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Improvement of potato cultivation technology in conditions of Middle Urals

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Abstract. Potato is an important food and industrial crop, occupying one of the leading places in the world production of crop products. Its tubers contain all the necessary nutrients: carbohydrates, proteins, vitamins, essential amino acids, organic acids, mineral salts. Potato is traditionally the second most important crop product in the Russian Federation after grain crops. In terms of production, Russia occupies one of the leading places in the world in terms of the gross harvest of potato tubers (10 % of the world volume), but in terms of productivity it is significantly inferior to all the leading potato growing countries of the world. **Methods**. To increase the yield and quality of the products obtained, it is of great importance to optimize the area for feeding potato. The studies were carried out on the experimental field of the educational and experimental farm “Uralets” of the Ural State Agrarian University (USAU), the village “Studencheskiy”, for three years (2016–2018) in the climatic zone of the Middle Urals. **Purpose of research**. The purpose of the research is to study the influence of the feeding area of Gala potato, the use of fungicides on the yield and quality of tubers in the Middle Urals. Gala potato variety, feeding area and fungicides were taken as the object of research. **Scientific novelty**. The scientific novelty of the research lies in the fact that for the first time in the conditions of the Middle Urals it was established that the highest yield of all the studied options was obtained with a feeding area of 2450 cm^2 (70 × 35 cm) using the fungicide Shirlan 36.6 t/ha (factor B), which is 31.1 % higher than control (factor A) with HCP_{05} = 0.79. **Results.** In experiments in the variant with a feeding area of 1400 cm^2, the largest leaf area from 1 hectare was 27.47 thousand m^2 and the maximum photosynthetic potential was 2.03 million day m^2/ha. It is economically efficient to plant potato tubers in the developed technology with the use of the fungicide shirlan in the variant with a feeding area of 2450 cm^2 (planting scheme 70 × 35 cm), where the lowest cost price (4446 rubles/t), the highest profit (269 172 rubles/ha) and the highest profitability were obtained (165.43 %).
Keywords: potato, area of nutrition, educational-experimental farm, leaf area, photosynthetic potential, harvest, shirlan, cost, profit, profitability.

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Introduction

Potato is an important food and industrial crop, occupying one of the leading places in the world production of crop products. Potato is a raw material for many industrial plants, where starch, alcohol, synthetic rubber, plastics, lactic, acid, dextrin, glue and others are produced. Tubers and industrial waste are used for livestock feed (1 kg of potato contains 0.3 feed unit).

In the Russia, potato is cultivated on an area of more than 2.2 million hectares; the largest volumes of production of this crop are concentrated in the Central, Volga and Siberian federal circles. In recent years, in agricultural organizations and peasant (farm) farms, there has been a tendency for an increase in the area under potato planting and an increase in its yield [6], [7].

Today, more than three thousand potato cultivars are widely distributed in more than 125 countries, particularly under temperate, subtropical and tropical regions covering a major economic share in the global agricultural market [2].

In the 19th century, the potato was one of the most popular crops in Europe. Nowadays, its production has declined, but the potato remains a prominent crop, occupying the third place in terms of total production quantity on this continent. During the 20th century, the use of potato tubers in animal nutrition decreased significantly and led to a substantial drop-off in their production in many countries. Based on FAOSTAT data, over the past 50 years, potato production in Poland, Ireland, Germany and Italy has decreased by 81.0 %, 76.4 %, 66.9 % and 66.4 % respectively [16].

Currently, the potato is the fourth-most important food crop in the world, with a production of 377 million tons; the highest production is by China (22 %), followed by India, Russia, Ukraine and USA. The average global production of potatoes is 17.4 t/ha. USA is the most productive country, with an average of 44.2 t/ha, and the UK is close behind. However, the average potato production in China is 14.35 t/ha. Even using the same potato varieties, there is a large gap between higher yields and lower yields among countries [12].

In 2016, the world under potato was occupied by 19.3 million hectares [8].

Potato is one of the main food products of the Russian population. The structure of the domestic potato market in agricultural organizations and peasant (farmer) enterprises includes table potatoes – 4–5 million tons, seed potatoes – up to 1 million tons and potatoes for processing – up to 1 million tons [10].

In terms of the gross yield of potato tubers, Russia occupies one of the leading places in the world (10 % of the world volume), but in terms of yield it is significantly inferior to all the leading potato growing countries of the world. Potato growing in the world has a number of features, consisting in energy-intensive technology with a high removal of nutrients from the soil, increased mineralization of soil organic matter [5].

The gross harvest of potato in the Russian Federation in 2016 amounted to 31.1 million tons, which is 15.9 % more than the average for the last five years. In 2015, more was harvested: 33.6 million tons of potatoes. In 2017, the gross harvest of potatoes in farms of all categories amounted to 29.6 million tons, which is 5 % less than the gross harvest of 2016 [1], [11].

The average yield of potato in Russia is 15–17 t/ha, while its biological potential makes it possible to obtain yields of 30–40 t/ha and more [15]. To meet the needs of the population, Russia annually imports 500 thousand tons of potatoes, and the export of potatoes is 20 thousand tons [4].

In the Sverdlovsk region, potato is the most important crop in agricultural production, located and cultivated everywhere. Subject to the basic technological requirements, the climatic conditions of the agricultural zone of the region make it possible to form potato yield at the level of 30-40 t/ha. However, the yield of potato in the region remains low and in all categories of farms averages 12.0–14.0 t/ha. In potato growing, a variety acts as an independent factor in increasing the yield and quality of tubers; the increase from the introduction of a new variety can reach 30–40 % or more [9], [13].

Potato is an intensive cultivation culture. Therefore, all applied technologies are intensive. To obtain high yields, it is necessary: the use of highly productive varieties, the introduction of increased doses of organic and mineral fertilizers, the use of plant protection products, the presence of a complex of modern agricultural machines. The main goal of the technology is to obtain high yields with the lowest cost of tubers of high commercial or seed quality [14]. Improving the technology of growing potato is of great importance in increasing yields and improving quality, for a more complete supply of the population with this food product [9].

Among the agrotechnical methods that allow increasing the yield of potatoes, the most effective are changes in planting density and improvement of the mineral nutrition of plants. With an optimal planting density, the plants create a more powerful root system, a well-developed aboveground mass, which prevents weed growth. Such a plant quickly forms tubers and reaches maturity, and, therefore, makes it possible to start harvesting earlier and avoid significant crop losses during storage [3].

Currently, both in the Russian Federation and in the Middle Urals, a number of technologies are used, which primarily differ in row spacing: 70, 75 and 90 cm and on ridges (in two lines (110 + 30), (120 + 30) or (105 + 75) cm and in one line with row spacing 140 (150) (180) cm) [11]. Therefore, in order not to reduce, but to increase the gross production of potato, it is necessary to increase the yield by introducing new high-yielding, well-stored disease-resistant varieties and improving the elements of their cultivation technology. This problem is urgent.

The study of potato cultivation in different feeding areas with the simultaneous use of fungicides will improve the technology by optimizing the feeding area with the use of more effective fungicides in the fight against pathogens and recommend it for production in the Middle Urals.

Purpose of this research is to study the effect of the feeding area of potato variety “Gala”, the use of fungicides on the yield and quality of tubers in the conditions of the Middle Urals

Objectives: to achieve the goal for the study, the following tasks were set: to study the duration of interphase periods; determine biometric indicators of plants; determine the yield of potato tubers depending on the feeding area and the use of fungicides; to study the marketability and fractional composition of tubers; calculate the economic and energy efficiency of the studied agricultural practices.

Methods

The research was carried out on the experimental field of the educational and experimental farm “Uralets” of the Ural State Agrarian University (USAU), the village “Studencheskiy”, for three years (2016–2018) in the climatic zone of the Middle Urals. For the object of research in the experiment, we took a potato variety for table purpose, medium early, high-yielding Gala, bred by German breeders, originator Norika (Germany). In the experiment, two fungicides were studied: shirlan and infinito.

Table 1

Duration of potato interphase periods depending on the area of plant nutrition, 2016–2018

Feeding area, cm²	*From planting to germination (shoots)*	*From germination (shoots) to flowering*	*From flowering to drying out tops (harvesting)*	*From germination (shoots) to drying out tops (factor A)*	*From germination (shoots) to drying out tops (factor B)*	*From germination (shoots) to harvest (vegetation period)*	*From planting to harvest*
1400	*21*	*34*	*40*	*61*	*67*	*74*	*95*
1750	*21*	*35*	*40*	*62*	*69*	*75*	*96*
2100 (c)	*21*	*36*	*40*	*62*	*72*	*76*	*97*
2450	*21*	*37*	*40*	*64*	*75*	*77*	*98*
2800	*21*	*37*	*41*	*66*	*78*	*78*	*99*
r	*–*	*0.97*	*0.71*	*0.95*	*0.99*	*1.00*	*1.00*

Table 2

Biometric indicators depending on the area of nutrition and the use of fungicides, 2016–2018

Feeding area, cm^2	Plant height, cm	Number of stems pieces, thousand /ha	Leaf area, thousand m^2/ha	Average daily growth of leaf surface, cm^2	Photosynthetic potential, million days m^2/ha	Potato tops weight (t/ha) during harvesting, factor A	Potato tops weight (t/ha) during harvesting, factor B
1400	52.3	262	27.4	119.2	2.03	9.90	10.4
1750	51.6	222	23.4	121.2	1.76	5.90	27.0
2100 (c)	51.2	183	18.4	128.1	1.40	4.70	26.0
2450	50.1	155	16.3	134.8	1.25	4.80	46.5
2800	50.2	140	14.6	135.1	1.13	4.80	21.9
r	–0.96	–0.98	–0.98	0.96	–0.98	–0.80	0.51

Table 3

Economic productivity of potato leaves depending on feeding area, 2016–2018

Landing scheme, cm	Feeding area, cm^2	Leaf area of a single plant, m^2	Leaf area, thousand, m^2/ha	Productivity, t/ha	Economic productivity of leaves, t/thousand, m^2
70 × 20	1400	0.387	27.4	27.3	0.99
70 × 25	1750	0.412	23.4	27.9	1.19
70 × 30 (c)	2100 (c)	0.393	18.4	27.0	1.46
70 × 35	2450	0.398	16.3	24.9	1.52
70 × 40	2800	0.405	14.6	22.7	1.55
r	–	0.35	–0.98	–0.89	0.94

The soil of the experimental site is podzolized chernozem, according to its granulometric composition, it is heavy loamy with a humus content of 4.5 %, the reaction of the soil is weakly acidic, the availability of mobile phosphorus is low, exchangeable potassium is average. The depth of the arable layer is 25 cm, the availability of the available forms N, P and K is very low. Agrochemical parameters of soil: pH, saline = 5.4; N =185.9 mg/kg of soil; P_2O_5 = 238.9 mg/kg; K_2O = 268.5 mg/kg.

The experiment (two-factor) consists of 15 variants and 4 replications. The area of one plot is 20 m^2 (width = 2.5 m and length = 8 m), a total of 60 test plots, the total area of the experiment is 1200 m^2. The placement of plots in the experiment is systematic. The row spacing is 70 cm, and the distance between plants in a row is from 20 to 40 cm. The soil and climatic conditions of the Middle Urals are favorable for potato cultivation.

The Sverdlovsk Region is located on the Western and Eastern slopes of the Middle and Northern Urals and the adjacent West Siberian Lowland. The exception is its Southwestern part, which lies on the Ural plateau.

During the years of research, the hydrothermal coefficient changed significantly. In 2016, the hydrothermal coefficient was 1.4, in 2017 it is 1.8, and in 2018 it was within 1.3.

Thus, the climatic conditions of the Middle Urals in 2016 and 2017 were more humid and cooler than 2018, which made it possible to more fully study the effect of agro technical techniques on the yield and quality of potato tubers of the Gala variety.

Results

The results of the 2016–2018 Studies have shown that the size of the feeding area influenced the changes in the morphobiological indicators of potato plants, the degree of damage to them by pathogens, yield, the fractional composition and biochemical indicator of potato tubers of the Gala variety.

For three years of research, potato was planted on the same day on all variants, but on different dates. In 2016, potato was planted on June 03 for all variants, in 2017 –on May 30, in 2018 – on June 20.

Observations of the growth and development of potato plants showed that the duration of the interphase periods depended on the feeding area.

Phenological observations showed that the duration of the appearance of the first phase of development – germination did not depend on the feeding area. It has been established that the larger of the feeding area, the longer the onset of the flowering phase with the correlation coefficient r = 0.97, i. e. the connection is direct, strong. The feeding area influenced the duration of the potato vegetation period: the larger the feeding area, the longer the vegetation period with the correlation coefficient r = 1.00.

When using the fungicide shirlan (factor B), the duration of the period – germination – drying out tops increased in direct proportion to the feeding area: the larger the feeding area, the longer the period from germination to drying out tops with a correlation coefficient r = 0.99, i. e. dependence is strong.

Biometric observations showed that the feeding area (planting pattern) and favorable weather conditions during the period of the experiments were the decisive factors that had a significant effect on the formation of the above ground part of potato plants and contributed to the normal growth and development of plants throughout the growing season.

Observations of the growth of plants in height showed that during different periods of the growing season, the height of the stem was different in all periods of the growing season. On average, plant heights ranged from 50.1 to 52.3 cm.

According to the height of the studied variants, the feeding area: 1400 cm^2 (52.3 cm), 1750 cm^2 (51.6 cm), 2100 cm^2 (51.2 cm), 2450 cm^2 (50.1 cm) and at 2800 cm^2 (50.2 cm) cm). A tendency of dependence of the average plant height for the vegetation period on the feeding area was noticed: the larger the feeding area, the lower the plant height (r = –0.96).

Table 4

Potato yield (t/ha) depending on the feeding area (Factor A) and the use of fungicides (Factor B), 2016–2018

Landing scheme, cm	Feeding area, cm²	Control		Shirlan		Infinito	
		t/ha	%	t/ha	to control, %	t/ha	to control, %
70 × 20	1400	27.3	100	33.2	122	34.0	125
70 × 25	1750	27.9	100	35.4	127	33.9	122
70 × 30	2100	27.0	100	34.0	126	26.9	100
70 × 35	2450	24.9	100	36.6	147	26.2	105
70 × 40	2800	22.7	100	32.9	145	19.1	84
r		–0.89	–	0.06	–	–0.95	–
HCP_{05}		1.02		0.79		1.76	

Table 5

Fractional composition of potato tubers, 2016–2018

Feeding area, cm²	Control					Shirlan				
	Productivity, t/ha	Marketability, %	Fractions of tubers, %			Productivity, t/ha	Marketability, %	Fractions of tubers, %		
			> 55 mm	28–55 mm	< 28 mm			> 55 mm	28–55 mm	< 28 mm
1400	27.3	68	46.1	22.3	31.5	33.2	69	46.0	22.5	31.3
1750	27.9	73	49.2	22.9	27.9	35.4	74	49.7	24.0	26.2
2100 (c)	27.0	77	50.0	27.4	22.5	34.0	83	54.1	29.4	16.4
2450	24.9	83	54.6	29.3	16.0	36.6	85	53.8	31.1	15.0
2800	22.7	86	57.2	29.5	13.2	32.9	89	61.0	28.2	10.6
r	–0.89	0.99	0.98	0.95	–0.99	0.06	0.98	0.96	0.80	–0.97

In general, in experiments per 1 ha, between 140 thousand and 262 thousand stems were formed, the height of which differs according to the variants by 1.1–2.2 cm, i. e. very insignificant. The number of stems per 1 ha and per 1 m² correlated with the size of the feeding area at r = –0.98, the dependence is strong. On average, over three years, the leaf area per hectare varied from 14.58 to 27.47 thousand m², had an inverse and negative dependence on the feeding area: the larger the feeding area, the smaller the leaf area (r = –0.98).

The average daily growth of leaf surface ranged from 119.2 to 135.1 cm² and depended on the size of the feeding area: the larger the feeding area, the greater the average daily growth at r = 0.96. The value of the daily photosynthetic potential for three years ranged from 1.13 to 2.03 million m²/ha to a large extent increased from the feeding area: the larger the feeding area, the lower the photosynthetic potential indicator (r = –0.98), the relationship is inverse and negative.

In experiments, the mass of tops in the control variant ranged from 4.70 to 9.90 t/ha and had a negative dependence on the feeding area at r = –0.80. When treated with fungicide shirlan, it was in the range of 10.4–46.5 t/ha. At the same time, an average positive relationship was observed between the feeding area and the mass of the tops (r = 0.51).

From the data in table 3, it can be seen that the economic productivity of leaves had a direct positive dependence on the feeding area (planting pattern), i.e. with an increase in the feeding area, the economic productivity of leaves increases (r = 0.94). The highest economic productivity of leaves was obtained in the variant with a feeding area of 2800 cm² (planting pattern 70 × 40 cm) – 1.55 t/thousand. m². The lowest productivity was noted in the variant with a feeding area of 1400 cm² – 0.99 t/thousand m².

On average, over three years of research, the yield of potato in the control variant is inversely correlated between the feeding area and the yield value: with an increase in the feeding area, the yield decreases from 27.9 to 22.7 t/ha (r = –0.89), i. e. Feedback and negative.

Of all the variants studied, the highest yield was obtained with a feeding area of 2450 cm² (70 × 35 cm) using the fungicide Shirlan 36.6 t/ha (factor B), which is 31.1 % higher than the control (factor A). When using shirlan, no correlation was found between the area of plant nutrition and productivity (r = 0.06).

When processing with infinito, with an increase in the feeding area, the yield decreased from 34.0 to 19.1 t/ha. The relationship was negative (r = –0.95). The decrease in the yield level under the influence of the fungicide infinito can be explained by its systemic action in comparison with the drug of contact action – shirlan.

When potato plants were treated with the fungicide shirlan, the share of large, medium-sized tubers in the yield increased and amounted to 53.8–31.1 %, respectively, which is higher than the control variant, and in addition, a positive close relationship was established between the area of plant nutrition and the yield of marketable products. The correlation coefficient in the control (factor A) was 0.99 and when using shirlan (factor B) r = 0.98.

Similar positive close relationships between the feeding area and the large fraction of tubers were established both in the control (r = 0.98) and in the experimental (r = 0.96). With an increase in the feeding area, the proportion of average size of tubers increases. At the same time, a close positive relationship was established both in the control (r = 0.95) and in the experimental variants (r = 0.80). With an increase in the feeding area, the size of the small fraction decreased, while a close inverse relationship was established with the coefficient in the control –0.99 and in the experimental variant –0.97.

The calculation of economic efficiency showed that during the years of research, the production cost fluctuated within the range of 4446–9446 rubles/ton, the profit from 63 724 to 269 172 rubles/ha and the level of profitability in the range of 24.66–165.43 %. It is economically efficient to plant potato tubers using the Shirlan fungicide in a variant with a feeding area of 2450 cm^2 (with a scheme of 70 × 35 cm), where the lowest cost price (4446 rubles/ton), the highest profit (269 172 rubles/ha) and the highest profitability (165.43 %).

The analysis of energy efficiency showed that with an increase in the yield of potato in all variants, the total energy consumption for the crop increased from 80.7 to 120.7 thousand MJ/ha. Net energy income ranged from 15.8 to 32.3 thousand MJ/ha, depending on the yield. The energy cost in all variants was in the range from 3.30 to 4.42 thousand MJ/ha. The energy efficiency coefficient in all variants varied from 1.00 to 1.27.

Discussion and Conclusion

Studies carried out on the developed technology of cultivation of potato Gala variety with the use of fungicides in the conditions of the Middle Urals made it possible to draw the following conclusions:

1. According to phenological data, the onset of the “emergence of seedlings” phenophase occurred simultaneously in all variants, regardless of the feeding area in all years of research. In three years, the period from planting to full emergence of potato was 21 days. It was found that the area of plant nutrition influenced the duration of the potato growing season, i.e. the larger the feeding area, the longer the growing season at r = 1.00.

2. Observations of the growth of potato plants in height showed that during different periods of the growing season the height of the stem was different in all periods of the growing season. A tendency was noted for the dependence of the average plant height for the growing season on the area of plant nutrition: the larger the area of nutrition, the lower the height of the plants (r = –0.96). There was a slight increase in the number of stems with an expansion of the feeding area with a correlation coefficient (per plant r = 0.53, per 1 m^2 and per 1 ha r = –0.98). However, the leaf area per hectare had a clear dependence on the feeding area (from 100 to 188% at r = –0.98): with an increase in feeding area, the leaf area decreases.

3. The highest yield of all the studied variants was obtained with a feeding area of 2450 cm^2 (70 × 35 cm) using the fungicide Shirlan 36.6 t/ha (factor B), which is 31.1 % higher than the control (factor A).

To increase the yield and the level of profitability of the production of potato Gala variety, depending on the feeding area in the Middle Urals, we recommend using the variant with a feeding area of 2450 cm^2 (70 × 35 cm), which turned out to be the best in the experience when using the fungicide Shirlan, where the highest yield was obtained 36.6 t/ha, with the lowest cost price of 4,446 rubles/t with the highest profit of 269,172 rubles/ha and the highest profitability of 165.43 %. In general, in all variants of the experiment, the energy efficiency coefficient did not exceed 1.27.

References

1. Devyatkina L. N. Potato production: global and national discourses // Bulletin NGIEI. 2018. No. 5 (84). Pp. 122–134.
2. Hameed A., Zaidi Shan-e-Ali S., Shakir S., Mansoor S. Applications of new breeding technologies for potato improvement [e-resource] // Frontiers in plant Science. 2018. Vol. 9. Pp. 1–15. DOI: 10.3389/fpls.2018.00925. URL: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6034203/pdf/fpls-09-00925.pdf (appeal date: 08.09.2020).
3. Hasanova R. T. Influence of planting density and fertilization on the productivity of potato tubers // Bulletin of Science and Practice. 2019. Vol. 5. No. 10. Pp. 107–114. DOI : 10.33619/2414-2948/47/15.
4. Ivenin V. V., Ivenin A. V., Ivenina V. V. Agrotechnical features of growing potatoes. Saint Peterbourg: The “Doe” Guide, 2015. 336 p.
5. Ivenin V. V., Ivenin A. V., Sakov A. P., Bogomolov V. N., Novosadov A. A. Optimization of the Dutch soil cultivation system for potatoes: monograph / Under the total scientific ed. of prof. V. V. Ivenina. Nizhniy Novgorod: Nizhniy Novgorod State Agricultural Academy, 2017. 192 p.
6. Karpukhin M. Yu., Krupskiy I. N., Keita F. Technology for growing potatoes in the Middle Urals: scientific and practical recommendations. 2nd ed., ext. and reslave. Ekaterinburg, 2016. 26 p.
7. Kolchina L. M. Technologies and equipment for potato production. 2nd ed. Moscow: Yurayt Publishing House ; Rosinformagroteh, 2019. 163 p.
8. Lishchenko V. F. World Potato Production: Role in Nutrition, Volumes and Growth Dynamics, Regional Possibilities of Distribution, Influence of Consumer Demand and New Technologies // Monograph “Status and Prospects for the Development of the Food System of Russia (by the Example of the Potato Complex) / V. F. Lishchenko, B. V. Anisimov, N. N. Kolchin, V. I. Starovoitov, et al. Moscow: Economics, 2016. Pp. 15–30.
9. Mingalev S. K., Tyutenov E. S. Productivity and quality of potato tubers depending on the elements of cultivation technology in the conditions of the Middle Urals // Agrarian Bulletin of the Urals. 2017. No. 6. Pp. 24–27.
10. Shegelman I. R.,Vasilev A. S. Formation of a knowledge base in the field of technologies and physical effects for the preparation, storage and use of seed potatoes // EurAsian Journal of BioSciences.2020. No. 14. Pp. 201–212.
11. Starovoitova O. A., Zhevora S. V., Starovoitov V. I., Oves E. V., et al. Competitive technologies for seed production, production and storage of potatoes. Moscow: “Rosinformagroteh”, 2018. 236 p.
12. Tunio H. Mazhar, Gao J., Shaikh A. Sher. Potato production in aeroponics: An emerging food growing system in sustainable agriculture for food security [e-resource] // Chilean journal of agricultural research 80(1) January-march 2020. –P. 118-132. DOI: 10.4067/s0718-58392020000100118. URL: https://scielo.conicyt.cl/pdf/chiljar/v80n1/0718-5839-chiljar-80-01-118.pdf (appeal date: 06.09.2020).

13. Tyutenov E. S., Mingalev S. K., Chulkov V. A., Sapakrklycheva S. E. The influence of varieties and planting density on the formation of potato productivity // Konyaev readings: collection of scientific papers of the VI International Scientific and Practical Conference (December 13–15, 2017). Ekaterinburg: Ural State Agrarian University, 2018. Pp. 99–102.

14. Usanova Z. I., Oserbaev A. K., Zinyaev K. I., Pavlov M. N. Tubers, Biological features and technologies for the cultivation of potatoes and earthen pears / Ed. by Z. I. Usanova. Tver: LLC Triad Publishing House, 2018. 152 p.

15. Vakulenko V. V. Against potato diseases: the combined use of EpinExstra, Zircon and silicon-containing chelated micronutrient fertilizers Siliplant with fungicides provides effective protection of potatoes against diseases and helps to improve product quality // Potato and Vegetables. 2016. № 2. P. 34.

16. Wasilewska-Nascimento B., Boguszewska-Mankowska D., Zarzynska K. Challenges in the Production of High-Quality Seed Potatoes (*Solanum tuberosum* L.) in the Tropics and Subtropics [e-resource] // Agronomy. 2020. Vol. 10. No. 260. Pp. 1–15. DOI: 10.3390/agronomy10020260. URL: https://www.mdpi.com/2073-4395/10/2/260/htm (appeal date: 07.09.2020).

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