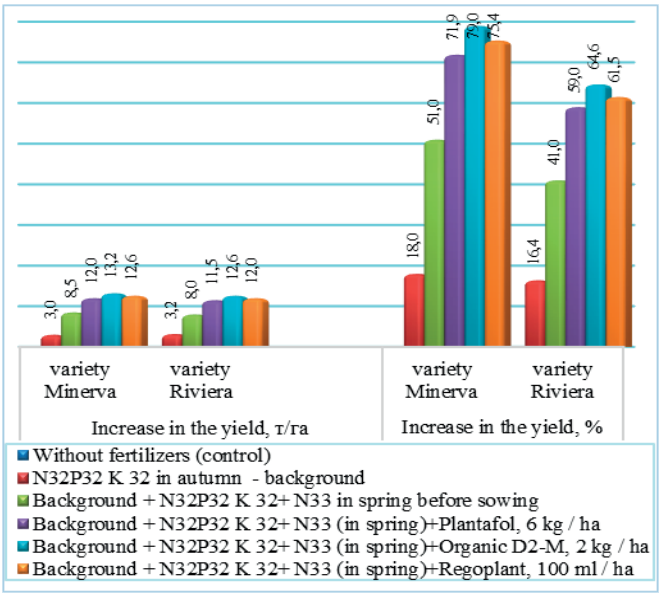

Figure 1. Increase in the yield of commercial potato tubers compared to non-fertilized control depending on the variety and nutrition variant (average for 2017-2019 yrs)

The maximum yield of commercial potato tubers of both varieties was provided by the use of Organic D2-M mineral fertilizers at the dose of 29.9 t/ha for the Minerva variety and at the dose of 32.1 t/ha for the Riviera variety. The use of Plantafol and Regoplant preparations for foliar nutrition also provided significant increases in the yield of tubers, but they were slightly lower compared to the use of Organic D2-M.

On average, for both potato varieties taken for research, the yield of tubers under the influence of fertilizer increased, and especially when mineral fertilizers were used together and foliar nutrition were carried out using biopreparations with the advantage of processing crops by Organic D2-M.

Studies have established a positive effect of plant nutrition on the main quality indicators of potato tubers (Table 2). Thus, the content of dry substance, vitamin C (ascorbic acid) and starch in tubers of both varieties significantly increased (Table 2). These quality indicators of tubers differed slightly by variety. Thus, the dry substance contained more in potato tubers of the Riviera variety, and more starch accumulated in tubers of the Minerva variety. To a lesser extent, depending on the variety, the content of ascorbic acid in potato tubers varied with a slight advantage of the Riviera variety.

Table 2. The main indicators of quality of potato tubers depending on variety and nutrition optimization (average for 2017-2019 yrs)

Background of nutrition (factor B)	Variety (factor A)					
	Minerva			Riviera		
	dry substance, %	vitamin C, mg %/100 g	starch, %	dry substance, %	vitamin C, mg %/100 g	starch, %
Without fertilizers (control)	16.5	14.8	14.2	19.5	15.8	11.9
$N_{32}P_{32}K_{32}$ in autumn - background	18.4	15.4	14.4	20.5	16.1	12.5
Background + $N_{32}P_{32}K_{32}$ + N_{33} in spring before sowing	19.0	15.8	14.5	21.3	16.3	12.8
Background + $N_{32}P_{32}K_{32}$+ N_{33} (in spring) + Plantafol, 6 kg/ha	19.7	16.3	14.8	21.8	16.5	13.6
Background + $N_{32}P_{32}K_{32}$+ N_{33} (in spring) + Organic D2-M, 2 kg/ha	19.9	16.5	14.9	21.9	16.7	13.8
Background + $N_{32}P_{32}K_{32}$+ N_{33} (in spring) + Regoplant, 100 ml/ha	19.9	16.4	14.8	21.8	16.6	13.7
HIP_{05}						
on factor A	0.2-07	0.1-0.4	0.7-0.9			
on factor B	0.4-0.9	0.2-0.6	0.2-0.3			
on factors AB	0.5-1.1	0.4-0.8	0.7-1.0			

These indicators of quality of potato tubers are important, they depend on the taste, digestibility of tubers and their energy value. The content of these ingredients determines the direction of using potatoes for food consumption, making chips, for processing (alcohol, starch), feed purposes etc. In recent years, some of the grown potato tubers were used to produce biodiesel, an environmentally friendly fuel (Polishchuk et al., 2011).

We determined what the yield of individual products from the crop of tubers formed by the studied potato varieties could be (Table 3).

Table 3. Influence of potato nutrition optimization on the conditional yield of individual tuber processing products (average for 2017-2019 yrs)

Background of nutrition (factor B)	Minerva (factor A)			Riviera (factor A)		
	Product of processing					
	starch, t/ha	alcohol, t/ha	bioethanol, l/ha	starch, t/ha	alcohol, t/ha	bioethanol, l/ha
Without fertilizers (control)	2.37	1.87	1.68	2.32	2.18	1.96
$N_{32}P_{32}K_{32}$ in autumn - background	2.84	2.20	1.98	2.84	2.54	2.28
Background + $N_{32}P_{32}K_{32}$+ N_{33} in spring before sowing	3.65	2.82	2.53	3.52	3.08	2.76
Background + $N_{32}P_{32}K_{32}$+ N_{33} (in spring) + Plantafol, 6 kg/ha	4.25	3.21	2.88	4.22	3.47	3.11
Background + $N_{32}P_{32}K_{32}$+ N_{33} (in spring) + Organic D2-M, 2 kg/ha	4.46	3.35	3.00	4.43	3.60	3.22
Background + $N_{32}P_{32}K_{32}$+ N_{33} (in spring) + Regoplant, 100 ml/ha	4.34	3.28	2.94	4.32	3.53	3.16

Notes: according to the Institute of potato NAAS of Ukraine the yield from 1 ton of raw potato tubers is: alcohol – 112 kg; ethanol – 100.4 l

As evidenced by the results of Table 3, optimization of nutrition of potato plants compared to the control significantly increases the output of all major products of tubers for the highest values in the variants of a combination of mineral fertilizers with the foliar nutrition of crop plants twice during the growing season with biopreparations, including

maximum levels of all ingredients were determined, allows to achieve when using the preparation Organic D2–M.

One of the two potato varieties studied has a slightly higher conditional yield of starch only which is provided by growing the Minerva variety, and more alcohol and bioethanol is provided by the Riviera variety, which can be clearly traced by the values shown in Figure 2. It clearly figures up the advantages of potato nutrition and especially for growing the crop in the most optimal way: $N_{32}P_{32}K_{32}$ (autumn) $N_{32}P_{32}K_{32} + N_{33}$ (spring) + Organic D2-M.

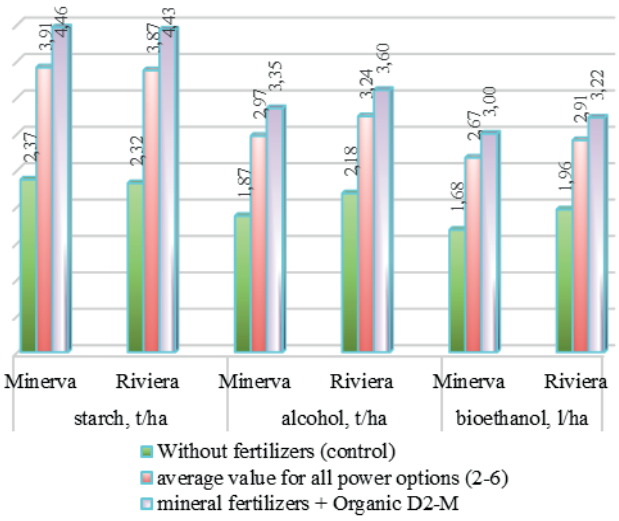

Figure 2. Conditional yield of processing products of potato tubers depending on fertilizers and biopreparations (average for 2017-2019 yrs)

CONCLUSIONS

Application of mineral fertilizers in the autumn and spring before planting compared with non-fertilized control significantly increases the yield of commercial tubers of both potato varieties and it improves the main indicators of their quality. The highest productivity of tubers is formed by carrying out two foliar nutritions with biopreparations on the background of fertilizer, and the maximum productivity is formed by using the preparation Organic D2-M. On average, in 2017-2019 yrs, the yield of tubers of the Minerva variety in this variant was 29.9 t/ha, and the yield of tubers of the Riviera variety was 32.1 t/ha, which exceeded the control by 13.2 and 12.6 t/ha or by 79.0% and 64.6%. In this case, you can get the highest conditional yield of starch, alcohol and bioethanol per hectare.

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