ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 9, Issue 4 , April 2022

Potato harvester with combined working tools

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ABSTRACT: Undercutting working bodies of modern potato harvesters when working on loamy soils with low moisture do not meet the agro technical requirements. Modern machines must perform undercutting, lifting and moving the layer of the potato bed to the separating bodies without huddling and collapse with the least energy consumption, losses and damage to tubers. The authors propose a combined undercutting working body with passive plowshares and active augers. The aim of the research is to substantiate the working mode of the auger of a potato harvester. The basic principles and methods of classical mechanics, mathematical analysis and statistics were used in this study. Experimental researches show, that rational parameters of the combined swept working body providing increase of productivity and improvement of quality at the minimum power inputs are: auger diameter 0.3 m, auger step over a blade 0.20-0.25 m and in a zone of transition of mass from a blade on elevator and over elevator 0.15 m, frequency of rotation of augers 2.0-3.0 s^{-1} at speed of unit 0.4-1.0 m/s.

KEY WORDS: soil, potatoes, potato harvester, ploughshare, auger, comb

I. INTRODUCTION

With the development of agriculture in the world there is an urgent need to improve production efficiency through extensive mechanization of cultivation and harvesting of crops. Potato is one of the most important food and industrial crops in Uzbekistan. Being a large and profitable branch of agricultural production, potato growing remains insufficiently mechanized in the country. One of the unresolved problems is the lack of harvesting machines that meet the agro technical requirements for undercutting tubers [1]. Agro technique requires that undercutting, lifting and moving the layer of potato beds to the separating bodies were made without huddling and disintegration. At the same time to prevent loss and damage of tubers with minimal soil withdrawal from the bed, and to have a stable stroke of undercutting bodies at any given depth of potato digging. The uniformity of supply of the swept mass on separating devices without dumping is also important. Therefore, the problem of search, research and improvement of sub-digging working bodies, justification of their rational design and optimum parameters, providing the above mentioned requirement, is very actual [2].

II. SIGNIFICANCE OF THE SYSTEM

The article presents the results of research on the development of a potato harvester with combined working tools. The study of literature survey is presented in section III, methodology is explained in section IV, section V covers the experimental results of the study, and section VI discusses the future study and conclusion.

III. LITERATURE SURVEY

R.Norchaev [1], D.Norchev [2] studied the creation and application of potato harvesters with active and passive working tools, the study of their performance and justification of parameters. The study of processes of interaction of soil with working tools were studied by F.M.Mamatov [3-15], D.Chuyanov [6], S.Toshtemirov [7, 13], I.Avazov [10, 11], H.Faizullaev [14] and others.
The purpose of the study is to justify the parameters of the auger of the potato harvester.

IV. METHODOLOGY

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

V. EXPERIMENTAL RESULTS

Designed by us potato harvester consists of a blade 1 and 2, on the outer edges of which the transport elements made in the form of counter rotating augers 3 and 4 are installed, on the axis of symmetry between the row is placed intermediate blade 5 above which the separator 6 is set in the form of a lancet foot. Separating elevator 7 is installed behind plowshares 1 and 2 (Fig. 1).

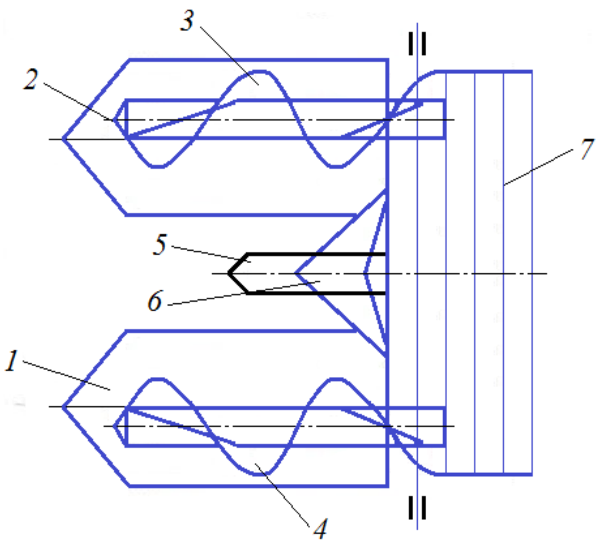

Fig.1. Technological scheme of experimental potato harvester:
1, 2 – ploughshares; 3, 4 – augers with left and right coils; 5 – intermediate ploughshare; 6 – mass separator; 7 – elevator

During the operation of the potato plough, the tuber mass, undermined by ploughshares 1 and 2, is transferred between the coils of augers 3 and 4. At the same time plant residues slip between the lumen of blades 3, 4 and 5. Intermediate ploughshare 5 is made shortened and because of this ploughshare is not digging the hard zone between the row, thereby reducing the flow of soil to subsequent working bodies. Further tuberous mass as a result of the interaction with a separator 6, moves in the direction of the augers 3 and 4, and thus eliminates dumping of the soil between the coils of augers 3 and 4. In addition, after directing the tuber layer in the direction of augers 3 and 4 soil mass is again broken, broken links with tubers, and the mass of the soil in a uniform layer moves to the separating body 7.

In order to substantiate the basic parameters and operating mode of auger combined subsoiling working body we conducted experimental studies [4-6].

The results of the study show that with increasing auger diameter, tuber loss decreases intensively in the beginning (Fig.2). With an increase in auger diameter of more than 0.3 m, tuber loss decreases slightly. The minimum loss of tubers are observed at the speed of the machine V=0.4-0.5 m / s and the frequency of rotation of augers n = 2.5c-1. At this operating mode of a working device and at diameter of screws D=0.25-0.35 m, losses of tubers make less than 3 %. The process of transportation of tuber layer occurs without bunching. Experiments show that the increase in diameter of augers increases the axial velocity of the transported mass and their productivity. In all operating modes, augers with a diameter of 0.3m ensure minimal tuber losses [7, 8].

At travel speeds of 0.85 and 1.0 m/s the tuber losses are 4.7% and 5.0% respectively. Due to the reduction of auger productivity, the working process proceeds with significant huddling of tuber mass in front of the ploughshare. This is explained by the fact that at high speeds of the unit movement, the auger does not have time to transport the tuber coarse tuber mass to the elevator. In this case, the tuber layer overflows through the auger shaft on the sides of the ploughshare, as a result of which tuber losses increase. At a speed of the unit 0.4-0.5 m / s and the frequency of rotation of augers 2.5 c^{-1}, in the process of moving the tuberous mass by augers with a diameter of 0.25 m is 2.0-2.5%. In this mode of operation the minimum losses of tubers were obtained during the work of the working body with auger diameter 0.3 m and amounts to 1.0-2.0%.

Experiments show that with increasing auger diameter, all the mass above the ploughshare was transported without unloading [9].

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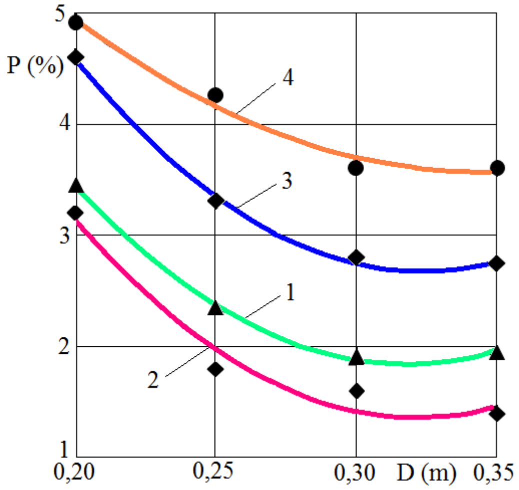

Fig. 2. Dependence of tuber losses on auger diameter at auger speed n=2.5c^{-1}

Figure 3 shows the effect of auger pitch to diameter ratio on tuber damage. The results of the study show that as the ratio of auger pitch to its diameter *S*/*D* increases, i.e., as the diameter of the augers decreases, the damage to tubers increases. The maximum damage to tubers is observed at the value of *S*/*D*=1.3. At a screw speed of 3.2 s^{-1} and a unit speed of 0.4-0.5 m / s, damage to tubers is about 5%. In this case, auger pitch *S*=0.25 m, and diameter *D*=0.2 - 0.3 m.

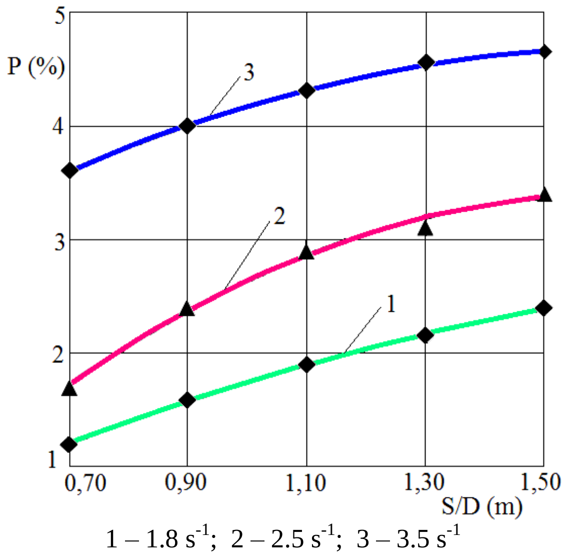

Fig. 3. Dependence of tuber damage on the change in the ratio of auger pitch to its diameter at different auger speeds: *V*=0.45m/s

The increase in damageability of tubers is explained by the fact that at *S*/*D*=1.25-1.3 and more the augers do not have time to transport the tuber mass over the ploughshare, as a result of which its huddling is observed. In this case, augers transport only the top layer of tuber coarse material, and the tubers are damaged by the outer edges of the screw augers. Experiments show that the maximum productivity of screws is observed at values *S*/*D* = 0.8-1.0. Reducing the *S*/*D* value by increasing the diameter of screws, contributes to increasing their productivity.

Minimum damage of tubers are observed at values *S*/*D*=0.70-0.90, speed of unit movement 0.4-0.5 m/s, frequency of auger rotation 1.8-2.5 s^{-1}. Damage of tubers in these modes of operation is respectively 1.1 and 1.5 %. In this mode, the process of transporting the tuber layer occurs without huddling. In the case when the tuber-bearing mass is transported without unloading the tubers have a shorter time of contact with the screw blades, therefore, less damage.

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International Journal of Advanced Research in Science, Engineering and Technology
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Consequently, the best performance of the combined pod-digging tool obtained with a diameter of augers 0.3 m, the ratio of pitch to diameter of 0.8-1.0 and frequency of rotation of augers 1.8-2.5 s^{-1}.

VI. CONCLUSION AND FUTURE WORK

1. Experimental studies have established that the rational parameters of the combined swathing tool, providing increased productivity and improved quality with minimal energy costs are auger diameter 0.3 m;
2. It is established that a screw pitch above the ploughshare is 0.20-0.25 m and in a zone of mass transition from ploughshare to elevator and above elevator is 0.15 m, frequency of screw rotation is 2.0-3.0 s^{-1} at speed of unit movement 0.4-1.0 m/s.

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