Improved potato digger

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Abstract. The article presents the results of performance analysis of potato harvester and potato digger which do not always work with due quality, make heavy losses and damage tubers, especially in the cultivation of potato in moderate soils. The principle of operation and functioning of the working parts of a potato digger, which allows ensuring the separation of potato tubers from soil lumps and stones and their collection into a container, are considered.

1. Introduction

Until recently, cotton [1] and wheat [2] were the main agricultural crops in Uzbekistan. Therefore, until now, more research has been directed towards the development of machines and technologies for harvesting cotton [3, 4, 5] and wheat [6, 7, 8]. However, in recent years, much attention has been paid to potato growing. In Uzbekistan the importance of the potato is emphasized by the volume of its consumption and production. Thus, the potato in the world is grown on an area of more than 19 million hectares. The leading place in potato production is occupied by China (more than 99.15 million tons), India (more than 48.61 million tons), the Russian Federation (more than 29.59 million tons) and the Republic of Uzbekistan produces about 2 million tons of potatoes [1, 2, 3, 4].

In Uzbekistan, potato production is concentrated in the private sector, mainly dekhkan farms of the population, as well as small farms, which produce a significant (about 89%) amount of marketable products. Potatoes are grown in mostly scattered fields with an area of 0.2-2.0 hectares with minimal levels of mechanization of the main work. In this regard, the production of potatoes in farms carried out with high labor costs and the problem of application of modern foreign equipment is connected on the one hand to the organizational work on potato cultivation on small-circuit areas, on the other, the high cost of the machines, which is practically not affordable to the producers of the potato [4].

The analysis of the current state of cultivation and harvesting of potatoes in the country, as well as foreign countries, showed that tillage in potato production constitutes 30-35% of total energy consumption, 8-10% the landing, and 50-60% mechanized harvesting. Considering that mechanized harvesting accounts for the largest share in the total balance of energy costs for potato production, the implementation of improving the issues of the technological process and energy saving of the machines in use should be carried out primarily by improving the quality of tuber selection and technical means for its conduct.
2. Materials and methods

The analysis of the current state of the cultivation and harvesting of potatoes in the country has shown that conditions are very different from other potato growing areas: potatoes are grown in irrigated land, the climate is dry and hot, and the soil is medium-hard in physical and mechanical structure. This specificity determines the set-up of a variety of technologies of growing potato, harvesting potato tubers, which take into account climate and soil characteristics.

Analyzing the machines used in the production of potatoes today, the leading place is occupied by potato diggers. They have a number of advantages compared to the combines and digger-loaders: low cost, the ability to work in all kinds of soil, the possibility of work in the field with a rut length of less than 200 m.

Potato diggers produced in our country and imported from abroad do not meet agro-technical requirements, are not adapted to local soil conditions. They are energy-intensive, metal-intensive and have a low quality of work.

Numerous experiments show that in moderate and severe climatic conditions with soil moisture less than 15-18 %, modern potato harvester works with significant losses and damage to tubers. This applies to potato diggers. Thus, in local conditions, after watering, a soil crust forms on a potato row, which causes a lot of unground soil lumps come to the working bodies of potato harvesters and potato diggers during harvesting. This circumstance reduces the separating ability of the working bodies of the machines, increases the loss and damage of tubers, which worsens the marketability of products.

The currently used clod-breaking bodies of potato harvesters do not fully provide the required quality of the technological process. In this regard, improving the quality indicators of the work of the potato digger by improving its clod-breaking working bodies is a real task.

When carrying out the research, methods of the general scientific methodology, such as observation, comparison, generalization, analysis and synthesis of analogy and others, are used, on the basis of which a constructive scheme of a potato digger is proposed, which provides the complete separation of soil and the destruction and separation of soil lumps, with minimal damage to tubers and energy-material costs, for digging potato tubers in specific soil and climatic conditions of the Republic.

3. Results and discussion

The proposed potato digger contains a frame 1 with drive mechanisms, a hitch system 2 and support wheels 3, on which the digging working bodies are mounted in the form of a passive plowshares 4, the main elevator 5, two pairs of clod-crusher 6, a bar wire 7 of a transverse conveyor-separator 8, a finger slide 9, unloading conveyor 10 and platforms of containers 11 (figure 1).

The passive plowshares are flat, two-section, provided with safety valves which are retracted with the entrance of large solid objects between the edge of plowshares’ rear and the canvas of the main elevator.

The main elevator 5 is a fenced canvas with closed circuits, the upper (working) branches of which move from the plowshares to the exit. The upper branch is shaken when moving with elliptical stars. Combustion devices 5 and 6 both consist of two pairs of pneumatic balloons rotating towards each other, between which a working slot is formed for the passage of a heap of potatoes. The balloons are of a cylindrical shape with excise pressure of 10-15 kPa. The peripheral speed of the upper balloon is greater than that of the lower one.

Transverse conveyor separator 7 is arranged of paralleled endless rubberized V-belts and the eccentric shaker.

Slide 8 is endless fingers canvas, mounted sliding to the horizon. The upper branch of the canvas moves against the direction of movement of the machine. The position of the upper branches of the canvas is regulated by changing the angle of inclination of the slide in the range from 15 to 35°.

The canvas of the unloading conveyor is between bars on rubberized belts, whose distance is 20 mm, and with paddles.

The potato digger works as follows. When the potato digger moves across the field, the plowshares undermine the potato rows and transfer the soil-potato mass to the main elevator.
Fig. 1. Structural diagram of the potato digger: 1-frame; 2-hitch; 3-wheels; 4-plowshares; 5-main elevator; 6-crusher; 7-bar wire; 8-conveyor-separator; 9-slide; 10-unloading conveyor; 11-container.

The main elevator destroys and moves the tuberous layer, the soil is sieved. The remaining soil-potato mass is transmitted to the clod-crusher. The first pair of balloons of crushers, turning toward each
other, captures soil-potato mass and crushes them, the larger lumps are destroyed. On the second clod-crusher, the processing of the soil-potato mass continues and smaller clods are destroyed here. Due to the fact that the turning speed of the upper balloons of clod-crushers is greater than the lower ones, the passing soil-potato mass is not only pressed by the balloons, but also stretched, which contributes to the intensive destruction of soil clods. Further, the remaining mass enters the transverse conveyor-separator, while the flow is narrowed with the help of the bar sheet. On the transverse conveyor-separator, further separation of the soil and potato mass takes place. Here, the intensity of separation is increased due to vibrations of the working branch of the paddle canvas. Further, tubers, lumps, soil particles and small plant impurities are transferred to the finger slide. Due to the difference in the coefficients of friction and friction-rolling, the lower part of the unloading conveyor belt rolls down to the potato tubers and oval-shaped soil lumps. The unloading conveyor equipped with paddles transports the tubers into a container. Plant residues, stones, flat stones are moved to the upper branch of the finger slide and dumped onto the harvested field.

The potato digger has a simplified design and low metal intensity, and will improve the quality of soil and potato tubers separation. At present, the applications for the invention have been filed, technical documentation for the potato digger is being developed [Request №IAP 2021 0050]

4. Conclusion
The use of this design when harvesting potatoes helps to improve the technological process of separating potatoes from the soil layer by breaking soil lumps into small particles with two pairs of clod-crushers and separating them on a transverse conveyor separator, as well as separating potatoes from soil clods and other impurities using a finger slide, collecting them in a container. The use of such a potato digger can significantly improve technical and economic indices of harvesting work in potato-farming.

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