PARAMETERS JUSTIFICATION OF THE IMPROVED POTATO DIGGER

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Abstract. *This potato digger is equipped with a mechanism for transmitting torque to oscillating rods. The experiments were carried out using a special laboratory-field installation. The process digging potatoes is characterized by high energy costs due to the interaction potato digger's ploughshares with the tuber-bearing soil layer. The purpose study is to substantiate the parameters potato digger's lattice plowshare. In the proposed potato digger, the ploughshare is made latticed and equipped with oscillating rods. Various lattice ploughshares were manufactured and single-factor experiments were carried out. During the experiments, the degree damage and loss tuber, as well as the traction resistance potato digger were taken as evaluation criteria. The results of experimental studies to determine the parameters ploughshare are presented. It is established that the optimal design scheme a potato digger is a scheme consisting torque transmission mechanisms, lattice ploughshares and forcibly oscillating rods. As a result theoretical studies, analytical dependencies and mathematical models were obtained that allow determining the parameters a lattice plowshare. Studies have established that in order to destroy the tuber formation to the required extent with minimal damage and loss tuber, as well as energy costs, the width lattice ploughshare should be 55 cm, the angle ploughshare installation relative to the horizon is 22°, the length ploughshare is 38 cm, and the width gap between the bars is 3 cm.*

Keywords: *potato, digger, lattice plowshare, rod, torque, vibration, rod*

1. Introduction

At the end of 2022 in the Republic of Uzbekistan, potatoes were planted on the main arable land by 67.9 thousand hectares, and as a recurring crop, 28.6 thousand hectares were planted in 3.0 million hectares. tons of potatoes were delivered. Potatoes are grown mainly in Andijan, Namangan, Samarkand, Surkhandarya, Tashkent and Fergana regions. According to the Food and Agriculture Organization of the United Nations (FAO), potatoes are grown on 22 million hectares in 150 countries around the world and it is planned to double its volume in the next 10 years. Based on this, it is

required to develop and put into practice tools for digging up the harvest root crops with high quality work and productivity, as well as with the lowest fuel consumption.

The total area cultivation in the Kashkadarya region is 65,945 hectares, which the area planted by the landlords is 60.214 hectares and the area cultivated on peasant farms is 5,731 hectares. From this it can be seen that potatoes are mainly planted by the landlords in small arable land (Fig.1). Since 91.3 percent arable land is made up land for land owners, the cultivation potatoes is handled in an individual manner. Growing potatoes in small contours is mainly 0.4-0.5 hectares and even smaller areas.

The development of a small gabarite potato digger, improved from the above, and the justification of its parameters, is considered important for the national economy of our republic.

2. Materials and methods

Experiments were carried out by aggregating a potato digger with a New Golland-110 tractor at a speed of 0.8-1.1 M/s aggregate. Experimental studies improved potato pickles were carried out in the summer season on farms Kashkadarya region Republic of Uzbekistan. The terrain field is flat, the soil experimental field is medium-light, sandy soil. The quality and energy indicators experimental potato digger were evaluated according to the following indicators: the completeness potato digger; potato loss; damage to potatoes; drag resistance cowler. Drag resistance potato digger TST 63.03.2001 "Tests of agricultural machinery. Methods of energy assessment" was determined by using tenzometric fingers. One-factor experiments were carried out to determine the optimal parameters potato digger’s lattice plowshare. Lattice ploughshares with different gripping widths and slots have been developed and manufactured for experimental studies. During the experiments, the degree damage and loss tuber, as well as the traction resistance potato digger were taken as evaluation criteria. The taxile transmitted literature [1, 5], an improved potato digger was developed based on early research as well as agrotechnical requirements poured into potato diggers (Fig.1).

The potato digger consists a frame 1 equipped with a suspension device, a main 2 and an intermediate coulter fixed to the frame, oscillating plows 3 attached to the main plows, and mechanisms that oscillate the plows. Oscillating motion to the tractor 3 is transmitted from the tractor power take-off shaft through a cardan shaft 4, a transmission box 5, a crankshaft 6, a drawbar 7, a bridle 8, a two-shouldered lever 9 and a lever 10. The technological process potato digger is as follows (Fig. 2).

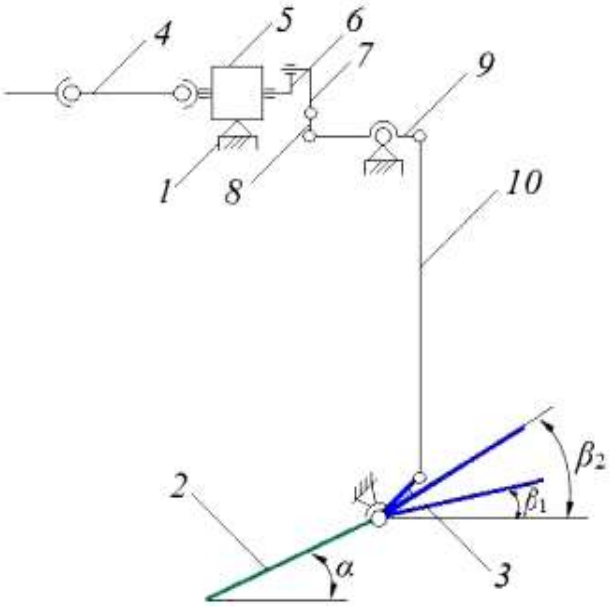


Figure 1. The scheme potato digger with a lattice ploughshare and oscillating rods: 1 – frame;
2 – ploughshare; 3 – rod; 4 – driveshaft; 5 – transmission; 6 – crankshaft; 7 – traction; 8 – leash; 9 – double–shoulder link; 10 – rod

The main ploughshares 2 separate the soil layer from the bottom soil with the nodes, crush it and partially separate it from the main mass, and then direct it to the oscillating ferules 3. The harrows intensively separate the tubers from the soil and throw them on the surface field. The process separating potatoes from the soil and sieving the soil is improved under the influence oscillating feruls 3. The intermediate blade potato digger scoops up the potatoes that fall between the rows and transfers them to the harvesters.

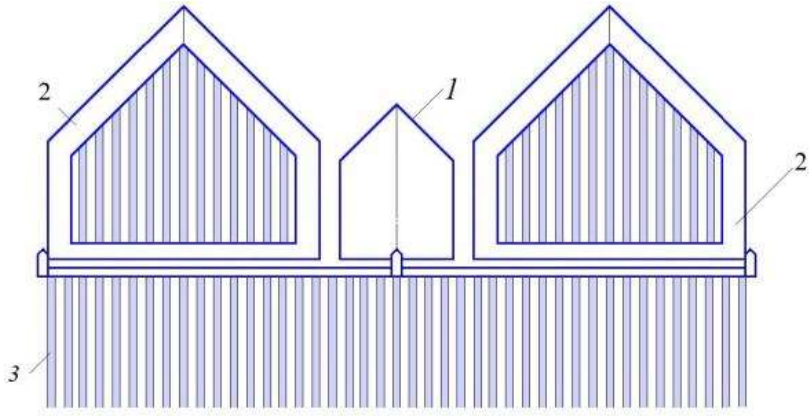


Figure 2. Grid plow and oscillating harrows: 1 – intermediate plow; 2 – ploughshare with a grid;
3 – oscillating wheels

The improved potato digger is equipped with a plow with a flat grid, its main parameters include: plow width B_l; angle inclination ploughshare to the horizon at the length the ploughshare is L_l; the opening angle ploughshare g, the width intermediate ploughshare B_{ol} (Fig. 3 and 4).

In the following years, the row spacing potatoes in Uzbekistan is 70 and 75 cm. Therefore, we will perform further calculations for a row spacing of 75 cm. We determine the width of the plow with a flat grid by the following known expression, provided that all the nodes located in the field are fully dug with minimum coverage of the soil (Fig.3)

$$B_l = b_m + 2\delta + 2(h - h_x)ctg\varphi_q - t_n, \quad (1)$$

where b_m – is the width placement buds in the nest, cm; δ – the displacement row planted with potatoes in relation to the axis of symmetry plow, due to the row not being straight and the machine not being precisely controlled, cm; h – digging depth, cm; h_x – the depth placement marginal nodules according to the width nodule socket, cm; φ_q – is the angle natural slope soil, º; t_n – is the thickness side blade, cm.

Due to the fact that the depth placement marginal nodes according to the width terminal socket is variable in a wide range and there is not enough accurate information on it, we determine it according to the following expression

$$h_x = h_1 + \frac{h_2 - h_1}{2} = \frac{h_1 + h_2}{2}, \quad (2)$$

where h_1 – is the depth of placement upper nodules in the bush, cm; h_2 – the depth of placement lower node in the bush, cm;

Based on our research, if h_1=7,5 cm and h_2=18,5 based on the expression (2), we determine that h_x=13 cm.

We put the value of h_x in (1) according to the expression (2).

$$B_l = b_m + 2\delta + 2(h - \frac{h_2 + h_1}{2})ctg\varphi_q - t_n, \quad (3)$$

If b_m=23-30 cm, δ=4 cm, h=20 cm, $h_ч$=13 cm and φ_q=38º, if t_n=0.5 cm, based on expression (3), we determine that it should be in the range of B_l=48,4-55,4 cm. Taking into account that the potato digger works in fields with a row spacing of 75 cm, we accept B_l=55 cm.

The potato digger is designed to dig potatoes in two boxes. Taking this into account, based on Fig.4, we determine the width intermediate plow by the following expression, taking into account the width row interval B_k, the width main plow and the width slot between the plows b_1 (Fig.4)

$$B_{ol} = B_k - B_l - 2b_1, \quad (4)$$

where B_k – is the row spacing width, cm; b_1 – the width slot between the plowshares, cm.

$$B_{ol} = B_k - \left[b_m + 2\delta + 2\left(h - \frac{h_2 + h_1}{2} \right) ctg\varphi_q \right] - 2t_n - 2b_1, \quad (5)$$

If B_k=75 cm, B_l=55 cm and b_1=3 cm, based on expression (5), B_{ol}=13,5 cm.

Based on the research conducted by scientists, the opening angle ploughshare is determined by the condition that its blade cuts grass residues and the roots potato stalks. According to it $\gamma = 0{,}5(0{,}5\pi - \varphi_1)$, φ_1 – is the maximum value of the angle friction soil and potato roots on the blade plow, º. By putting φ_1=40-45º in the expression, we determine that the angle opening ploughshare should be in the range of 80-90º. In potato diggers γ=90º is accepted.

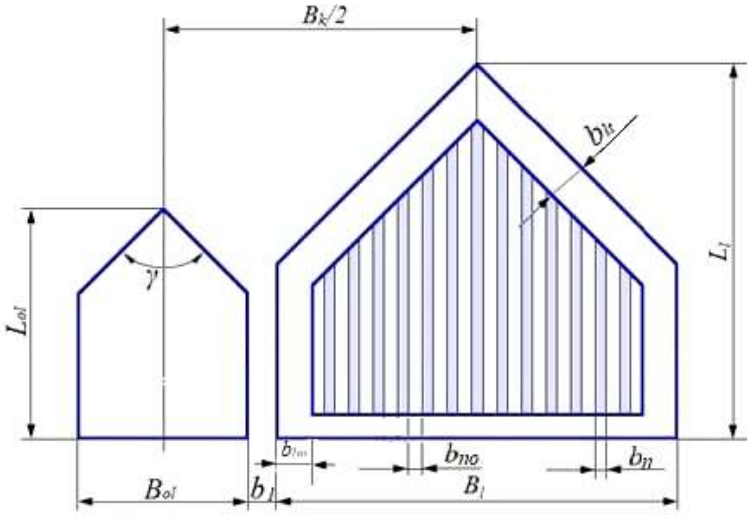


Figure 3. The scheme for determining the parameters grid plow

Conducted studies on determining the angle deviation a plow relative to the horizon. According to their research, angle a should be between 22-30º. We take α=22º.

It is known that the length of the ploughshare potato digger affects whether the nodular mass accumulates in front ploughshare. As the length ploughshare increases, the speed movement nodular mass along the surface ploughshare decreases, which, in turn, causes the soil to accumulate in front ploughshare and disrupt the technological process. Under the influence plow, the nodular mass should move freely and disintegrate sufficiently on its surface. The length ploughshare was determined. We determine by the following expression

$$L_l \le ctg(\alpha + \varphi)\left\{ \frac{\sigma_b}{\rho_x g} - \frac{2V_M^2}{g} \sin\tau[\cos\tau tg(\alpha + \varphi) - \sin\tau] \right\}, \quad (6)$$

where σ_b – is the temporary resistance to compression soil, Pa; ρ_x – volume density of soil, kg/m^3; τ – is the soil refraction angle, º; g – acceleration free fall, m/s^2; V_M – movement speed, m/s.

The angle of refraction soil in the expression (6).

$$\tau = arctg\frac{K-\cos\alpha}{\sin\alpha}; \tag{7}$$

$$K = \frac{a_1}{h}, \tag{8}$$

where K – is the coefficient soil subsidence; h – digging depth, cm; a_1 – is the thickness plow blade, cm.

If α=22º, φ=25º, σ_b= 6·10^3 Pa, τ=25º, K=1,1, ρ_x=1350 кg/m^3 and V_M=0,8-1,1 m/s (6) should not be larger than L_l=36-39 cm according to the expression. We accept L_l=38 cm.

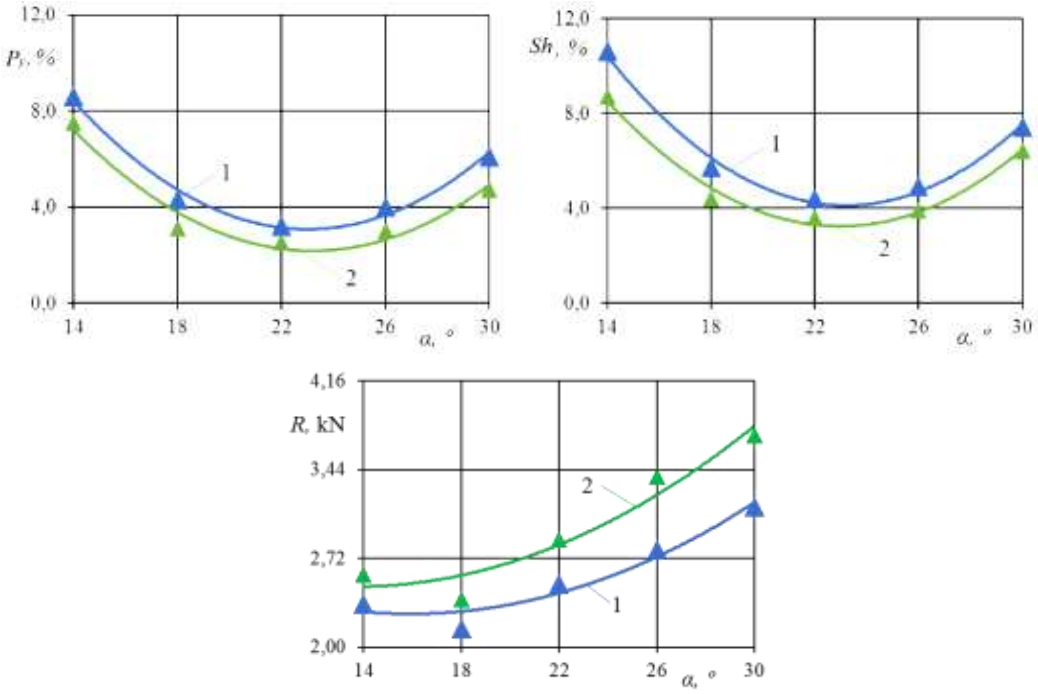
We determine the width lattice slots b_{no} on the condition that the nodes do not pass between them. According to previous studies, this distance should not be more than 3 cm. We accept b_{no}=3 cm. We take the width bars of the grid to be 1 cm, the width side of the ploughshare to be 10.5 cm, and the width blade gridded ploughshare to be 110 mm. In that case, the number furled fence

$$n_{nx} = \frac{B_l - 2b_{lyo}}{b_{no} + b_n}. \tag{9}$$

Since B_l=*55* cm, b_{po}=*3* cm, b_{ly} =*10.5* cm and b_p=*1* cm, the number lattice hives per expression (9) will be 8 pieces.

3. Results and discussion

The results experimental studies are shown in Figures 3 and 4. According to the results obtained (Fig.4) with an increase in the angle inclination lattice plowshare, losses and damage to potatoes first decrease, and then increase according to the law concave parabola. This can be explained by the fact that the time movement tuber-bearing mass soil on the surface the ploughshare first decreases, and then increases with an increase in the angle inclination ploughshare. The traction resistance potato digger increased with an increase in the angle inclination at both speeds. The main reason for this is that with increasing speed, the impact ploughshare on the tuberous soil and the inertia forces acting on the ploughshare from the soil increases.

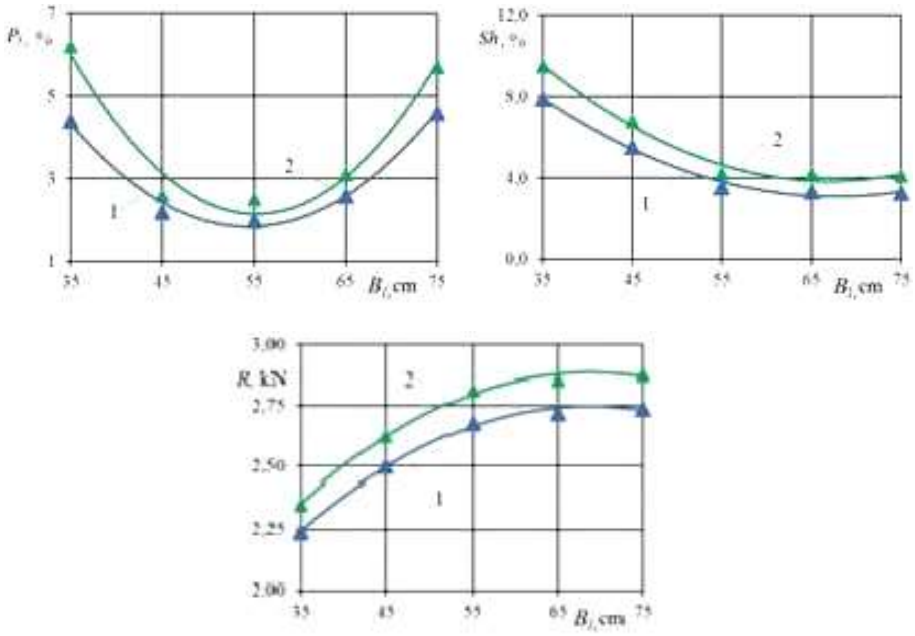


1 – V=0,8 m/s; 2 – V=1,1 m/s

Figure 4. Graphs of changes in potato losses (R_u), damage (Sh) and traction resistance (R) potato digger depending on the angle of inclination (α) lattice plowshare to the horizon

Based on the above, the angle inclination plowshare to the horizon is assumed to be 22º.

The influence width lattice plowshare on the quality and energy indicators potato digger. To justify the width lattice ploughshare, lattice ploughshares with widths of 35, 45, 55 and 65 cm were experimentally developed and manufactured. According to the results experiments (Fig.5), with an increase in the width lattice plowshare, potato losses first decrease and then increase according to the law concave parabola. Damage to potatoes decreases with an increase in the width ploughshare. This is due to the fact that with smaller values width ploughshare, the tuberous mass is not completely covered by them and the tubers are damaged by the blades of the ploughshares. When the width ploughshare is more than 60 cm, the volume of soil covered by it increases, which leads to a decrease in the degree separation tubers from the soil and, accordingly, an increase in their loss. At the same time, the damage does not change significantly. According to the results experiments, the width ploughshare should be 55 sm.



1 – *V*=0,8 m/s; 2 – *V*=1,1 m/s

Figure 5. **Graphs of changes in potato losses (P_y), damage (*Sh*) and traction resistance(*R*) potato digger depending on the width plowshare (B_l)**

4. Conclusions

As a result theoretical studies carried out, analytical dependencies and mathematical models were obtained that allow determining the parameters and operating mode an improved potato digger with lattice ploughshares and oscillating rods. To destroy the tuberous formation to the required extent with minimal energy consumption, the width lattice ploughshare should be 55 cm, the angle ploughshare installation relative to the horizon is 22 °, the length ploughshare 38 cm, and the width gap between the bars is 3 cm.The most optimal design scheme an improved potato digger is a system consisting of transmission mechanisms, lattice ploughshares and forcibly oscillating rods.

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