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Potato digger with a digging workpart of the "Paraplaw" type

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Abstract. One of the reasons hindering potato farming development on Uzbekistan's farms is the low supply of inexpensive mini-production equipment for harvesting potatoes. The use of high-performance potato harvesters in small areas is uneconomical. The authors proposed a potato digger with a digging working body of the "Paraplaw" type. The study aims to develop a potato digger with working bodies of the "Paraplaw" type. A prototype of a mini potato harvester was made, and its economic tests were carried out. The basic principles and methods of classical mechanics, mathematical analysis, and statistics were used in this study. The developed digging work part is made in the form of rippers with inclined racks installed towards each other, and their chisels are equipped with ripping elements in the form of rods. The results of the digger tests have been given. It was found that during the operation of the improved potato digger, tuber losses were reduced by 2.9%, and productivity increased by 13.2% compared to the serial one.

1 Introduction

One of the reasons hindering potato farming development in Uzbekistan's farms is the low supply of inexpensive, productive mini equipment for harvesting potatoes. Since potato harvesting is the most labor-intensive process, it is obvious that using high-performance potato harvesters in small areas is uneconomical. Therefore, there is an urgent need to develop mini potato diggers that can reduce economic costs. Potato harvesting with minimal labor and money can be achieved by creating less energy-intensive machines [1-2]. The effectiveness of the technology can be ensured only if it is developed and applied, taking into account the specific soil and climatic conditions of local farms. The quality of the technological process of potato harvesting largely depends on the work of the digging organs, which in turn should facilitate the separation process [3-4]. In this regard, studying the influence of the parameters of the working bodies of potato diggers on the qualitative indicators of the technological process is an urgent task of great importance for the national

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economy of Uzbekistan.

Studies of loosening working bodies of the "paraplaw" type were carried out by Mamatov F [1-2], Fayzullaev H [5, 7, 8], Kodirov U [8, 9], Ravshanov H [4, 5, 8, 11], Kurbanov Sh [10] and others. He studied the physico-mechanical properties of loamy and soils, and theoretical and experimental studies justified the main parameters of the working body of the "paraplaw" type [12-20]. However, these studies do not consider using working bodies of the "paraplaw" type on potato diggers.

The research area is the development of a potato digger with a digging working body of the "Paraplaw" type.

2 Materials and Methods

The basic principles and methods of classical mechanics, mathematical analysis, and statistics have been used in this study.

Experimental studies were conducted under laboratory and field conditions based on generally accepted methods following current industry standards. The actual depth of the undercutting working tools was determined after the machine passed the accounting plot using a ruler and a rod placed on the top of the ridge.

After the machine passed, the completion of harvesting and losses of tubers were determined on the accounting plots. The following were taken into account: free tubers on the soil surface, tubers on the soil surface but not detached from the tops, and tubers left in the soil (covered and uncovered). When determining tuber losses (buried and unburied), plots were dug manually with a shovel to a depth exceeding 3 cm of the bottom tuber and then collected in a container by species and weighed. Weighing results were used to calculate the mass fraction of each type of loss from the total weight of tubers on the recording plot. Tubers weighing less than 20 g (thickness up to 28 mm) were not included in the losses.

The potato digger developed by us (Figure 1) is made in the form of rippers with inclined racks installed towards each other, and their chisels are equipped with ripping elements in the form of rods, and the angle of installation of the rods to the horizontal plane is greater than the angle of installation of the chisel. In addition, the angle of installation of the bit and the bars of the rear ripper is greater than the angle of installation of the bit and the bars of the front ripper, and the free ends of the bars of the rear ripper are located at a higher level than the bars of the front ripper.

Based on the conducted research, a potato harvester with the working bodies of "Paraplaw" type diggers was made (Fig.1). Potato harvester consists of support wheels 1, two diggers 2 and 3, made in the form of a working body of "Paraplaw" type with inclined struts and mounted towards each other. The inclined part and digging teeth are equipped with bars 4.

Figure 1 shows a diagram of the digging working body of the potato digger. The digging working body contains a frame 1, on which rippers 2 and 3 with inclined racks 4 are installed sequentially. Each ripper with an inclined rack consists of a rack 4, on which a knife 5 and a shoe 6 are fixed. A chisel 7 is mounted on the shoe 6. A ripping plate 8 is fixed to the inclined part of the rack behind the knife 5. Rods 9 are installed in the back of the chisel 7. In the longitudinally vertical plane, the chisels and rods of the rear and front ripper have different angles of inclination to the horizontal plane, i.e., $\alpha_2 > \alpha_1$ and $\beta_2 > \beta_1$, while $\beta_1 > \alpha_1$ and $\beta_2 > \alpha_2$, where α_2 and α_1 are, respectively, the angle of inclination to the horizontal plane of the bit of the rear and front ripper; β_2 and β_1 are, respectively, the angle of inclination to the horizontal plane of the rods of the bit of the rear and front rippers. The free ends of the bars of the rear ripper 3 are located at a high level h2 than the bars of the front ripper 2, i.e., $h_2 > h_1$, where h_2 andh_1 are respectively the height of the location of the free end of the bars of the rear and front rippers.

The digging working body works as follows. Ripper 2, penetrating into the soil below the tuber zone, cuts the left half of the ridge by 2-3 cm. At the same time, the chisel 7 of the ripper 2, penetrating into the sub-cardboard layer, cleaves the soil. The resulting cracks spread to the surface of the ridge at a certain angle. Moving forward with the unit's speed, chisel 7 raises a separate soil from the array. At this moment, a knife 5 is inserted into the zone of the soil deformed by the chisel 7. The knife 5 and the rack 4 are installed at an angle to the horizon, considering the zone of propagation of deformations and soil destruction. The soil, chipped off with a chisel 5, rising along it, enters the rods 9 of the chisel 7 with a large inclination angle, onto the knife 5, then onto the loosening plate 8. At the same time, bending and stretching of the soil with tubers in longitudinal and cross sections occurs, as well as some displacement of it towards the second half of the ridge, which will lead to its intensive destruction. This process is completed when the club mass descends from the working surfaces of the loosening plate 8 and rods 9 under the action of inertial forces and gravity.

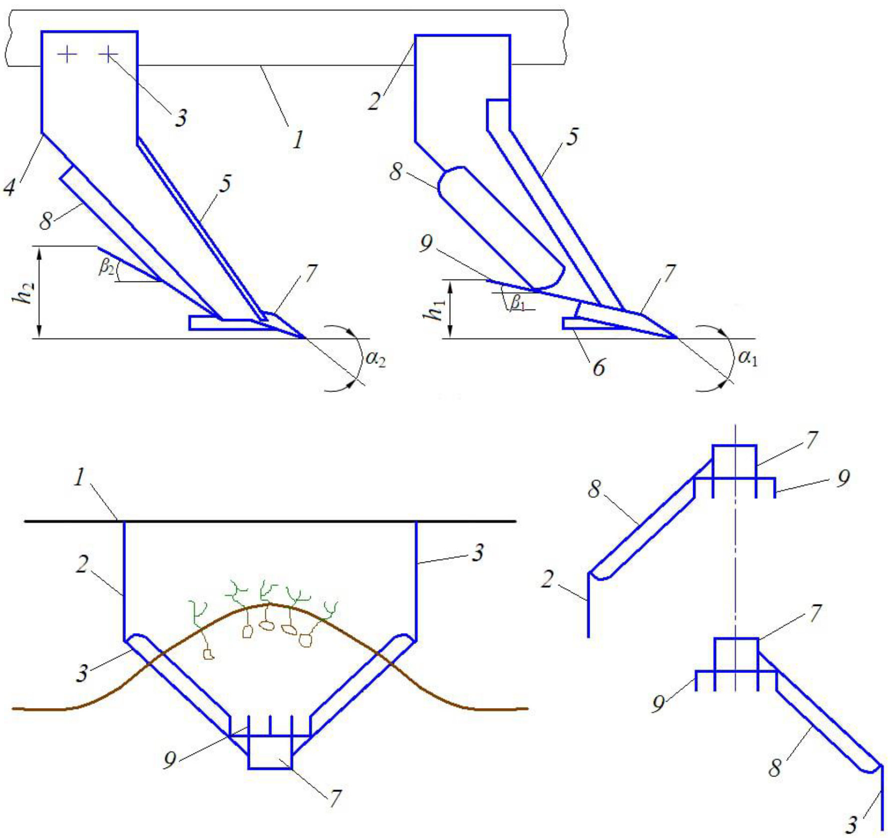

Fig. 1. The scheme of the digger with workparts of the "paraplaw" type

Following the displacement of the left half of the bed, the rear ripper 3 acts on the right half of the bed. Due to the large angles of inclination α_2 of the chisel and the rods β_2 of the rear ripper 3 to the horizontal plane than the angles of inclination α_1 of the chisel and the rods β_1 of the front ripper 2, as well as the large level h2 of the location of the free end of the rods of the rear ripper than the level of the location h1 of the rods of the front ripper 2, under its influence, intensive destruction of soil lumps occurs, separation of tubers from the soil.

3 Result and Discussion

Based on the conducted research, the potato digger with the working bodies of "paraplaw" type was made (Figure 2). Potato digger consists of supporting wheels 1, two diggers 2 and 3, made in the form of a working body of "paraplaw" type with inclined legs and set towards each other. The inclined part and digger bits are equipped with bars 4.

Execution of the digging working body in the form of rippers with inclined legs improves the efficiency of soil clods destruction. It is known that rippers with inclined legs loosen the soil better and have less energy consumption compared with other rippers [1, 3]. Due to the installation of ripper tines towards each other, working tools consistently undercut the left and right half of the ridge and produce intensive destruction of soil clods. Supplying the rack and chisel with bars and making the angle of setting the chisel and bars of the rear ripper larger than the angle of setting the chisel and bars of the front ripper, as well as the location of free ends of bars of the rear ripper at a greater level than bars of the front ripper contribute to intensive destruction of soil clods and cleaning tubers from the soil. All of this contributes to increasing the efficiency of soil clods destruction, clearing the tubers from the clumped soil, which reduces labor costs for post-harvest processing of the pile.

Based on the conducted research, a potato digger with working bodies of the "paraplaw" type was manufactured (Figure2). Figure 3 shows the process of the potato digger with working bodies of the "paraplaw" type.

Comparative tests of potato diggers were carried out in the fields of farms of the Karshi district of the Kashkadarya region of Uzbekistan with a row spacing of 70 cm in an aggregate with the MTZ-80 tractor. During the tests, the moisture and hardness of the soil, the shape and size of the potato bed, and the shape and location of tubers in the bed were measured. The test results are shown in Table 1.

Table 1. Potato digger test results

Name of indicators	Serial	Enhanced
Timing of tests	July 2021	June 2021
Pretreatment	Topdressing (KIR-1.5)	Topdressing (KIR-1.5)
Working speed of the unit, m/s	0.98	1.09
Digging depth, m	0.2	0.2
Number of tubers on the soil surface, %	92.3	94.8
Left in the soil, %	0.83	0.82
Covered with soil, %	6.87	4.38
Total losses, %	7.7	5.2
Damage to tubers, total by weight, %	4.09	4.03

Fig. 2. General view of the potato digger with working bodies of the "paraplaw" type

Fig. 3. The process of work of the potato digger with working bodies of the "paraplaw" type

Economic tests of the serial and improved potato digger showed that during the operation of the improved potato digger, tuber losses are reduced by 2.5% compared to the serial due to a decrease in the number of tubers sprinkled with soil. During the operation of the improved potato digger KTN-2B, it was found that an increase in the impact on the tuberous layer at the beginning of the technological process allows for increasing the operating speed of the unit by 11.61%. The calculation of the economic effect showed that by reducing the traction resistance of the digging organs and increasing the intensity of the impact of the working organs at the beginning of the technological process on the tuberous pile, the productivity of the machine increased by 13.2%.

4 Conclusion

A potato digger with the working bodies in the form of rippers with inclined stands installed towards each other, whose chisels are provided with ripping elements in the form of rods, and the angle of installation of rods to the horizontal plane is greater than the angle of installation of the chisel. The implementation of the digging working body in the form of loosening tools with inclined struts contributes to the efficiency of breaking up soil clods and improving the quality of the technological process of potato digging. It's found that during the operation of the improved potato harvester with the working bodies of the "paraplow" type, the loss of tubers is reduced by 2.5%, and the productivity of the machine increases by 13.2% compared with the serial.

Using a mini potato harvester with digging working bodies of "paraplaw" type on small areas is expedient, which contributes to the development of potato farming.

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