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Economic and energy efficiency of potato cultivation in different feeding areas and the use of fungicides in the Middle Urals

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Abstract. The main factor in increasing the productivity of potatoes is the improvement of its cultivation technology. **The purpose** of the research was to determine the economic and energy efficiency of cultivating potato of the Gala variety under different feeding areas and the use of fungicides. **Methods.** The research was carried out on the experimental field of the educational and experimental farm of the Ural State Agrarian University during 2016–2018, in a two-factor field experiment according to the following scheme: Factor A (feeding area): 1400, 1750, 2100, 2450, 2800 cm^2; Factor B (use of fungicides): "Shirlan": 1400, 1750, 2100, 2450, 2800 cm^2; "Infinito": 1400, 1750, 2100, 2450, 2800 cm^2. The objects of research in the experiment were medium early potato variety Gala and fungicides such as contact action "Shirlan" (0.3 l/ha) and "Infinito"systemic action (1.2 l/ha). **The results** showed that when using the fungicide "Shirlan" (factor B), the best in the experiments was the variant with a feeding area of 2450 cm^2 (70 × 35 cm), where the highest yield of 36.6 t/ha was obtained, with a low cost price – 4446 rubles/ton, high profit – 269 172 rubles/ha and profitability – 165.43 %. In experiments on all variants, the energy efficiency coefficient did not reach 1.27. **The scientific novelty** of the research lies in the fact that for the first time the influence of the feeding area (factor A) and the use of fungicides (factor B) on the yield, economic and energy efficiency of potato cultivation in the Middle Urals was studied.

Keywords: potato, feeding area, variety, yield, economics, energy, fungicide.

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Introduction

Potato is one of the most important food crops in both developed and developing countries. In terms of production, it ranks third among the main food crops in the world after wheat and rice. The production and processing of potatoes requires a lot of energy due to their bulk and wateriness. Potato is a short-term crop, producing 90–120 days, with the highest yields per day per unit area compared to other main crops [12].

Currently potato is grown all over the world on an area of about 19 million hectares, and world production is 378 million tons [3]. Potato is grown in more than 100 countries of the world [1].

The average world potato production is 17.4 t/ha. The USA is the most productive country with an average of 44.2 t/ha, followed by the United Kingdom [15]. The average potato yield in Russia remains one of the lowest in Europe – at the level of 14–16 t/ha, which is several times less than in Western European countries [4].

Potato is generally viewed as a source of energy, i.e. as food for humans and animal feed. More than 4000 varieties of potato are grown in the world, which indicates a high plasticity [5]. The agronomic plasticity of potato allows it to be grown in various climatic conditions [14].

Potato is considered to be a good option for improving the health and nutrition of the population, more productive than main grains, and have a higher economic value than grains [2].

Potato growing is one of the largest agricultural industries in the Russian Federation. Potato act as a universal food product for the population, a valuable raw material for the processing industry, used as feed for farm animals [16]. The area under crop planting in Russia is 2.1–2.2 million hectares, however, in terms of average yield; it significantly lags behind European countries [9].

The introduction of new technology into production and its improvement is possible only if the products are competitive on the market. It is necessary to produce products that will have a low cost, and its production will be profitable even in adverse conditions. Therefore, all changes in the technology of growing crops must be reasonable and reasonable [6].

In modern conditions of agriculture, important requirements for the elements of cultivation technology that are developed and introduced into production are a decrease in the unit cost of a product, a decrease in energy costs and, as a result, an increase in profit. One of the ways to increase the yield of potatoes and reduce costs per unit area is the introduction of modern technologies [11].

The success of obtaining a high yield of potato depends, first of all, on the right variety. In turn, the formation of a market economy in the agricultural sector requires a reliable mechanism for regulating the market of varieties by assessing not only economic suitability, but also their economic efficiency and commerciality [10].

The cost of potato is one of the most difficult economic indicators of the economic and financial work of the industry. It includes a large complex of material and labor costs for cultivation, harvesting, sorting and storage of products [13].

Along with the variety, an effective agricultural method for growing potatoes, which increases the yield and quality of products without additional costs, is the correctly chosen planting time, taking into account the biological characteristics of the cultivated varieties. The share of the variety in the increase in production is 30–50 % [9].

The economic efficiency of potato production is influenced by yield, gross yield, including the output of the commodity standard and non-standard fractions, as well as production costs and the possible selling price [7].

In the Middle Urals, a new medium-early, high-yielding variety Gala has recently been spreading, characterized by relative resistance to pathogens and good preservation of tubers in winter. The cultivation technology of the variety under these conditions has not been studied, therefore, the study of the methods of cultivation of this variety is justified and actually. Increasing the economic efficiency of potato production contributes to an increase in farm income, obtaining additional funds for wages and improving the social conditions of workers in potato growing.

Methods

The purpose of this research is to determine the economic and energy efficiency of the cultivation of potato of Gala variety, depending on the feeding area and the use of fungicides in the conditions of the Middle Urals. The main objective is to calculate the economic and energy efficiency of cultivating potato of the Gala variety, depending on the area of nutrition and the use of fungicides.

The research was carried out in a two-factor field experiment according to the following scheme: Factor A (feeding area): 1400, 1750, 2100, 2450, 2800 cm^2; Factor B (using of fungicides): "Shirlan": 1400, 1750, 2100, 2450, 2800 cm^2; "Infinito": 1400, 1750, 2100, 2450, 2800 cm^2, on the experimental field of the educational and experimental farm "Uralets" of the Ural State Agrarian University (USAU), Studencheskiy village, during 2016–2018. The repetition is fourfold; the placement of variants in repetitions is systematic. The objects of research were a medium early, high-yielding potato variety Gala, bred by German breeders, and fungicides such as contact action "Shirlan"and systemic "Infinito", which are now becoming widespread.

The soil of the experimental site is podzolized chernozem, heavy loamy in granulometric composition with a humus content of 4.5 %, the reaction of the soil environment is weakly acidic, the availability of mobile phosphorus is low, exchangeable potassium is medium. 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 podzolized chernozem soil: saline pH – 5.4; N – 185.9 mg/kg; P_2O_5 – 238.9 mg/kg; K_2O – 268.5 mg/kg.

The climate of the Middle Urals is sharply continental and is characterized by the originality of all seasons. During the years of research, the hydrothermal coefficient (HC) varied significantly from year to year. In 2016, it was 1.4, in 2017 it was 1.8, and in 2018 it was within 1.3. Thus, the weather conditions of the Middle Urals in 2016–2017 were characterized by wetter and cooler than 2018, which made it possible to more fully study the influence of agrotechnical techniques on the yield and quality of potato tubers of the Gala variety.

Results

The article presents the results on the economic and energy efficiency of the cultivation of potato of the Gala variety at different feeding areas and the use of fungicides in the conditions of the Middle Urals.

Economic efficiency is the final beneficial effect of the use of means of production and living labor, the return on total investment. In agriculture, this is getting the maximum amount of products per unit area with the least labor and cost. The economic assessment allows you to determine the effectiveness of the results obtained and choose the most optimal variant.

The results of research on economic indicators are presented in table 1.

Table 1

Economic efficiency of growing potato of the Gala variety, depending on the feeding area and the use of fungicides, 2016–2018

Feeding area, cm^2	Productivity, t/ha	Sales proceeds per hectare, rubles	Expenses		Profit per hectare, rubles	Cost of 1 ton, rubles	Profitability level, %
			per 1 ha, thousand rubles	including seeds, %			
Control (untreated, factor A)							
1400	27.3	322 140	258.4	78.40	63 724	9 466	24.66
1750	27.9	329 220	212.6	76.34	116 596	7 621	54.84
2100 (c)	27.0	318 600	175.3	74.25	143 280	6 493	81.73
2450	24.9	293 820	160.2	72.57	133 589	6 435	83.37
2800	22.7	267 860	143.8	70.87	124 021	6 336	86.22
"Shirlan" treatment (factor B)							
1400	33.2	391 760	260.7	78.40	130 960	7 855	50.21
1750	35.4	417 720	215.0	76.34	202 686	6 074	94.26
2100 (c)	34.0	401 200	182.2	74.25	218 904	5 362	120.08
2450	36.6	431 880	162.7	72.57	269 172	4 446	165.43
2800	32.9	388 220	146.2	70,87	241 930	4 447	165.37
"Infinito" treatment							
1400	34.0	401 200	280.0	78.40	121 123	8 238	43.25
1750	33.9	400 020	231.0	76.34	169 018	6 814	73.17
2100 (c)	26.9	317 420	197.0	74.25	120 340	7 327	61.06
2450	26.2	309 160	173.0	72.57	136 078	6 606	78.62
2800	19.1	225 380	154.9	70.87	70 405	8 114	45.43

From the analysis of the data in table 1, it follows that in the control variant without the use of fungicides, the cheapest potatoes with a cost price of 6,336 rubles/ton were obtained in the variant with a feeding area of 2800 cm² (70 × 40 cm). This was due to the low consumption of funds for seed – 3.38 % less than in the control, but with the lowest yield of 22.7 t/ha and the highest profitability of 86.22 %. The highest profit of 143,280 rubles/ha was obtained in the variant with a feeding area of 2100 cm² (70 × 30 cm) – which is 15 % higher than in the variant with the lowest cost price. Thus, of these two good variants, preference should be given to the variant with a higher yield and the highest profit with a high profitability of 81.73 %, where 1 ruble will be obtained 0.82 rubles of cost.

When testing the systemic fungicide "Infinito", the result is less effective. The highest yield was in the variant with a feeding area of 1400 cm² (70 × 20 cm) – 34.0 t/ha, and when using "Shirlan", 36.6 t/ha. The lowest prime cost – 6,606 rubles/t from the use of infinite was obtained with a feed area of 2450 cm² (70 × 35 cm), and from the use of "Shirlan" – 4,446 rubles/t. A high profit – 169,018 rubles/ha, was obtained in the variant of 1750 cm² (70 × 25 cm) with the use of "Infinito", and with the "Shirlan" – 269,172 rubles/ha. The maximum profitability with the use of infinite was obtained in the variant of 2450 cm² (70 × 35 cm) and amounted to 78.62 %, and with the "Shirlan" – 165.43 %.

The given data on the use of the fungicide "Infinito" show that in terms of profitability the option with a feeding area of 2450 cm² (70 × 35 cm) turned out to be the best, where 0.78 rubles were received for each ruble of cost.

If we compare the effectiveness of fungicides, it can be noted that when using the fungicide "Shirlan", 1.65 rubles were received for each ruble of costs profit, or 2.11 times higher than when using "Infinito". Thus, comparing the data obtained on the economic assessment of the studied variants of factor A and B, we can conclude that the use of the fungicide "Shirlan" as an element of technology in combination with a plant nutrition area of 2450 cm² (70 × 35 cm) is advantageous.

The data obtained on the optimization of the feeding area and the use of fungicides is included in the developed technology, the economic indicators of which are shown in table 2, in comparison with the existing technology.

One of the most important conditions for increasing the sustainability of modern agricultural production is the development and implementation of optimal systems for managing energy flows in agricultural landscapes in order to increase the utilization rate of natural solar and anthropogenic energy in the formation of agricultural crops.

In the energy aspect, the methodology for assessing technologies is reduced to determining the ratio of total energy costs for performing the amount of agrotechnical operations, including direct costs of energy carriers and indirect materialized in material and technical resources, and the energy value of the resulting crop. The calculation of energy costs begins with an analysis of the technological map of the cultivation of an agricultural crop. On the basis of the technological map, a summary table is compiled, which includes indicators for the entire list of technological operations of the technology of growing crops the volume of work in physical terms, the composition of the unit performing the operation (propulsion unit and agricultural machine), unit productivity, labor and fuel costs. In accordance with the data of the flow chart and additional regulatory materials considered, in the process of describing the methodology, the calculation of energy costs and their efficiency is performed [8].

The energy efficiency of potato cultivation is presented in table 3.

Table 2

Economic efficiency of growing potatoes with different technologies 2016–2018

Technology, feed area, cm²	*Productivity, t/ha*	*Sales proceeds, rubles/ha*	*Costs per hectare, thousand rubles*	*Profit per hectare, rubles*	*Cost per ton, rubles*	*Profitability level, %*
Existing technology (control), 2100	*27.0*	*318 600*	*175,3*	*143 280*	*6 493*	*81.73*
Developed technology (shirlan), 2450	*36.6*	*431 880*	*162,7*	*269 172*	*4 446*	*165.43*

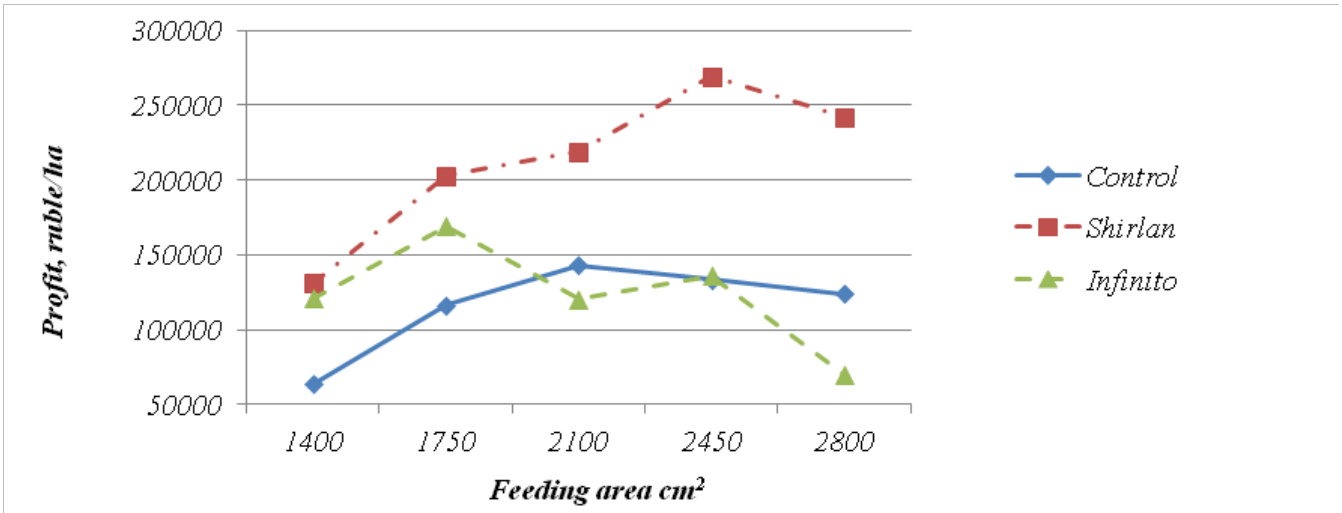

Fig. 1. Profit (rubles/ha) depending on the feeding area and the use of fungicides, 2016–2018

Table 3

Energy efficiency of potato cultivation under different feeding areas and the use of fungicides, 2016–2018

Feeding area, cm²	*Productivity, t/ha*	*Total energy consumption for the crop, MJ/ha*	*The amount of energy in the crop, thousand MJ/ha*	*Net energy income, thousand MJ/ha*	*Energy cost, thousand MJ/ha*	*Energy efficiency coefficient*
Control (untreated, factor A)						
1400	*27.3*	*98.0*	*114.7*	*23.7*	*3.59*	*1.17*
1750	*27.9*	*92.0*	*117.2*	*24.2*	*3.30*	*1.27*
2100 (c)	*27.0*	*91.0*	*113.4*	*23.4*	*3.37*	*1.25*
2450	*24.9*	*86.0*	*104.6*	*21.6*	*3.45*	*1.22*
2800	*22.7*	*80.7*	*95.3*	*19.6*	*3.56*	*1.18*
“Shirlan” treatment (factor B)						
1400	*33.2*	*120.1*	*139.4*	*29.3*	*3.62*	*1.16*
1750	*35.4*	*119.6*	*148.7*	*31.3*	*3.26*	*1.24*
2100 (c)	*34.0*	*115.0*	*142.8*	*30.0*	*3.38*	*1.24*
2450	*36.6*	*120.7*	*153.7*	*32.3*	*3.32*	*1.27*
2800	*32.9*	*110.1*	*138.2*	*29.1*	*3.35*	*1.26*
“Infinito” treatment						
1400	*34.0*	*115.7*	*142.8*	*28.1*	*3.40*	*1.23*
1750	*33.9*	*112.4*	*142.4*	*28.0*	*3.32*	*1.27*
2100 (c)	*26.9*	*100.8*	*113.0*	*22.2*	*3.75*	*1.12*
2450	*26.2*	*98.9*	*110.0*	*21.6*	*3.77*	*1.11*
2800	*19.1*	*84.4*	*80.2*	*15.8*	*4.42*	*1.00*

The analysis of energy efficiency showed that in the control variant, the total energy consumption for the crop ranged from 80.7 to 98.0 thousand MJ/ha. Net energy income increased from 19.6 to 24.2 thousand MJ/ha. The energy cost has changed from 3.30 to 3.59 thousand MJ/ha, and the energy coefficient from 1.17 to 1.27.

With the use of the fungicide “Shirlan”, the greatest energy consumption for the crop was obtained in the variant with a feeding area of 2450 cm² – 120.7 thousand MJ/ha, the maximum net energy income – 32.3 thousand MJ/ha. The lowest energy cost was obtained in the 1750 cm² variant – 3.26, and the highest energy coefficient in the 2450 cm² variant – 1.27.

With using fungicide “Infinito”, the highest total energy consumption for the crop was obtained in the variant 1400 cm² – 115.7 thousand MJ/ha and the maximum net energy income – 28.1 thousand MJ/ha. The highest energy cost was obtained in the variant with a plant nutrition area of 2800 cm² – 4.42 thousand MJ/ha, and the highest energy coefficient in the variant with a plant nutrition area of 1750 cm² – 1.27.

Discussion and Conclusion

Research conducted on the economic and energy efficiency of cultivation of potato of the Gala variety at different feeding areas and the use of fungicides in the conditions of the Middle Urals allowed us to do the following conclusions:

1. Of all the studied variants, it is economically profitable to cultivate potato of the Gala variety using the fungicide “Shirlan” (factor B) in the option with a feeding area of 2450 cm² (70 × 35 cm) in the conditions of the Middle Urals. At the same time, the yield was 36.6 t/ha, which is 31.1 % higher than the control (factor A), the prime cost – 4,446 rubles/t, profit – 269,172 rubles/ha, and profitability – 165.43 %.

2. The analysis of energy efficiency showed that in the control variant, the total energy consumption for the crop ranged from 80.7 to 98.0 thousand MJ/ha. Net energy income increased from 19.6 to 24.2 thousand MJ/ha. The energy cost has changed from 3.30 to 3.59 thousand MJ/ha, and the energy coefficient from 1.17 to 1.27. In experiments on all variants, the energy efficiency coefficient did not reach 1.27.

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