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THE RESPONSIVENESS OF TAMASHA POTATOES TO BIOLOGICAL FERTILIZERS

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Abstract. The article presents the results of research work carried out in the direction of studying the influence of biological fertilizers on the yield and qualityof the Tamasha potato variety on heavy loam dark chestnut soils of Central Kazakhstan. It was carried out on a land plot with a humus content of 2.73-2.79 %, total nitrogen - 0.147-0.172 %, total phosphorus - 0.20-0.25 %, a high level of supply of mobile phosphorus and potassium, a low content of nitrate nitrogen, a weakly alkaline soil pH. The research work carried out showed that potatoes have a high need for biological fertilizers, which, according to the types of fertilizers, gave an additional yield of up to 20 %, and also had a positive effect on quality indicators. It was shown that the effectiveness of biological fertilizers depends not only on its composition, but also on the influence of external factors, including first the soil conditions and the supply of potatoes with macronutrients.

Key words: potato, soil, biological fertilizers, productivity, efficiency.

INTRODUCTION

Fertile soil plays a crucial role in maintaining the stability of the country's agro-industrial complex and providing a conducive environment for both ecological and economic aspects. It serves as a guarantee for the sustainable production of crops. Nevertheless, the intensive farming systems employed on farms may compromise soil quality. Enhancing soil composition, preventing soil-borne infectious diseases, and implementing a scientifically grounded crop rotation system positively impact soil properties, including agrophysical, chemical, and biological aspects [1].

Since the country gained independence, the agro-industrial complex has consistently witnessed a rise in production and an increase in labor productivity. The industry's fixed assets have been modernized, leading to a growth in exports of agricultural products. Under market conditions, aligned with the growing population, the demand for food products escalates each year, emphasizing the increasing necessity for high-quality products.

Solanum tuberosum L.,one of the most widely cultivated tuberous crop, it belongs to the *Solanaceae* family. The homeland of potatoes is Central and South America, it was brought to India by Portuguese sellers at the beginning of the XVII century [2, 3]. The demand for the crop among the population immediately increased, and 2.13 million hectares were planted in India, with an average of 20.5 tons to 44 million tons per hectare [4].

Potatoes hold a significant place on the menu as one of the most crucial food items. The average daily potato consumption per citizen in the country stands at approximately 120-130 kg, underscoring the pivotal role of potatoes as a staple akin to a «second bread» for the people of Kazakhstan [5, 6].

It turns out that 75 % of the total cultivated potato area in the country is occupied by private land plots, and only 25% is occupied by agricultural production. However, in recent years, the share of potatoes grown in agricultural collectives has been increasing, and this figure is planned to increase several times in the coming years [7].

Potatoes exhibit a high sensitivity to environmental conditions and demand specific soil composition for optimal growth. Frequent fluctuations in air temperature have a correspondingly strong effect on crop yields [8, 9].

The potato crop requires a large supply of fertilizers, especially high requirements for phosphoric fertilizers [10-12]. However, inefficient systematic application of fertilizers negatively affects the soil ecosystem and leads to heavy metal poisoning [13, 14].

Heavy metals such as Pb, Cd, Ni and Cr found in fertilizers are important elements for plants, however, therefore, its excessive use is toxic to potato plants and humans [15].

According to the Bureau of national statistics of the agency of the Republic of Kazakhstan for Strategic Planning and reforms, the potato yield in 2022 amounted to 20.5 t/ha[16].If we take into account the fact that the level of development of potato farming directly depends on the economic situation, potatoes are one of the most profitable sectors, such as vegetable crops. According to the specifics of each region, the cost of production per potatoe is 15-20 tenge, the cost of sales is 50-60 tenge, profitability ranges from 50 % to 300 % [17]. This indicates a high demand for the crop in the market.

To meet the country's potato needs, it is impossible to increase the yield and quality of this crop without preserving and expanding the available acreage and increasing soil fertility, as well as it is important to introduce new domestic competitive, high-yielding potato varieties into production, which are distinguished by resistance to biotic and abiotic factors, high preservation and suitability for industrial processing.

However, despite this, potato yields are significantly lower compared to other countries (Belarus, Russia, USA, Canada, etc.). One of the main reasons is due to the fact that potatoes do not take into account the need for basic nutrients in the soil, their requirements for fertilizers. Currently, the results of numerous research works of scientists in the study of the biological features of potatoes, its selection and cultivation technology have been published in Kazakhstan [6, 17-20]. However, such important questions as determining the conditions of mineral nutrition of potatoes and the need for biological fertilizers are not considered.

In this context, the objective of this research was to investigate the biological requirements of potatoes under varying mineral nutrition conditions and assess its responsiveness to biological fertilizers.

MATERIALS AND METHODS

Object of research. In the conditions of Central Kazakhstan, the goal was to determine the influence of biological fertilizers on the yield and quality of potatoes and their need for nutrients in the soil.

Research was conducted on the content of humus in heavy loam dark chestnut soil at the Karaganda Research Institute of Crop Production and Selection LLP in the Bukhar-Zhyrau District of the Central Kazakhstan region. The soil analysis revealed humus levels ranging from 2.73 % to 2.79 %, total nitrogen concentrations between 0.147 % and 0.172 %, and phosphorus levels ranging from 0.20 % to 0.25 %. The experiment involved sixteen variations with three repetitions each, covering a square area of 20.0 m^2.

Before planting potatoes, both potato tubers and their aboveground organs during budding and flowering stages were treated with biomineral fertilizers, including Humate Souffler (applied at a rate of 0.25-0.3 l/ha), Bioorganic (BioStim Universal - 0.5-2 l/ha), and micro-fertilizers (Intermag Profi Kartofel, 1.0-2.0 l/ha).

In preparation for the planting season, soil samples were taken from all variations, assessing nutrient levels and moisture content in 0-20 cm and 20-40 cm layers. Additionally, control versions were sampled at every 0-20 cm layer, reaching a depth of one meter. Soil analyzes were carried out by methods generally accepted in agrochemistry for carbonate soils. In the samples obtained, the following indicators were determined: soil moisture – by weight

method, nitrate nitrogen – by reaction with disulfophenolic acid (according to the Grandval-Lyazhu method), mobile phosphorus and exchange potassium from one soil extract – by Machigin.

Planting was carried out using a «Grime» potato planter machine, with a sowing rate set at 3.5 t/ha and the Tamasha potato variety employed. After planting, immediate soil compaction measures were implemented.

RESULTS AND DISCUSSION

The agricultural year of 2014-2015 was marked by a cold autumn, limited snowfall, and a delayed spring, with an annual precipitation exceeding the average by 90 mm. Additionally, the monthly average air temperature was 2-3°C lower than the annual average, as depicted in figure 1.

In the months of April and May, persistently low air temperatures, coupled with substantial precipitation, posed challenges for tillage and sowing activities. Potato planting, in particular, was deferred until the latter part of the third decade of May. Consequently, the harvest was delayed by 2-3 days beyond the stipulated deadline, aligning with the specific characteristics of the potato variety.

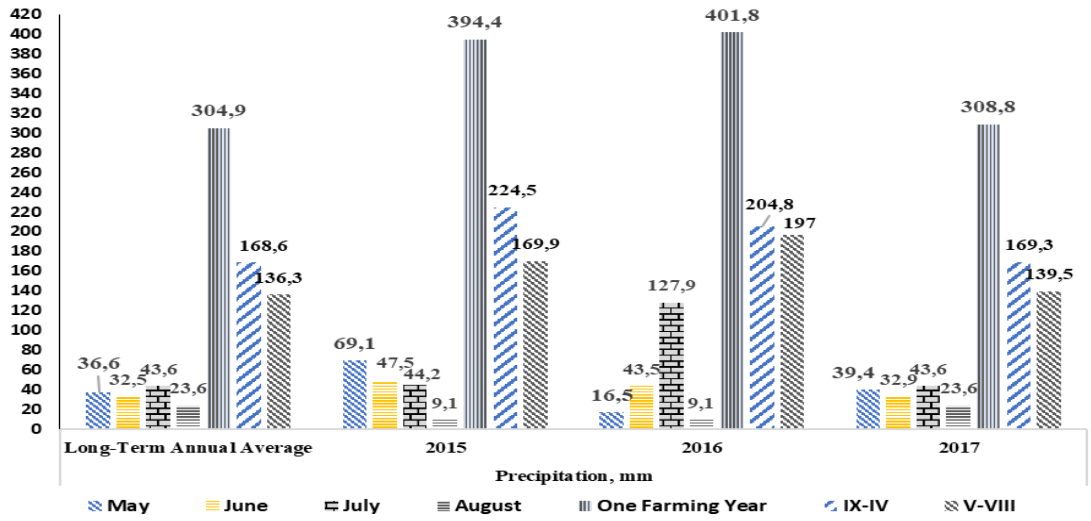

Figure 1 - Amount of precipitation in the years of the study (according to the meteopost data of LLP «KRIGP&S»)

During the vegetation period of the crop (V-VIII months), there was a total precipitation of 169 mm, surpassing the average annual indicator by 34 mm or 44 %.

The agricultural year of 2015-2016 proved favorable for potato cultivation in the Bukhar Zhirau district. Precipitation from September to August reached 451 mm, exceeding the average annual precipitation by 146.9 mm. Additionally, the precipitation of 43.7 mm in March-April contributed to high soil humidity, positively impacting potato germination (figure 2).

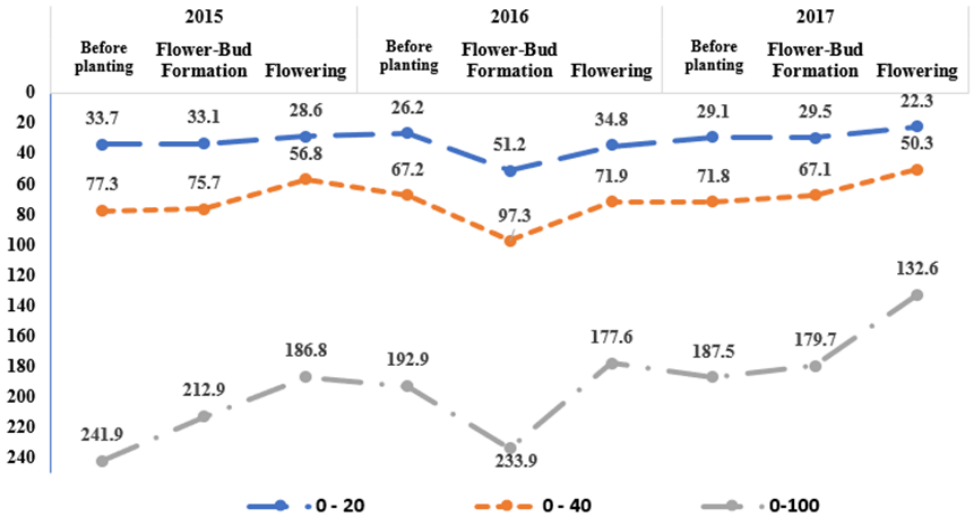

Figure 2 - Effective soil moisture content and dynamics in potato fields, mm

In the subsequent agricultural year of 2016-2017, climatic conditions remained at the average multi-year level. However, lower temperatures in May-June adversely affected the development of potato tubers.

Hydrothermal conditions also played a crucial role in determining soil moisture levels. Before planting potatoes, the productive moisture content in the 0-40 cm soil layer was 70.1 mm, 55.9 mm, and 73.3 mm in the respective study years. Irrigation (200-300 m^3) during the budding and flowering period of potatoes helped maintain satisfactory soil humidity until harvest.

Winter-spring rainfall in the study years increased soil moisture, with the productive moisture content in the one-meter soil layer before potato planting measuring 241.0 mm in 2015, 193 mm in 2016, and 188 mm in 2017.

June-July rainfall further contributed to maintaining soil moisture at satisfactory levels until harvest. The hydrothermal conditions had a notable impact on the mineral nutrition of potatoes and ongoing soil processes, as indicated in table 1.

The nitrate nitrogen content in the soil exhibited variations corresponding to spring-summer hydrothermal conditions. Prior to planting potatoes in 2015, the nitrogen level in the 0-40 cm soil layer was low, measuring 8.8 mg/kg, while in 2016, it was at a medium level (19.3 mg/kg). The levels in the lower layers (40-60 cm) were approximately similar to those in the upper layer.

In conditions of high humidity, the nitrate content indicates the leaching of nitrogen into the lower layers.The movement of nitrogen to lower soil layers indicates a dynamic interaction influenced by moisture levels, emphasizing the crop's heightened demand for nitrogen throughout its growth period under these conditions.

During the budding phase of potatoes, there was a gradual decrease in nitrogen content in the soil, indicating its utilization for crop development. Subsequently, during the flowering period, the nitrification process intensified, leading to an increase in nitrogen levels in the soil.

Table 1 - Amount of nutrients in the soil of the experimental plot, mg/kg

Soil layers, cm	Before planting			Budding period			Flowering period		
	$N–NO_3$	P_2O_5	K_2O	$N–NO_3$	P_2O_5	K_2O	$N–NO_3$	P_2O_5	K_2O
	2015								
0 - 20	9.8	80.8	845	6,7	78,3	878	7,5	78,5	864
20 – 40	7,8	52,1	545	5,6	35,6	512	7,0	35,0	550
0 – 40	8,8	66,4	695	6,2	57,0	695	7,2	56,8	707
40 – 60	9,0	44,0	510	5,0	38,0	530	8.0	29.6	522
60-80	8.4	20.4	258	5.0	17.2	295	7.2	15.6	247
80–100	7,8	10.2	240	4.9	12.0	235	7.2	15.6	228
2016									
0 - 20	20.4	82.4	951	17.3	8 2.0	943	23,0	81,6	940
20 – 40	18,2	56,0	730	13,0	64,0	729	10,8	64,0	761
0 – 40	19,3	69,2	840	15,2	73,0	836	16,9	72,8	850
40 – 60	22,2	36,4	590	15,7	34,8	586	16.1	2 2.8	536
60-80	18.2	1 4.8	269	11.2	17.6 _	220	15.2	14.8	275
80–100	17.8	1 5.2	280	15.1	12.4	271	16.0	9.2	245
2017									
0 - 20	7,8	72.2	885	9.4	62.3	838	9,2	65,0	851
20 – 40	7,3	69,8	763	8,9	51,0	758	8,1	52,2	735
0 – 40	7,6	71,0	824	9,2	56,6	798	8,6	58,6	793
40 – 60	3,4	38,1	442	7,2	27,0	467	5,4	13,6	424
60-80	3.2	16.6	293	5,6	5,6	280	4.9	5.8	275
80–100	2.8	6.8	286	5.2	4.8	235	3.8	5.8	233

In terms of mobile phosphorus content in the plowed layer of soil (0-20 cm), it was notably high, ranging from 80 to 82 mg/kg. This high level can be attributed to the application of substantial amounts of organic fertilizers in previous years. In the lower soil layers, the phosphorus content immediately decreased, with the primary concentration found in the 0-20 cm layer. The subsequent decrease in lower layers was approximately 2-2.5 times less. This emphasizes the significance of the top layer in providing phosphorus nutrition for potatoes.

Over the years of research, the content of potassium in the soil is also very high, as is phosphorus (845; 951; 885 mg/kg). Throughout the crop's growing season, the potassium levels remained constant. The findings from research indicate that potassium content decreases due to plant uptake, but this reduction is compensated by replenishment with other fractions in the soil.

The applied biological fertilizers are rich in all mineral and organic substances necessary for the growth and development of potatoes in terms of their qualitative composition. The BioStim Universal biofertilizer contains amino acids (10 %), nitrogen (6 %) and potassium (3 %), which are necessary for creating a crop. The amino acids it contains are the main material for the plant's enzyme system and protein biosynthesis. This, in turn, has a positive effect on the elongation of plant shoots, during flowering, product formation.

Humate Kalia Souffler is an organic-mineral fertilizer containing a high content of humic substances (80 %). During the stages of plant growth and fruiting, the active humic acid compounds present in the fertilizer play a proactive role, exerting a positive influence on the plant's development.

Intermag Profi Kartofel is a concentrated liquid microfertilizer. It increases the resistance of potatoes to diseases,

external environmental condi-tions, has a positive effect on the starch content of tubers, and the quality pro-perties of the product. The balanced trace elements contained in it (MgO, SO_3, B,Cu, Fe, Mn, etc.) and total nitrogen (15 %) fully meet the nutritional needs of potatoes.

The application of biological fertilizers enhanced the mineral nutrition conditions for potatoes. In comparison to the control group, plants treated with biological fertilizers exhibited robust stem formation, leaves took on a deep green hue, leading to an augmented intensity of photosynthetic processes. This, in turn, had a favorable impact on harvest formation. The influence of biological fertilizers on the yield ofpotato varietiesis detailed in table 2.

Table 2 - Effect of fertilizers on potato productivity, t/ha

№	Treat-ments	2015			2016			2017		
		Producti-vity	Additional productivity		Producti-vity	Additional productivity		Producti-vity	Additional productivity	
			t/ha	%		t/ha	%		t/ha	%
1	Control	29.6	-	-	20.2	-	-	28.3	-	-
2	Bio-mineral fertilizer	35.1	5.5	18.6	22.7	2.5	12.4	30.6	2,3	8.1
3	Bio-organic fertilizer	34.1	4.5	15.2	22.4	2.2	10.9	31.9	3.6	12.7
4	Microfer tilizer	30.1	0.5	1.7	20.3	0.1	0.5	29.0	0.7	2.5
	m, %		2.93			1.93			2.05	
	LSD_{05}		2.75			0.75			1.78	

The yield under control in 2015 was 29.6 t/ha; in 2016 - 20.2, in 2017 – 28.3 t/ha. The additional productivity obtained from biomineral fertilizers in the years of the study varied from 2.3 to 5.5 t/ha, according to the climatic features of the year and types of fertilizers. The highest yield was obtained from the«Humate Souffler» fertilizer (35.1 t – in 2015, 2.5t/ha - in 2016, 2.3 t/ha – in 2017), the same indicator was obtained from the «BioStim Universal» fertilizer. Additional productivity for these years amounted to 4.5 t/ha, 2.2 t/ha, and 3.6 t/ha, respectively. The «Intermag Profi Kartofel»fertilizer consistently performed at the control level over the three years, suggesting a low content of trace elements in the fertilizer required for potato crop productivity.

Throughout the study years, climatic conditions had a negative impact on potato crop formation. In 2015, an abrupt temperature drop on August 25-26 (-3 and -5°C) caused frostbite, resulting in withered and darkened leaves within a week, leaving only the stems green.

Due to abundant precipitation in June-July 2016 (171.4 mm, which is 95.3 mm higher than the average), low air temperature, high soil moisture, the terrestrial organs of potatoes were affected by late blight. The first signs of diseases were observed on the stems and leaves of potatoes. Spots of purple color appeared on the leaves, increased in size, and subsequently the aboveground organs completely faded.

Climatic conditions for the 2016-2017 agricultural year were at the level of average perennials. However, low temperatures in May-June negatively affected the timing of the formation of potato tubers shows that with the effective use of biological fertilizers, it is possible to

change the chemical composition of the resulting products, to increase their qualitative properties (figure 3).

Research studies have shown that biological fertilizers have a different effect on the quality of products. Moisture in the tuber affects the activity of the processes taking place in it, which is especially important during storage. The moisture content of potato tubers taken in the study fluctuated between 80-83. There was no pattern between the options.

The ash content in the potato crop varied according to the types and chemical composition of fertilizers applied, from 0.85 to 0.89 % according to variants. The applied fertilizers had a low impact on the amount of ash.

The importance of fiber in the daily diet of a person is high. It gives food nutritional properties and has a positive effect on the cleansing of the body. The fiber content in the yield of the Tamasha variety under study ranged from 0.82 to 0.90. Climatic conditions had a much greater impact on the qualitative composition of the tuber than biological fertilizers.

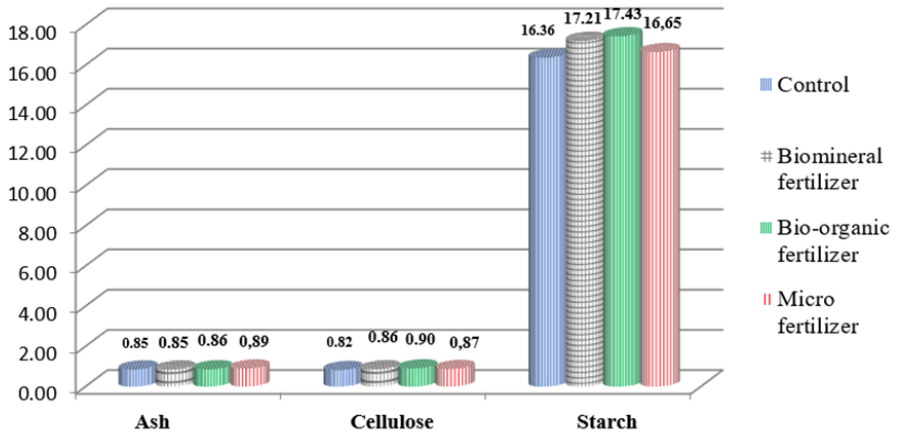

Figure 3 - Effect of biological fertilizers on product quality of potato (2015-2017 average indicators), %

One of the most important quality indicators of potatoes is starch. 75 % of the dry mass of the potato tuber touches the starch content and is the main carbon. Its content is 8-17 % in table varieties according to the characteristics of the variety, and starch in extractive varieties ranges from 15-25 %. The high starch content increases its taste qualities [10].

According to the standard classification of starch, 14-16 % is considered medium, 17-21 % – high [11]. In our experiments, potatoes have an medium starch content. Under the influence of the introduced biofertilizers, its content increased by 0.29-1,07 %. Research studies has also shown that all biofertilizers when used, have a high economic efficiency, and the efficiency of the fertilizers used corresponds to their cost.

CONCLUSION

Research work carried out in 2015-2017 on heavy loam dark chestnut carbonate soils of Central Kazakhstan showed that the effectiveness of biological fertilizers corresponded not only to its chemical composition, but also to the conditions of the external environment, including soil conditions and soil supply with nutrients. Compared to the control soil, biological fertilizers increased the potato yield by 10-18 %.

According to the results of the study, biological fertilizers for the yield and quality of potatoes proved that there cannot be certain types that guarantee high results in all cases, and showed that in the future it is necessary to study in this direction and more deeply.

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ТҮЙІН

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КАРТОПТЫҢ ТАМАША СҰРПЫНЫҢ БИОЛОГИЯЛЫҚ ТЫҢАЙТҚЫШТАРҒА ЖАУАПТЫЛЫҒЫ

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Мақалада Орталық Қазақстанның ауыр құмбалшықты күңгірт қара-қоңыр топырағында картоптың Тамаша сұрпының өнімділігі мен сапасына биологиялық тыңайтқыштардың әсерін зерттеу бағытында жүргізілген ғылыми-зерттеу жұмыстарының нәтижелері келтірілген. Құрамында қарашірік мөлшері 2,73-2,79 %, жалпы азот - 0,147-0,172 %, жалпы фосфор - 0,20-0,25 %, жылжымалы фосформен және калиймен қамтамасыз етілу деңгейі жоғары, нитрат азотының мөлшері төмен, топырақ ерітіндісінің әлсіз сілтілі жер телімінде жүргізілді. Жүргізілген ғылыми-зерттеу жұмыстары картоптың биологиялық тыңайтқыштарға қажеттілігі жоғары екенін көрсетті, тыңайтқыштардың түрлеріне сәйкес 20 %-ға дейін қосымша өнім беріп, сапалық көрсеткіштеріне де оң әсер етті. Биологиялық тыңайтқыштардың тиімділігі оның құрамына ғана емес, сыртқы факторлардың әсерінен, оның ішінде алдымен топырақ жағдайы мен картоптың макроэлементтермен қамтамасыз етілуіне байланысты екендігін көрсетті.

Түйінді сөздер: картоп, топырақ, биологиялық тыңайтқыштар, өнімділік, тиімділік.

РЕЗЮМЕ

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ОТЗЫВЧИВОСТЬ КАРТОФЕЛЯ СОРТА ТАМАША НА БИОЛОГИЧЕСКИЕ УДОБРЕНИЯ

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В статье представлены результаты научных исследований, проведенных на тяжелосуглинистых темно-каштановых почвах Центрального Казахстана, по изучению влияния биологических удобрений на урожайность и качество картофеля сорта Тамаша. Содержание основных показателей почв: гумус 2,73-2,79 %, общий азот - 0,147-0,172 %, общий фосфор - 0,20-0,25 %. Почва имеет высокий уровень обеспеченности подвижным фосфором и калием, низкое содержание нитратного азота, слабую щелочность почвенного раствора. Проведенные исследования показали, что картофель имеет высокую потребность в биологических удобрениях, дали прибавку урожая до 20% и положительно влияли на качественные показатели. Установлено, что эффективность биологических удобрений зависит не

только от их состава, но и от влияния внешних факторов, в том числе, в первую очередь, от состояния почвы и обеспеченности картофеля макроэлементами.

Ключевые слова: картофель, почва, биологические удобрения, урожайность, эффективность.

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