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Optimization Of Parameters Of A Rod Intensifier Of A Potato Digger With The Method Of Mathematical Planning

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Abstract. In this article, the method of mathematical planning of multifactorial experiments is used to determine the optimal values of the parameters of a potato digger equipped with an elastic rod intensifier, obtained in single-factorial experiments. It is assumed that the influence of factors on the evaluation criteria is fully explained by a second-order polynomial, and the experiments were carried out according to the Hartley-4 (X_4) plan.
Keywords: optimization, parameter, intensifier, potato, degree of soil separation, degree of potato damage, degree of potato loss.

Potato is one of the main food products for humans. The growing world population increases the demand for potatoes along with other food products. In this regard, the use of energy-saving machines with high productivity in potato harvesting occupies one of the leading places. "According to the report of the Food and Agriculture Organization of the United Nations dated May 30, 2022, given that in 2020, potatoes were planted on an area of more than 20 million hectares in 150 countries of the world, with an annual production of 359 million tons of crops, potato production by 2025 will increase to 500 million tons, by 2030 it is planned to reach 750 million tons" [1], which means it is necessary to put into practice technical means and weapons that ensure potato harvesting with high productivity and quality and low fuel consumption. Based on this, it is important to master the production of machines with high-quality, technically and technologically advanced, energy-saving and energy-saving working bodies and use them when harvesting potatoes.

Today, research and development work is being carried out all over the world aimed at improving highly efficient, low-damaging potato tubers, resource-saving methods and technical means of harvesting potatoes. In particular, special attention is paid to improving potato harvesting methods, creating machines with highly efficient working bodies, substantiating the technological process and parameters of their operation.

Potato harvesting is one of the most labor-intensive processes in growing potatoes. Currently, 75% of all costs in potato production are associated with the harvesting process. In the conditions of the soil and climate of our republic (high summer temperatures, low relative humidity, soil compaction due to irrigation), potato harvesting machines have not led to their widespread use. Because the results of potato harvesting machine tests have shown that during the harvesting process the sifting level in elevators and sieves decreases and it becomes difficult to separate potatoes from the soil due to the fact that the soil layer of the potato bed is not crushed well enough and is divided into large pieces of soil [2].

Therefore, the process of harvesting potatoes in Uzbekistan is carried out by imported potato diggers. Due to the fact that potatoes are dug up by these machines and dumped on the soil surface unevenly, a lot of manual labor is required during their harvesting. In the elevators of existing potato diggers, due to the low process of sifting soil and solid soil parts of potatoes and separating them from potatoes, damage and loss of potato cubes are observed, exceeding the established agrotechnical requirements. Based on the above, this work is one of the urgent tasks for the creation of a technical and technological basis for the development of an energy-saving potato digger for the soil and climatic conditions of our Republic. Developed foreign countries producing potato diggers show that it is necessary to implement and study several technical solutions in order to reduce the energy consumption of the potato digger and improve the quality of its work. First, in order to crush hard lumps on the surface of the potato digger elevator, which negatively affect the quality of the potato digger, it is advisable to install a special support-clod-breaking device on the potato

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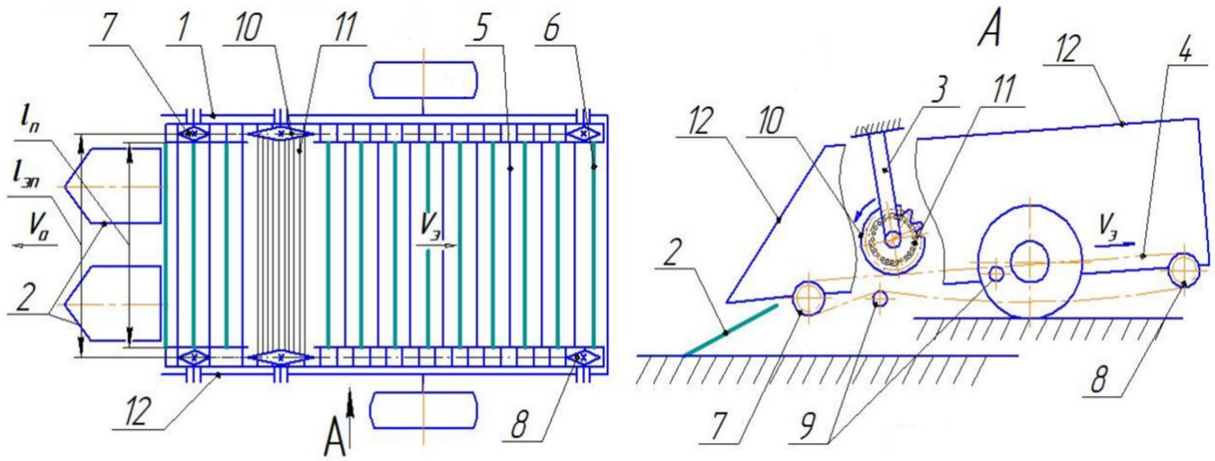
digger at the beginning of the technological process. Then reduce the distance between the ploughshares, then dig the desired part of the potato bed and spread it on the sieves, the number of elevators should be reduced to transfer less soil mass and increase the level of their sifting, as well as reduce losses and damage to potato tubers. In this regard, to ensure the level of soil sifting in accordance with agrotechnical requirements by reducing the volume of metal without increasing the number of potato digger sieves by one, a potato digger design with elastic rods is proposed, on its elastic rod intensifiers. The intensifier consists of two toothed stars and an axis connecting them from the centers, as well as elastic rods installed along their perimeter. The toothed sprockets of the intensifier are mounted on chain drives, and due to the movement of the potato digger sieve, it rotates, i.e. no additional chain drives are required to move the rod intensifier. The design of the potato digger equipped with a rod intensifier is as follows (Fig. 3.1).



1-frame; 2-digging share; 3-intensifier stand; 4-main elevator; 5-elevator rod; 6-elastic rod; 7, 8-driving and driven sprockets; 9-tension roller; 10-toothed sprocket of the intensifier; 11-elastic rods of the intensifier; 12-machine bodies.

Fig. 1. Design diagram of a potato digger equipped with elastic rods [3]

In order to determine the optimal values of the parameters of a potato digger equipped with an intensifier with elastic rods in single-factor experiments, the optimal values were determined using the method of mathematical planning of multifactor experiments. It was assumed that the influence of factors on the evaluation criteria is fully explained by a second-order polynomial, and the experiments were conducted according to the Hartley-4 (X_4) plan [4,5]. According to the results of theoretical studies and single-factor experiments, the following parameters have the greatest influence on potato damage and losses: the diameter of the intensifier star, the number of rods, the diameter of the braided circle along the perimeter of the intensifier star, the speed of the unit, the degree of separation of the potato soil mass. The factors were conditionally determined as follows: X_1 is the diameter of the star of the rod intensifier, X_2 is the number of rod intensifiers, X_3 is the diameter of the braided circle along the perimeter of the intensifier star, and X_4 is the total speed of movement.

Table 1. Factors, their designations, variation range and levels

Factors and their units of measurement	Conventional designation	Variation interval	Levels		
			Below (–1)	Basic (0)	Upper (+1)
Sprocket diameter of rod intensifier, m	X_1	0,05	0,5	0,55	0,6
Number of rod intensifiers, pieces	X_2	5	30	35	40
Diameter of the braided circle around the perimeter of the intensifier star, m	X_3	0,01	0,28	0,29	0,3
Total speed of movement, m/s	X_4	0,2	0,8	1,0	1,2

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In conducting multifactorial experiments, the degree of soil separation Y_1 (%), the degree of potato damage Y_2 (%) and the degree of potato loss Y_3 (%) were taken as evaluation criteria.
In order to reduce the influence of uncontrolled factors on the evaluation criteria, the sequence of experiments was determined using a table of random numbers.
The data obtained in the experiments were processed using the PLANEXP program. To evaluate the homogeneity of dispersion, the Cochran criterion was used, to evaluate the value of the regression coefficients - the Student criterion, to evaluate the adequacy of regression models - the Fisher criterion.
The data obtained in the experiments were processed in the order specified above and the following regression equations were obtained, adequately representing the evaluation criteria:
- the degree of separation of the potato-soil mass, %:

$$\begin{aligned} Y_1 &= 81,7+0,45X_1+0,87X_2+0,42X_3+0,25X_4- \\ \%: \quad & -1,17X_1^2+0,51X_1X_2-0,47X_1X_4-0,31X_2^2- \\ & +0,56X_2X_3+0,30X_2X_4+0,61X_3^2+0,21X_3X_4-0,98X_4^2; \end{aligned} \quad (1)$$

- degree of potato damage, %:

$$\begin{aligned} Y_2 &= 2,61+0,028X_1+0,025X_2+0,032X_3-0,027X_4+ \\ & +0,039X_1^2+0,015X_1X_2+0,017X_1X_3+0,018X_1X_4-0,015X_2^2+ \\ & +0,020X_2X_3+0,032X_2X_4+0,014X_3^2-0,025X_3X_4+0,019X_4^2; \end{aligned} \quad (2)$$

- degree of potato loss, %:

$$\begin{aligned} Y_3 &= 2,85-0,051X_1-0,088X_2-0,040X_3+0,11X_4+ \\ & -0,015X_1^2-0,027X_1X_2-0,027X_1X_3+0,033X_1X_4-0,055X_2^2+ \\ & +0,021X_2X_3-0,019X_2X_4-0,024X_3^2+0,20X_4^2; \end{aligned} \quad (3)$$

The solutions of regression equations (1)-(3) in order to ensure the required quality of work with low energy consumption at a speed of 0.8-1.2 m/s showed that the diameter of the rod intensifier sprocket is 0.55 m, the number of elastic rods is 35 pieces, the diameter of the circle installed along the perimeter of the rod intensifier sprocket should be 0.29 m. With these values of factors, the degree of separation of the potato-soil mass was 83.1 percent, and the degree of damage and loss of potatoes was less than 3 percent.

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