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## ENERGY SAVING POTATO-DIGGER MACHINES

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### Abstract:

The article presents the results of theoretical and experimental research on the substantiation of the parameters of the working bodies of energy-saving potato diggers for irrigated lands in Uzbekistan. The developed design diagrams of energy-saving potato diggers and diagrams of their technological process with an indication of the main parameters are described.

The rational parameters of the digging machines, which ensure the minimum energy consumption when digging potatoes, have been determined: the width of the main share is 45 cm, the intermediate share is 10-15 cm, the opening angle is  $90^{\circ}$ .

The parameters of the supporting-clod-breaking device were optimized: width 450 mm, diameter of the middle part 204 mm, diameter of the circle along which elastic rods are located 421 mm, diameter of the device disk 550 mm, diameter and length of elastic rods 3.0-4.0 mm and 555mm, their number 45 pcs, vertical load 1.0 kH,

The rational parameters of the ripper and the swathe were found: the angle of the ripper's circumference is not less than 1200, the arc step is 38.9 cm, the radius of the circle is 22.5 cm, the length of the ripper's arc is 47.1 cm, the length of the ripper is 120 cm, the width of the swathe is device - 140 cm, the angle of installation of the swathe grates - 450, the length of the grates - 50 cm, the length of the grate bars - 45 cm.

Comparative tests indicated an increase in the degree of soil separation in the summer and autumn periods, respectively, by 19.2-23.6% and 17.9-19.8%, an increase in the completeness of potato harvesting by 6.5-10.0% and 7.1- 8.9%, a decrease in the degree of damage to tubers by 8.4-11.1% and 4.7-5.3%, an increase in the productivity of the unit by 25.0%, a decrease in labor costs by 60.0%, and operating costs for 31.5% when using an experimental potato-digger machine with the recommended parameters of the equip.

The use of the recommended walk-behind tractor with an improved technology potato-digger reduces damage to tubers by 5-6%, increases productivity by 20%, reduces labor costs by 50%, and operating costs by 19%.

### Key words:

Potato-digger, walk-behind tractor, clod-breaking device, sectional share, elevator, ripper  
抽象的 :

文章介绍了乌兹别克斯坦灌溉地节能型马铃薯挖掘机工作体参数论证的理论和实验研究成果。介绍了开发的节能型土豆挖掘机设计图和工艺流程图，并标明了主要参数。

确定了挖掘机的合理参数，以确保挖掘土豆时的最低能耗：主部分宽度为 45 厘米，中间部分为 10-15 厘米，开口角度为 90°。

对支撑破块装置的参数进行了优化：宽度450 mm，中间部分直径204 mm，弹性杆所在圆的直径421 mm，装置盘直径550 mm，直径和长度弹性杆 3.0-4.0 mm 和 555mm，数量 45 根，垂直载荷 1.0 kH，

求出松土器和条带的合理参数：松土器圆周角度不小于120°，圆弧步长38.9厘米，圆半径22.5厘米，松土器圆弧长度47.1厘米，裂土器的长度是 120 厘米，条的宽度是设备 - 140 厘米，条篦的安装角度 - 45°，篦子的长度 - 50 厘米，篦条的长度 - 45 厘米。

对比试验表明，夏季和秋季土壤分离程度分别提高了19.2-23.6%和17.9-19.8%，马铃薯收获完成度提高了6.5-10.0%和7.1-8.9%，块茎损伤程度降低8.4-11.1%和4.7-5.3%，单位生产率提高25.0%，人工成本降低60.0%，使用时运行成本降低31.5%具有推荐参数的实验土豆挖掘机。

使用推荐的手扶式拖拉机和改进的马铃薯挖掘机可减少 5-6% 的块茎损伤，提高 20% 的生产力，降低 50% 的劳动力成本和 19% 的运营成本。

关键词：

挖土豆机、手扶拖拉机、破土器、分段共享、电梯、松土器

### Introduction:

Currently, potato growing in the republic needs the introduction of advanced technologies equipped with highly efficient technical means adapted to the economic and soil-climatic conditions in the area. A potato digger for digging potato tubers from potato beds should provide high-quality digging in accordance with agrotechnical requirements with minimal energy consumption, be less metal-consuming and labor-intensive to maintain. Ukraine, Russia, Belarus, China, India, Italy, Germany are the main countries engaged in the improvement and creation of potato diggers [1]. The Ukrainian

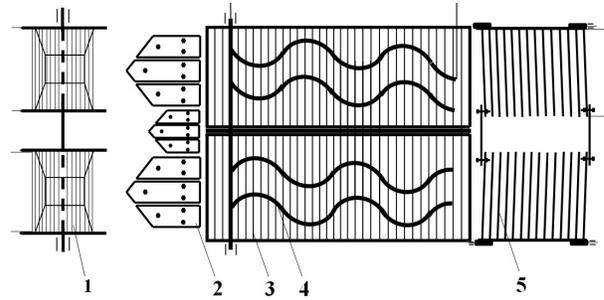
company *Агромашиноп* offers a double-row vibrating potato digger equipped with sectional shares and discs. The potato digger developed by the Chinese company *Xiear* is also equipped with sectional shares. The length and width of the section shares are 450 and 100 mm, respectively. [2] To reduce dumping and increase the degree of crumbling of the soil mass, *Ping Zhao* offers sectional shares with curved surfaces, while *aMd Akhir* offers sectional shares with an opportunity to change the installation angle to the horizon [2, 3].

The abovementioned potato-digger machines are equipped with sectional shares to reduce traction

resistance, as well as to reduce clogging of the share by weeds. However, these plowshares also dig up excess soil in the potato bed and as a result the mass is unloaded in front of the plowshare, and it results with the loss of tubers and reducing productivity. To prevent unloading of the soil in front of the trimming shares, *Arfa*[4] offers a potato-digger with discs with trapezoidal notches around the circumference at the edges of the shares. The Indian company *Peanut* offers a potato-digger equipped with discs mounted on the edges of the shares. The diameter of the discs is 500-550 mm [5].

Based on foreign experience in the design of potato diggers [6, 7, 8, 9, 10, 11,12,13,14] and taking into account the soil and climatic characteristics and a variety of physical, mechanical and technological properties of the soil in different periods of harvesting potatoes, and also agro-technical requirements, general requirements for a potato digger are formulated. Taking these requirements into account, we have developed a constructive diagram of a potato digger and a diagram of the technological process of its operation with an indication of the main parameters (Fig. 1.) [15, 16, 17, 18].

The potato-digger consists of a support-clod-breaking device 1, reduced sectional shares 2, an elevator 3, and undulating rippers 4, fixed to the frame, and a swathes 5, which can be installed longitudinally and transversely to the frame of the potato-digger. Reduced sectional shares 2 consist of two main shares and one intermediate share. Wave Rippers 4 is made from 12mm diameter rods, rubber coated and attached to the frame. The swathes 5 consists of two parts rigidly connected to the frame at an angle. It is made in the form of a lattice, which is covered with rubber and is installed transversely to each other and relative to the elevator.



**Illustration 1: The potato-digger operation in the process of technology scheme**

The forms of farming are intensively developing in the Republic on low-cultivated land plots of farms and dehkan farms, where vegetables and potatoes are mainly produced.

Due to the lack of means of small-scale mechanization for working in low-contour areas, many operations for the cultivation of vegetables and potatoes are carried out manually, which is associated with an increase in labor, material costs, when in developed foreign countries, mobile means of small-scale mechanization are widely used on low-contour household plots.

Currently, motoblocks are produced abroad by the USA, Japan, Italy, Germany, Switzerland, China and other states. The largest number of motoblocks are produced by firms from the USA, Japan, Germany and France.

The use of motor blocks increases labor productivity in plowing by 5-10 times (depending on the condition of the soil), in transport operations by 5-15 times in comparison with manual labor.

Depending on the purpose and the corresponding requirements, walk-behind tractors of different capacities, various layout schemes and designs are produced.

Based on the study of the experience of using walk-behind tractors in low-contour areas for the cultivation of vegetables and potatoes, in particular, on the experimental farm of the Scientific Research Institute of Vegetable and

potato crops, we have identified the main agro-technological operations that the walk-behind tractor should provide. Taking into account the basic requirements stated for a walk-behind tractor, we have developed temporary initial requirements for a walk-behind tractor for use in the cultivation of vegetables and potatoes in rural areas and farm complexes, which are given in the appendix.

We have chosen a Chinese-made walk-behind tractor (Caliber TDK-12) with a diesel engine with the characteristics given below as a prototype for further research. Based on the temporary initial requirements for a walk-behind tractor for use in low-contour areas during the cultivation of vegetables and potatoes.



**Figure 2 - Selected walk-behind tractor**

Technical characteristics Caliber TDK-12

Weight, 115 kg;

Plowing depth, 14cm;

Plowing width, 70cm;

Dimensions, 750x376x532mm;

Power (h. p.) 12.

The purpose of this work is to develop and substantiate the parameters of the working bodies of energy-saving potato diggers. The following tasks are outlined in accordance with the goal:

- Substantiation of the parameters of sectional shares.
- Substantiation of the parameters of the support-clod-crushing apparatus.
- Development and validation of the parameters of the ripper.
- Development and validation of the parameters of the swathing device
- Determination of agro technical indicators (losses and damage to potato tubers) of the work of a motor-block potato-digger.

#### **Methods:**

The methods of theoretical and agricultural mechanics, mathematical statistics are applied in theoretical studies. The methods of mathematical planning of experiments and tensometry, as well as the methods given in the existing normative documents were applied in the experimental studies.

To determine the traction resistance of the potato digger, strain gauging (tenso-metry) was carried out with the help of tenso-fingers. *Tenso-fingers* were installed instead of both the lower and upper connecting finger of the hitch of the potato digger. Four wire strain gauges with a resistance of 200 Ohm are fixed to the *tenso-fingers* parallel to their axis. Before and after the experiments, the *tenso-fingers* were calibrated. The calibration was carried out on a special calibration unit. The loading and unloading of the *tenso-fingers* was carried out by means of loads weighing 10 kg.

To determine the performance indicators of the ripper for damage to potatoes, the completeness

of digging in and separation of the soil, a coil with a film wound on it was fixed to the rear of the potato digger. When the unit moved, the film was unwound and not-separated clods of soil, as well as potato tubers, fell onto the film (Fig. 3).



Fig. 3: Blade with not-separated mass

We have developed and manufactured undulating rippers with various parameters for the experimental research. A multivariate experiment was implemented to determine the rational parameters of the swathing device.

Also, the implementation of research tasks provided for the determination of agro-technical indicators (losses and damage to potato tubers) of the work of a motor-block potato digger (Fig. 4).



**Figure 4 – The operation of the potato-digger**

### Results and Discussion:

The analytical dependences have been derived to determine the width, opening angle, installation angle to the share's horizon,

longitudinal distance between the main sectional share and the supporting-clod-breaking device as a result of theoretical studies.

As a result of the optimization of the search, the rational parameters of a reduced sectional undercutting working body were determined, which ensure an increase in productivity and an improvement in the quality of separation with minimal energy consumption: the width of the main share is 0.45 m, the intermediate share is 0.1 m, and the opening angle is 90°.

The calculations determined that the horizontal width of the swathing device should be at least 1.4 m. The angle of installation of the swathing grids is not less than 45° degrees. The distance between the rods is no more than 3 cm. The length of the gratings is not less than 50 cm. The length of the grating bars is not less than 43 cm and no less than 17 pcs of rods.

The obtained regression equations were solved on the basis that losses and damage to potato tubers did not exceed 3.0-4.0%, and the degree of soil separation was maximum and the following rational values of factors were obtained: the length of the rods of the swathe grid - 45 cm; angle of installation of the swathe to the frame of the potato digger - 45 degrees. With these values of the factors, the degree of soil separation of the experimental setup is 69-70%, and the loss of tubers is 3.2-3.3%, damage to potato tubers is 3.3-3.5%.

As a result of the optimized search, the optimal values of the parameters of the corrugated ripper were determined, which ensure an increase in productivity and improve quality with minimal energy consumption, they are: ripper length - 120 cm, the angle of a ripper - 120°, circle radius of a ripper 0.225 m.

Experimental and theoretical studies of the parameters established that a decrease in losses

and the degree of damage to potato tubers and an increase in productivity is achieved with: the width of the swathing device horizontally - not less than 1.4 m; the angle of installation of the swathing grids not less – 45°; the distance between the rods - not more than 0, 03 m; the length of the gratings - not less than 0.5 m; the length of the grating bars - not less than 0.45 m and the number of bars - not less than 17 pcs.

According to the results of experimental data, the maximum degree of soil separation is provided by the angle of installation of the grate 45°, while the minimum losses and damage to potato tubers occur when the length of the rods of the swathing grate is 45-50 cm and the speed of movement is 0.8 m / s, while the degree of separation is 74%, the loss of tubers 3.21-3.3%, and damage to potato tubers 3.3-3.17%.

The research results of the developed energy-saving potato-digger machine were accepted by JSC *BMKB-Agromash*, its experimental model KK-2 was made. The results of extensive economic tests carried out on the farms of the Yangiyul, Chinaz and Kuyi-Chirchik districts of the Tashkent region showed that the experimental potato-digger KK-2 provides high agro-technical indicators in comparison with the serial KN-2 according to such basic criteria as the degree of soil separation, completeness of digging and minimal damage to potato tubers.

The use of the developed experimental potato-digger increases the degree of soil separation by 19.2-23.6% and 17.9-19.8%, respectively in the summer and autumn periods, increases the completeness of the potato harvest by 6.5-10.0% and 7.1 -8.9%, reduces the degree of damage to tubers by 8.4-11.1% and 4.7-5.3%, the productivity of the equip increases by 25.0%,

labor costs are reduced by 60.0%, and operating costs by 31.5%.

The use of a walk-behind tractor with an improved technology of recommended potato-digger reduces damage to tubers by 5-6%, increases productivity by 20%, and reduces labor costs by 50% and operating costs by 19%.

According to the list of prices in January 6, 2020 the annual economic effect from the use of a cultivator is 715954.5 *soums*, from a potato planter which cost 733558 *soums*, from a seeder which cost 826,540 *soums*, from a potato-digger of 3017049.12 *soums* per walk-behind tractor.

The research results of the developed energy-resource-saving potato-diggers were accepted by JSC *BMKB-Agromash*, and their experimental samples were made. The results of extensive economic tests carried out in the experimental farms of ‘*ИММЕСХ*’ and ‘*ННОБКУК*’ showed that experimental models provide high agro-technical indicators in comparison with the other devices in this group.

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