UDC 631.316.022

RESULTS OF THEORETICAL RESEARCH ON THE CHISEL-TYPE WORKING BODY OF A UNIVERSAL IMPLEMENT.

Jurayev Fazliddin Urinovich
Doctor of Technical Sciences, Professor, Department of
"Agricultural and Water Management Machinery and Technologies,"
Bukhara State Technical University.
E-mail: fjuraev66@mail.ru
Saidova Guljamol Komilovna
Doctoral Student, Bukhara State Technical University.
E-mail: guljamolsaidova30@gmail.com

Abstract. The article presents the results of theoretical research on the parameters of the loosener blade and the wing angles of the chisel-shaped blade of a universal tillage device. It was determined that the width of the loosener (spike-type) blade ensures complete loosening of the treated soil layer without forming compacted walls at its bottom. The curvature radius of the loosener blade and the opening angle of the chisel-shaped blade wings prevent soil adhesion to the working surfaces and reduce the formation of soil heaps in front of the blade. The working width of the chisel-shaped blade was substantiated based on the condition that the soil, under the influence of its wings, is directed toward the side-loosened zones formed by the loosener wings and fragmented along horizontal planes with minimal energy consumption.

Keywords: universal device, energy consumption, loosener blade, chisel-shaped blade, wing loosening angles, spike-type blade, penetration depth, curvature radius.

Introduction. In recent years, significant attention has been paid worldwide to the development of energy- and resource-efficient technologies in agriculture. In leading and technologically advanced countries, extensive scientific research is being carried out to create modern agricultural machines and implements that ensure efficient soil cultivation while reducing energy consumption and preserving soil fertility. One of the important directions in this field is the improvement of technologies and technical means used for inter-row cultivation in orchards. The development of universal agricultural implements capable of performing several technological operations simultaneously is considered a promising approach to increasing the efficiency of soil cultivation processes.

Inter-row tillage in orchards plays a crucial role in maintaining favorable soil conditions for plant growth, improving soil aeration, controlling weeds, and ensuring effective moisture retention. However, in traditional tillage systems, soil cultivation is usually performed through a sequence of separate agrotechnical operations. Typically, fields are ploughed during the autumn period, and before sowing, additional operations such as crushing soil clods, leveling the soil surface, harrowing, and ridge formation are carried out when necessary. Each of these operations requires the use of separate agricultural machines and implements.

The use of multiple machines for performing individual agrotechnical operations leads to an increase in the number of passes of tractors and implements across the field. As a result, fuel consumption, labor costs, and overall energy expenditures increase significantly. In addition, repeated mechanical impacts on the soil negatively affect its physical and mechanical properties. Excessive soil disturbance may cause the destruction of soil aggregates, deterioration of soil structure, compaction of the lower soil layers, and disruption of the soil water-air regime. These factors ultimately lead to a decrease in soil fertility and negatively affect crop productivity

Furthermore, the necessity of using separate machinery for each agrotechnical operation increases operational costs for farmers. The purchase, maintenance, and operation of multiple agricultural machines require additional financial resources, which significantly raises the overall cost of agricultural production. Therefore, reducing the number of technological operations and minimizing the mechanical impact on soil have become important objectives in modern agricultural engineering.

One of the most effective ways to address these challenges is the development of combined or universal soil-tillage implements capable of performing several operations in a single pass. The use of such implements makes it possible to reduce fuel consumption, decrease labor requirements, lower operating costs, and improve the overall efficiency of soil cultivation processes. At the same time, minimizing the number of machine passes across the field helps preserve soil structure and maintain its favorable physical properties.

In this regard, the development of a universal implement for inter-row tillage in orchards, as well as the theoretical substantiation of its technological process and the optimal parameters of its working bodies, is an important scientific and practical task. The creation of such an implement will make it possible to ensure high-quality soil loosening, improve the efficiency of soil cultivation, reduce energy consumption, and enhance the overall productivity of orchard management systems. To overcome these problems, in the conditions of our republic, no sufficient scientific research has been carried out to develop universal implements for inter-row tillage in orchards, substantiate their parameters and operating regimes. Therefore, the development of a technology that ensures high-quality inter-row tillage, reduces mechanical impacts on the soil during sowing to preserve its structure, and saves additional costs, as well as the creation of an energy- and resource-saving implement and the theoretical substantiation of its parameters, is an important task [1–3].

Discussion. The crumbling angles of the ripper share and the wings of the chisel-type blade of the implement are determined based on the condition of effective soil crumbling with minimal energy consumption [4; pp. 78–79]:

$$\alpha_{yu} = \alpha_{o'} = \arcsin\Big\{\Big\{-\sin\left(\varphi_1 + \varphi_2\right)$$

$$+\sqrt{\sin^2\left(\varphi_1 + \varphi_2\right) + \left[2 + \frac{1}{2}\cos\left(\varphi_1 + \varphi_2\right)\right]\cdot\left[1 + \cos\left(\varphi_1 + \varphi_2\right)\right]}\Big\}:$$

$$:\left[2 + \frac{1}{2}\cos\left(\varphi_1 + \varphi_2\right)\right]\Big\}, \qquad (1)$$

where , φ_1, φ_2 – are the internal and external friction angles of the soil, respectively ^{o}

.

According to the data given in the literature, φ_1 = 25°–30° and φ_2 = 40°–45° re accepted [5; p. 16; 6; pp. 14–18], and based on expression (1), it is determined that the crumbling angles of the ripper share and the wings of the chisel-type blade should be in the range of 15.9°–25.3°. The width of the ripper (tine) share of the implement is determined using the following expression, based on the condition that the soil layer being tilled is completely loosened, i.e., no compacted layer forms at its bottom [7; p. 50]:

$$b_{yu} = \frac{\left(m + ctg\alpha_{yu}\right)h}{\left[\dfrac{T_e}{10\cdot K_c}\left(1 + 3tg\psi\right) - k\right]}, \qquad (2)$$

or considering ψ = 90° – (αyu + φ1) [8; p. 62]:

$$b_{yu} \geq \frac{\left(m + ctg\alpha_{yu}\right)h}{\left[\frac{T_e}{10 \cdot K_c}\left(1 + 3ctg\left(\alpha_{yu} + \varphi_1\right)\right) - k\right]}, \quad (3)$$

where: *m, k* – dimensionless coefficients depending on the physical-mechanical properties of the soil;

h – penetration depth of the ripper share into the soil, m; T_e – specific resistance of soil compaction (in horizontal direction), Pa; K_c – specific resistance of soil shear, Pa.

Taking $m = 4.2$, $k = 2.5$, $T_e = 1.4 \cdot 10^6$ Pa, $K_c = 2 \cdot 10$^4 Pa [9; p. 28], and h = 0.15 m, and substituting the above-mentioned values of αyu and φ1 into expression (3), it is determined that the width of the ripper share must be at least 4.6 cm.

The curvature radius of the ripper (tine) share is determined using the scheme shown in Figure 1. Accordingly:

$$R_{yu} = \frac{h}{\cos\alpha_b - \cos\alpha_0}, \quad (4)$$

where α_b, *α0* – initial and final soil entry angles of the ripper share, respectively, °.

Taking $\alpha_b = \alpha_{yu} = 30°$ and α0 = 90° [9; p. 140] and substituting the above value of h, it is determined that the curvature radius of the ripper share should be 17.3 cm.

The opening angle of the wings of the chisel-type blade of the implement is determined from the condition that soil should not stick to its working surfaces and should not accumulate excessively in front of it [10; p. 79]:

$$2\gamma_{o'} = 90° - \varphi_1 \quad (5)$$

Substituting the values of φ_1 mentioned above into this expression, it is determined that the opening angle of the wings of the chisel-type blade should be in the range of 60°–65°.

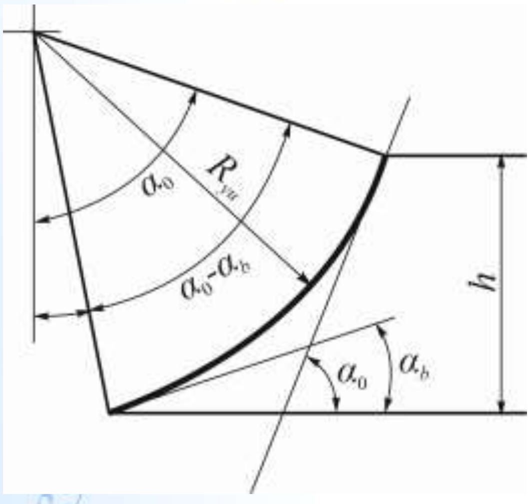

Figure 1. Scheme for determining the curvature radius of the ripper (tine) share of the implement.

The working width of the chisel-type blade of the implement is determined based on the condition of soil fragmentation along horizontal planes directed to the lateral loosened zones formed by the ripper wings [7; p. 71]:

$$b_{o'} \leq \frac{2h\cos\left(\gamma_{o'}+\varphi_1\right)}{\cos\varphi_1\ \cos\frac{1}{2}\alpha_{o'}} \qquad (6)$$

Substituting the values of h, $\gamma_{o'}$, $\alpha_{o'}$ and φ_1 obtained above into this expression, it is determined that the maximum working width of the chisel-type blade should be 27 cm.

Conclusion. The theoretical research presented in this study has allowed the substantiation of the key parameters of a universal implement designed for inter-row tillage in orchards. The analysis showed that the crumbling angles of the loosener (ripper) share should be within the range of 15.9°–25.3° to ensure effective soil fragmentation while minimizing energy consumption. The width of the loosener share must be at least 4.6 cm to guarantee complete soil loosening without forming compacted layers at the bottom. Additionally, the curvature radius of the loosener blade should be 17.3 cm, which optimizes soil penetration and prevents excessive soil adhesion.

The opening angle of the wings of the chisel-shaped blade should range from 60° to 65°, and the working width should not exceed 27 cm. The spatial arrangement of the implements—transverse distance up to 25.6 cm and longitudinal distance at least 52 cm—ensures uniform soil processing and high-quality inter-row cultivation. Equipping the implement with 11 working tools provides reliable execution of the technological process while maintaining energy efficiency and preserving soil structure.

References

1. Saidova G.K. *The effect of the parameters of the universal bed former on its performance indicators.* Agricultural Engineering Solutions, 2025, 3(11).
2. Jo‘rayev F.O‘., Saidova G.K. *“Research objectives, tasks, and preliminary experimental results of the universal implement for inter-row cultivation in orchards.”* International Scientific and Technical Conference on “Topical Issues of Agroecosystem Sustainability in the Efficient Use of Natural Resources,” TIIAME National Research University, Bukhara Institute of Natural Resources Management. Published in *Water and Land Resources* Journal, No. 4, 2024, p. 60.
3. Саидова Г. Предварительное результаты эксперименталных исследований универсального устройство для обработки между садовыми рядами, цель и задачи исследования” Международный современный. Научно практический журнал научный импульс. 28 Декабря, 2024. 405 с.
4. Toshpo‘latov B.U. *Improvement of the technological working process of the chisel-cultivator and substantiation of its parameters. Dissertation for the degree* of PhD. – Tashkent, 2020. – 127 p.
5. Соколов В.Н. Исследование параметров орудия для предпосевного уплотнения и выравнивания почвы в хлопководстве: Дис. ... канд. техн. наук. – Янгиюл, 1974. – 150 с.
6. Калимбетов М.П. Совершенствование технологического процесса работы и обоснование параметров малы-выравнивателя: Дис. … канд. техн. наук. – Янгиюл, 2007. – 130 б.
7. Тухтакузиев А. Механико-технологические основы повышения эффективности почвообрабатывающих машин хлоководческого комплекса: Дисс. ...док.тех.наук. – Янгиюл, 1998. – С. 336.
8. Чирцов С.П. Исследование и обоснование параметров рабочих органов для сева хлопчатника с нагартыванием гребней: Автореф.дисс … канд.техн.наук.– Янгиюл, 1978. - 18 с.
9. Нартов П.С Дисковые почвообрабатывающие орудия. –Воронеж: Воронецкий ун-

т. 1972. –С. 182.

10. Abdimominov I.I. *Selection of the type and substantiation of parameters of loosening tools used in pre-sowing tillage by combined machines.* Dissertation for the degree of PhD. – Gulbahar, 2022. – 156 p.