Study on the parameters of bars of the potato digger ploughshare

Farmon Mamatov[1*], *Akmal* Karimov[1*] and *Golib* Shodmonov[1]

[1]Karshi Engineering-Economics Institute, 225, Mustakillik ave, 180100, Karshi, Uzbekistan

Abstract. Currently, potato diggers used in agricultural production in Uzbekistan have a number serious drawbacks. In particular, they have a high material and energy capacity, and their use in small farms and personal subsidiary farms is considered less effective. The purpose study is to substantiate the parameters vibrating rods potato digger ploughshare. The authors proposed a potato digger with lattice ploughshares equipped with vibrating rods. Swinging rods are attached to the main ploughshares, the oscillation which is carried out from the tractor power take-off shaft. A diagram a ploughshare with vibrating rods and a mechanism for transmitting motion is given. The laws theoretical mechanics are used in the research. In the experiments, losses and damage to potatoes, as well as traction resistance, were taken as a criterion for evaluating the performance potato digger. As a result theoretical studies carried out, analytical dependencies and mathematical models were obtained that allow determining the parameters rods. It is proved that the length bars the potato digger ploughshare should be 25 cm, the number bars is 14 pieces, the distance between the bars is 3 cm, the diameter the bars is 1 cm.

1. Introduction

Currently, potato diggers used in the agricultural production our republic have a number serious drawbacks. In particular, they have a high material and energy capacity, and their use in small farms and personal subsidiary farms is considered less effective. This worsens the quality indicators potato digging, reduces productivity, increases fuel consumption and other costs. The study bar ploughshares was engaged in F Maiviatov [1-2], M Bentini [3], D Horton [4], J Boxuan [5], S Younis [6], X Shengshi [7], F Mamatov [8], G Sineokov [9] B Tulaganov [10], S Hrushetsky [11], Al-Mallahi [12], Y Syromyatnikov [13-15], Q Su [16] and et all. T.T.Kusov [17] conducted comparative studies a passive plowshare with a rod vibration plowshare. They found that there is no unloading in front digging body during the operation vibrating ploughshare, the tuber layer crumbles better. With the distance between the bars equal to 0.3 m, the separation was 50-85%. V.I.Himmelfarbom [18] conducted studies a potato digger, whose ploughshare was made whole with the first roar. He notes that with the rotation speed eccentric shaft in the range 480-530 rpm, with an oscillation amplitude 26 mm and an angle inclination ploughshare 20 degrees, the traction resistance is 23-25% less than that a serial potato digger. Y Syromyatnikov [15] proposed a finger-type digging working organ. The author has considered in detail the process interaction digging working body with the tuberous formation, analytically substantiated the cases formation compaction core, theoretically determined the dependence resistance force to digging on the design parameters and operating modes. Based on the analysis previous studies, we have developed an improved potato digger with passive lattice ploughshares and active oscillating rods. The purpose study is to substantiate the parameters vibrating rods potato digger ploughshare.

2. Materials and Methods

The potato digger (Fig.1) consists intermediate ploughshare 1, lattice ploughshare 2 and rivets 3. Vibration movement to the bolts is transmitted from the tractor power transmission shaft. In the process technological work the potato digger, the main ploughsharees divert the soil layer on which 2 tubers are located, separating them from the ground and directing them to the grooves 3. Hives 3 vibrate to separate the hairs from the soil and throw them on the surface the field.

*Corresponding author: fmamatov_50@mail.ru

The main parameters potato peeler hives include: L_C – the length of the hives, m; β_c – the angle maximum mounting hives to the horizon, grad; D_c – the diameter hove, m; b_c – the distance between the hives, m.
The parameters and operating mode oscillating rods potato digger were determined taking into account the separation potatoes from the tuberous mass to the required extent without damage.
We take the transverse surface the groove in a circle. According to previous research, hives such a shape are less damaging to potatoes. We take the groove diameter D_x 10 mm, the distance between the grooves b_x 3 cm.
We define the number vertices by the representation in qyi, depending on the width of the ploughshare B_l, the diameter vertices D_X, and the distance between them B_X

$$n_{ps} = \frac{B_l + b_x}{D_x + b_x}. \tag{1}$$

Since B_l=55 cm, b_x=3 cm and D_x=1 см (2.6) the number vibrating hives per expression will be 14.5 pieces. We accept 15 PCs.
From the condition that the soil and potatoes do not accumulate in kferul, we determine its length by the expression in sheep [9]

$$l_c \le \frac{\sigma_s}{\gamma} ctg(\beta_{av} + \varphi), \tag{2}$$

where σ_s – is the temporary marginal resistance soil to compression, Pa; γ – volumetric weight soil, N/m3;
If β_{av}=24º, φ=25º, σ_s=2.6·10^3, if γ=8,1*10^3 kg/m^3 (2) according to the expression the L_C value should not be greater than 28 cm. We take l_c = 25 cm.

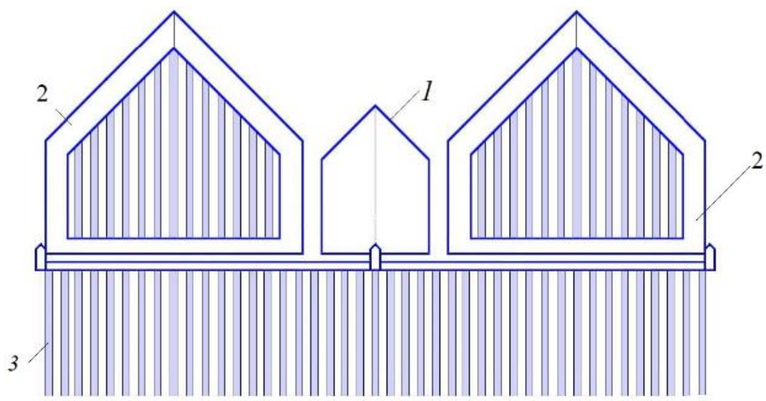


Fig. 1. Diagram of a ploughshare with vibrating rods: 1 – intermediate ploughshare; 2 – lattice ploughshare; 3 – oscillating ferules

The tensile resistance force ferules consists the sum organizers in the sheep (fig.1).

$$R_{sx} = R_{sk} + R_{in}, \tag{3}$$

in this case, the R_{sx} – tufted mass is shifted along the surface ferul and the resistance generated from the rise, N.
From the inertial force mass rising along the R_{in} – ferul surface the resulting resistance, N.
We determine the resistance generated by the displacement and lift fertile soil along the surface ferul by the expression on the sheep [9]

$$R_{sk} = G_s \cos\beta_c (\sin\beta_c + f\cos\beta_c); \tag{4}$$

where G_c – is the weight mass in the grooves, N.
Weight mass in hives

$$G_c = \gamma_k g D_c F_c (1 + \frac{W}{100}). \tag{5}$$

where γ_k – is the quoted density tangent mass, kg/m^3; W – is the soil moisture; F_c – is the cross – sectional surface tangent mass in the direction movement, m^2.
To simplify the determination value of F_c, we take ferul in the horizon case. Based on fig.1

$$F_c = n_c L_c \frac{(h_1 + h_2)}{2}, \quad (6)$$

where h_1 and h_2 – is the height tangent mass at the head and tip groove, respectively, m; n_c – is the number grooves, pcs.

Let the value F_c be set to (2)

$$G_c = \gamma_k g D_c n_c L_c \frac{(h_1 + h_2)}{2}(1 + \frac{W}{100}). \quad (7)$$

By putting the value of G (3) by expression (2), we determine the resistance generated by the displacement and lift fissile soil along the surface ferul

$$R_{sk} = \gamma_k g D_c n_c L_c \frac{(h_1 + h_2)}{2}(1 + \frac{W}{100})\cos\beta_c(\sin\beta_c + f\cos\beta_c). \quad (8)$$

The inertial force mass rising along the surface ferul is related to the acceleration the mass

$$R_{in} = R_{in1} + R_{in2}; \quad (9)$$

R_{in1} – the inertia force generated by the lift the tangent mass along the surface notch in the direction motion, N; R_{in2} – is the inertia force caused by the oscillatory motion tangent mass,

$$R_{in1} = \frac{G_c}{g} a_{ave}, \quad (10)$$

where is the mean acceleration where is the mean acceleration a_{ave} – tangent mass, m/s^2.

Average acceleration of finished mass in the l length of ferul – tangent mass, m/s^2.

$$a_{ave} = \frac{V_a}{\Delta t}, \quad (11)$$

where Δt – is the distance transition time in the linear mass L_c long, s; and Δt – is the absolute velocity linear mass, m/s.

Time to pass the legume mass

$$\Delta t = \frac{L_c}{V_r}. \quad (12)$$

We find the absolute and relative velocities smoky mass by the expressions in the sheep

$$V_a = V_m \frac{\sin\beta_c}{\sin(\beta_c + \theta)} \quad (13)$$

$$V_r = V_m \frac{\sin\psi}{\sin(\beta_c + \theta)} \quad (14)$$

Acceleration fusiform mass from the above

$$a_{ave} = V_m^2 \frac{\sin\beta_c \cos(\beta_c + \varphi)}{L_c \cos^2\varphi}. \quad (15)$$

Let's put the value of G_c and a_{ave} in terms of (3) and (2) expressions in terms of (1)

$$R_{in1} = \gamma_k D_c n_c V_m^2 \frac{(h_1 + h_2)}{2}(1 + \frac{W}{100}) \frac{\sin\beta_c \cos(\beta_c + \varphi)}{\cos^2\varphi}, \quad (16)$$

The tangent mass is determined by the expression on the fold of the inertia force R_{in2}, which arises from the vibrational motion groove.

$$R_{in2} = \frac{G_c}{g}\omega^2 R_i, \quad (17)$$

in this, the distance from the center rotation of the R_i – ferul to the center gravity tangent mass, m.

We can put the value G_c (3) by expression (1)

$$R_{in2} = \gamma_k D_c n_c L_c \frac{(h_1 + h_2)}{2}(1 + \frac{W}{100})\omega^2 R_i. \quad (18)$$

R_{un1} and let the values R_{iun2} (3) and (18) in terms of expressions (5)

$$R_{inx} = \gamma_k D_c n_c V_m^2 \frac{(h_1 + h_2)}{2}(1 + \frac{W}{100})(\frac{\sin\beta_c \cos(\beta_c + \varphi)}{\cos^2\varphi} + \omega^2 R_i). \quad (19)$$

To determine the total tensile resistance strength feruls (1) the expression R_{sk}, and by putting the values R_{in} (4) and (19) in terms expressions (5) we have the expression on it after some modification

$$R_{cx} = \gamma_k D_c n_c L_c \frac{(h_1 + h_2)}{2}(1 + \frac{W}{100})\{\cos\beta_c(\sin\beta_c + f\cos\beta_c) + \\ + V_m^2(\frac{g\sin\beta_c \cos(\beta_c + \varphi)}{\cos^2\varphi} + \omega^2 R_i)\}. \quad (19)$$

(19) according to the analysis expression, the resistance grooves the potato digger to pull depends on its parameters, the physical-mechanical properties the soil (φ_1, ρ, f, σ_o) and the mode operation. γ_k=1300 kg/m^3, D_c=0.01 m, n_c=15, L_c=0.25 m, h_1=0.65 m ; h_2=0.18 m; W=16%; β=24º, V_M showed 308.7 N when V_m=0.8-1.2 km/h, g=9.8 m/s^2, φ=22º, ω=14 s^{-1}, R_i=0.25 m determined.

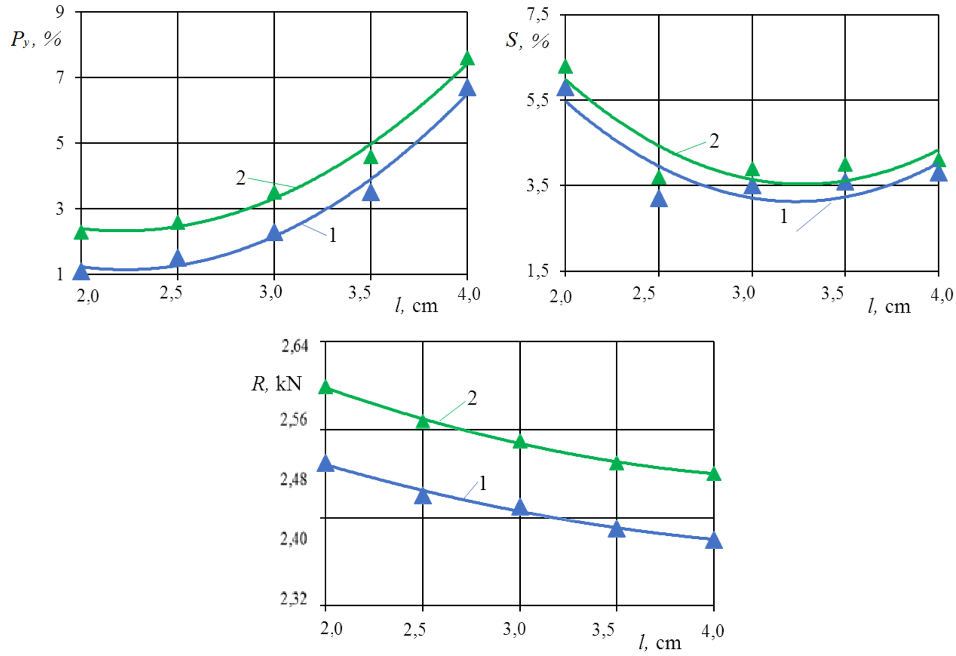
Fig. 2. Lattice ploughshare and honeycomb lattice ploughshare

3. Results and Discussion

Experimental studies have been conducted by varying the distance between ploughshare rivets from 0.02 to 0.04 m with an interval of 0.005 m. In experiments, the coverage width the ploughshare is 550 mm, its deviation slope angle is 220, the length the ploughshare rivets is 25 cm, the angle installation rivets with respect to the average horizon is 24 degrees, the frequency vibration rivets is 58 s^{-1} accepted.
As a criterion for evaluating the performance indicators a potato digger, loss potatoes, damage and resistance the digger to traction were adopted.
From fig.3, it can be seen that as the distance between ploughshare hives increases at speeds of 0.8 and 1.2 m/s, the loss potatoes increased in the case the bottleneck parabola, while the damage decreased first and then remained almost unchanged after the slit increased by 3 cm. The drag resistance the cowler was reduced by the bubble parabola as the slit was enlarged. With a distance up to 3 cm between the hives, the loss of potatoes is less than 3%, and damage is less than 5%. Therefore, we take the distance between the grooves by 3 cm.
In experiments, ploughshare rivets were modified with an interval of 10 cm between 15 cm and 45 cm in length. In this case, the coverage width the ploughshare is 550 mm, its angle inclination is 220, the angle installation the rivets with respect to the average horizon is 24 degrees, the frequency vibration the rivets is 58 s^{-1}.
As a criterion for evaluating the performance indicators a potato digger, loss of potatoes, damage and resistance the digger to traction were adopted.
From fig.4, it can be seen that at speeds 0.8 and 1.2 m/s, the loss potatoes with an increase in ploughshare hiss to 28 cm in length decreased by the law the bottlenose parabola, practically unchanged in values greater than 28 cm in length. The decrease in the loss potatoes with an increase in the length the hives can be explained by the increase in the time it takes for the soil mass to interact with the hives, as a result which the sieving improves. As ploughshare

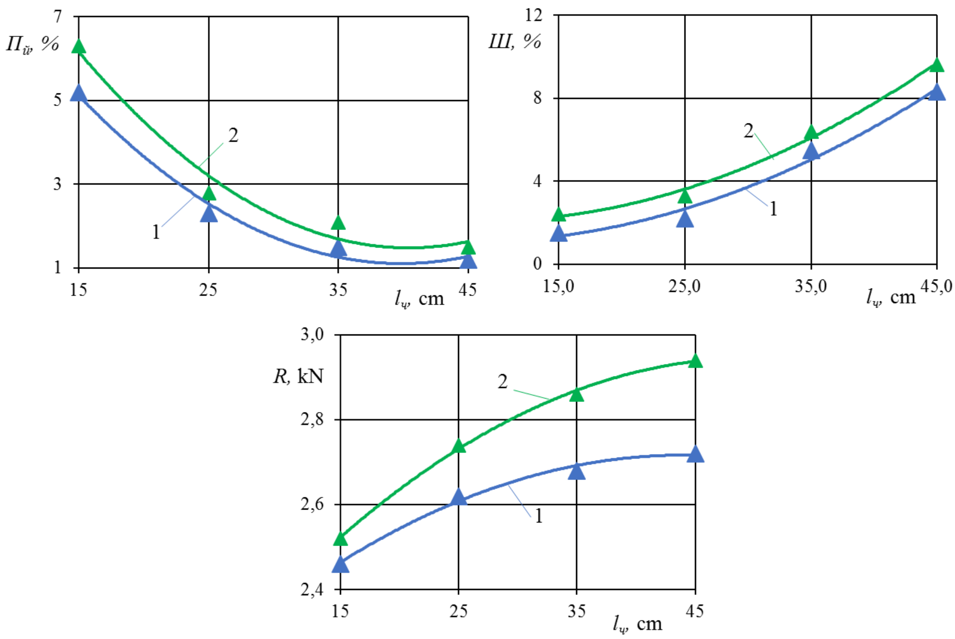
hives increase in length, potato damage has increased under the law the bottlenose parabola. Justifying this, too, by increasing the time it takes for the cockroaches to interact with the hives. This corresponds to the results complete theoretical studies.

At both speeds, the resistance to dragging the cowler increased as the length rivets increased. This can be explained by the increase in the amount energy that is being spent to shift the legume soil mass under the influence rivets.



1 - V=0,8 m/s; 2 - V=1,2 m/s

Fig. 3. Graphs the change in the distance between the rivets loss, damage and drag resistance cartridge

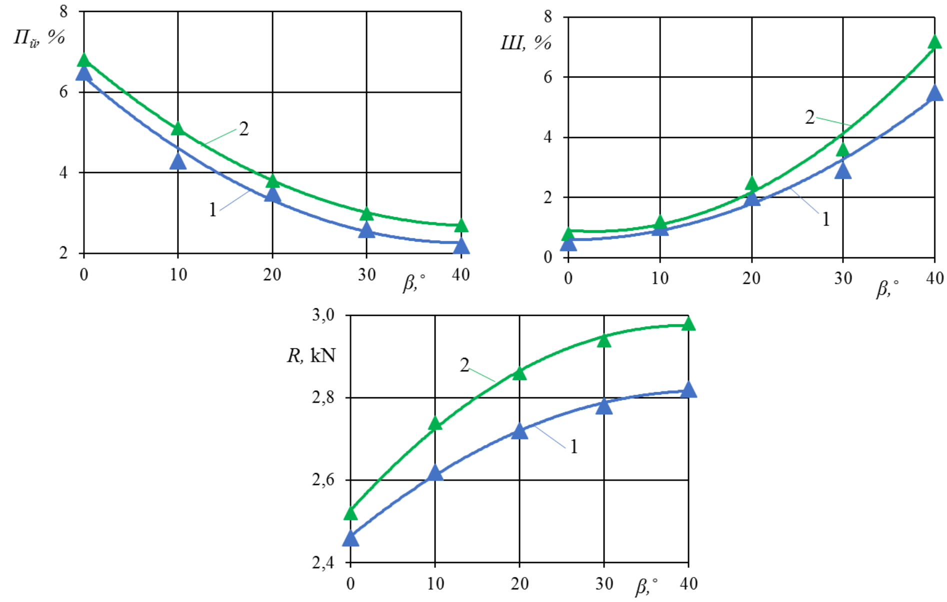


1- V=0,8 m/c; 2 - V=1,2 m/c

Fig. 4. Graphs change that depend on the length the hives, the damage, loss potato and the resistance the holster to pull

In the studies, experiments were carried out with an interval 10^0 from 0 to 40 degrees with an angle setting ploughshare hives to the horizon. In experiments, the coverage width the ploughshare was taken 55 cm, its slope angle was 22^0, the length the rivets was 25 cm.

From figure 4, it can be seen that at speeds 0.8 and 1.2 m/s, the loss potatoes with an angle fixing the grooves to the horizon decreased according to the law the bottleneck parabola, increased damage, and resistance to pulling the bucket increased according to the bubble parabola. At intervals of 200-350 angle of installation rivets to the horizon, the digger meets the agrotechnical requirements for the loss and damage potatoes. Therefore, the vibration the rivets should be in the range of 200 -350.



1- *V*=0,8 m/c; 2 -*V*=1,2 m/c

Fig. 5. Graphs change potato loss, damage and resistance to drag depending on the angle installation the hives with respect to the horizon

4. Conclusion

Analytical dependences and mathematical models are obtained to determine the parameters oscillating rods. It is proved that the length the bars potato digger's ploughshare is 25 cm, the number bars is 14 pieces, the distance between the bars is 3 cm and the diameter bars is 1 cm, the accumulation tuberous mass on the ploughshare is excluded and damage to the tubers is ensured at the required level.

Reference

1. F. Maiviatov, F. Karshiev, Sh. Gapparov, *IOP Conf. Series: Earth and Environmental Science* **868**, 012060 (2021)
2. F. Maiviatov, K. Ravshanov, S. Mamatov, I. Temirov, D. Kuvvatov, A. Abdullayev, *IOP Conf. Series: Earth and Environmental Science* **868**, 012066 (2021)
3. M. Bentini, C. Caprara, R. Martelli, *Biosy. Eng., Postharvest Technology* **94** (1), 75-85 (2006)
4. D. Horton, R.L. Sawyer, Potato *Phys, Acad Press*, Orlando, FL (1985)
5. B. Jia, W. Sun, Z. Zhao, et al., Design and Field Test of a Remotely Controlled Self-propelled Potato Harvester with Manual Sorting Platform, *Am. J. Potato Res*. (2023)
6. S.M. Younis, M.I. Ghonimy, T.H. Mohamed, *Misr J. Ag. Eng.* **23**(2), 292-313 (2006)
7. X. Shengshi, W. Chunguang, D. Weigang, *Engenharia Agricola*. **39**, 548-554 (2019)
8. F. Mamatov, U. Umurzakov, B. Mirzaev, G. Eshchanova, I. Avazov, *E3S Web of Conferences* **264**, 04065 (2021)
9. G.N. Sineokov, I.M. Panov, Theory and calculation of tillage machines, Mashinostroenie, Moscow (1977)
10. B. Tulaganov, B. Mirzaev, F. Mamatov, Sh. Yuldashev, N. Rajabov, R.F. Khudaykulov, *IOP Conf. Series: Earth and Environmental Science* **868**, 012062 (2021)
11. S. Hrushetsky, V. Yaropud, V. Duganets et al., *INMATEH-Agricultural Engineering* **59**, 101-110 (2019)
12. A. Al-Mallahi, T. Kataoka, H. Okamoto et al., *Biosystems Engineering* **105**, 257–265 (2010)
13. Y. Syromyatnikov et al., *Jour of Terramechanics* **98**, 1-6 (2021)
14. Yu. Syromyatnikov, A. Ivanov, M. Kalimullin, S. Lopareva, A. Luchinovich, D. Loparev, *IOP Conference Series: Earth and Environmental Science* **981**, 042031 (2021)
15. Yu.N. Syromyatnikov, S.A. Voinash, A.V. Nanka, *Sc. and innov. vectors of devel.* **70**, 3 (2018)

16. Q. Su, K. Naoshi, L. Minzan et al., *Computers and Electronics in Agriculture* **152**, 261-268 (2018)
17. T.T. Kusov, *Tractors and Agricultural Machines* **4**, 18 (1992)
18. V.I. Gimmel'farb, Study of vibrating working bodies of machines for harvesting potatoes and root crops in the conditions of the North-West of Russia, Leningrad-Pushkino (1964)