RESULTS OF RESEARCH ON THE DYNAMICS OF WEAR OF THE EXPERIMENTAL COPY OF THE CULTIVATOR'S WORKING BODIES

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ABSTRACT

In this research, the wear dynamics of the experimental working body named "Soil-Tillage Composite Working Organ," patented as utility model No. FAP 02305 by the Ministry of Justice of the Republic of Uzbekistan, were investigated under field conditions. The experimental design aimed to compare the wear resistance of the new composite working organ with the conventional arrow-shaped tines used in KXU-4M cultivator units. Field tests were conducted in the Jizzakh region on cotton inter-row cultivation areas, and measurements were systematically recorded during soil treatment processes covering up to 76.5 hectares. The geometric wear parameters, including coverage width, blade thickness, and sharpening angle, were analyzed. Statistical analysis of the results showed that the newly designed working organ exhibited durability 1.8–2.0 times greater than that of the conventional arrow-shaped tine. The proposed design eliminates the main shortcomings of traditional tines by using double parallelogram-shaped modules that can be rotated and reused, ensuring longer operational life and stable agro-technical performance.

KEYWORDS

Soil-tillage composite working organ; cultivator; abrasive wear; KXU-4M; durability; experimental tine; parallelogram module; wear resistance; field testing; agricultural machinery efficiency.

1. INTRODUCTION

Enhancing soil tillage technologies in agriculture plays a crucial role in preserving soil fertility, minimizing energy use, and improving the operational reliability of farming machinery. Specifically, the durability and wear resistance of arrow-shaped tines in KXU-4M cultivator units—commonly utilized for inter-row cultivation of cotton—directly influence both the performance efficiency and lifespan of the equipment. The main drawback of conventional tines lies in the rapid wear of the nose part, which results in the premature failure of the wings, making the entire component unusable before its full potential is utilized. To overcome this limitation, a new design called the "Soil-Tillage Composite Working Organ" was developed and patented as a utility model (Patent No. FAP 02305, June 27, 2023, Ministry of Justice of the Republic of Uzbekistan). This innovative design incorporates double parallelogram-shaped modules that can be rotated and reused, allowing both cutting edges to be utilized sequentially. This configuration not only minimizes material waste but also greatly enhances the wear resistance and overall service life of the implement. The primary goal of the present study is to examine the wear behavior of the newly developed composite working organ under actual field conditions and to compare its performance with that of conventional arrow-shaped tines. Field tests were conducted in the "Yorqin Said Khojakbar" farm located in the Zafarobod district of the Jizzakh region. During the tests, data on coverage width, blade thickness, and sharpening angle were systematically recorded and analyzed statistically. The results demonstrated that the new composite working organ exhibits 1.8–2.0 times higher wear resistance compared to conventional

DOI:10.5121/acij.2025.16601

tines. Hence, the proposed “Soil-Tillage Composite Working Organ” can be regarded as an effective technical innovation aimed at prolonging the service life and enhancing the operational efficiency of agricultural cultivator systems.

2. MATERIALS AND METHODS

The Ministry of Justice of the Republic of Uzbekistan granted a utility model patent No. FAP 02305 on June 27, 2023, for the experimental blade intended to replace the existing arrow-shaped blades used in KXU-4M units for inter-row cultivation of cotton in the country. The aforementioned “Collective Working Body for Tillage” was produced by “BMKB-Agromash” JSC and subsequently underwent field testing.

The primary purpose of the field tests is to evaluate the wear resistance of the “Soil-Tillage Working Body” under real field conditions and to assess the reliability of the KXU-4M cultivator unit by enhancing the wear resistance of its arrow-shaped tines. Since today the "Chirchikkhishlok-khozhalimash" plant of our Republic produces 65G steel, the "Soil-tillage working body" was also made of 65G steel.

Field tests were conducted at the “Yorqin Said Khojakbar” farm in Zafarabad district of Jizzakh region to study the dynamics of abrasive wear of experimental cultivator tines. Before starting the field tests, the new structured arrow-shaped tines were drawn in a horizontal plane with a red pencil on an A3 hard drawing sheet. During the field tests, the structured arrow-shaped tines were measured when they were cultivated on areas of 1) 8.5 ha 2) 19 (27.5) ha 3) 8 (35.5) ha 4) 14 (49.5) ha 5) 17 (66.5) ha 6) 10 (76.5) ha. In the methodology developed for studying the wear dynamics of the “Composite Working Body of the Soil Cultivator”, micrometric measurements were scheduled to be taken after every 10 hectares of operation, with an allowable deviation of 2–8 hectares from this planned interval. When we conducted field tests, due to the remoteness of the experimental area from our workplace, 2 micrometers were obtained when processing 19 hectares of land, which differs from the value specified in the methodology by 1 hectare.

In the field tests, three of the current arrow-shaped paws and two of the "Soil Cultivator Assembly Working Body" were installed in one unit and were carried out between the cotton rows during the 2nd and 3rd cultivation periods of summer cultivation in July and August. The physical and mechanical properties of the soil in the area where the field tests were conducted are presented in Table 1. The results obtained in the field tests were processed, analyzed and statistically processed in the Excel program.

The dynamics of their wear during the cultivation of 76.5 hectares of land was studied according to the parameters of the "Combined Soil Cultivator Working Body" shown in Figure 1.

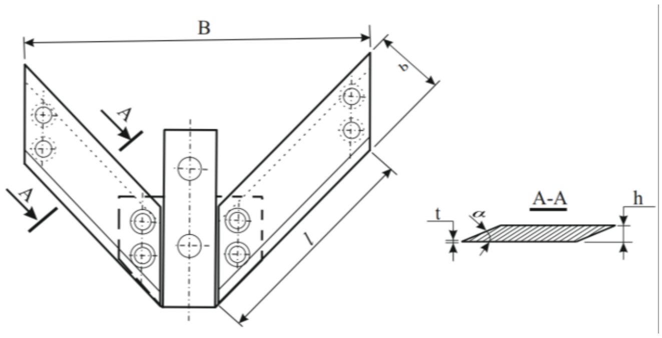
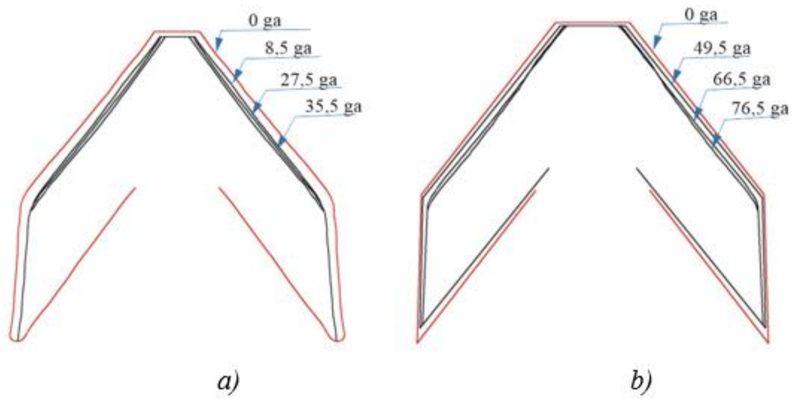


Figure 1. Controlled parameters of a structured arcuate lattice

When comparing the consumption of the " compound tillage working body", we can see the following results.

First, the dynamics of wear was drawn on A-3 hard paper. The profile change of the working body during operation was drawn on A-3 hard paper at each measurement. We can see that in Figure 2. the profiles of the experimental working body in the treated areas corresponding to wear are shown, the red line is the new state before treatment.



a) initial state; b) subsequent transformed state.

Figure 2. During operation of the combined working body eaten contours

In the practically used arrow-shaped claw, the main parameters were the length of the beak and the width of the wing, and the beak was worn out after 30 mm of wear, and the width of the wing was worn out after 15 mm of wear. In the "combined working body for tillage", instead of such a beak, that is, on the bracket, a softening claw of the CHKU-4A cultivator, as shown in Figure 3., is installed. This softening claw has 2 beaks, and each of them is allowed to wear out up to 30 mm.

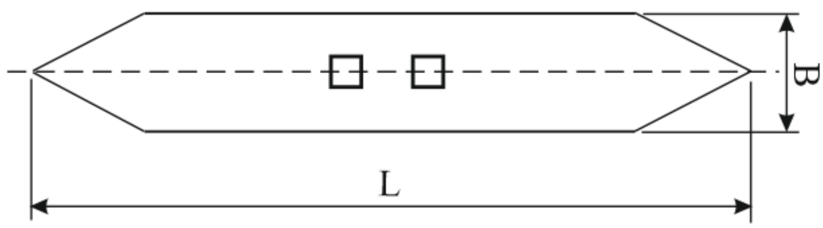


Figure 3. The softening blade of the CHKU-4A cultivator

soil tillage implement " before and after working on an area of 7 6.5 ha is shown in Fig. 4- a and b -Figures are shown in [12].

Figure 4. Assembly worker a) new condition of the organ ; b) condition after processing 7 6.5 ha of land

In a composite working body, almost all parameters can be taken as basic parameters. The graph of the distribution of the coverage widths is shown in Figure 5 and the distribution intensity is shown in Figure 6:

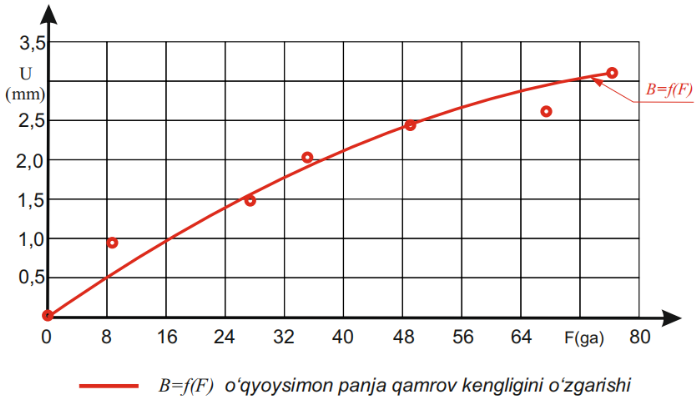


Figure 5. Dynamics of wear of the coverage width of the folding working body

1) The width of the range change as a result of eating

$$U = -7{,}1F^2 + 62{,}8F + 47{,}23, \qquad (1)$$

when processing an area of 76.5 ha , which is a very good indicator, that is, such a reduction in the coverage width is at the level of agrotechnical requirements. The empirical formula for the dynamics of the coverage width reduction is given below Figure 2.

As can be seen from Figure 3., the erosion intensity across the coverage area varies from 0.05 mm/ha to 0.25 mm/ha when processing an area of 76.6 ha, which is a very good indicator.

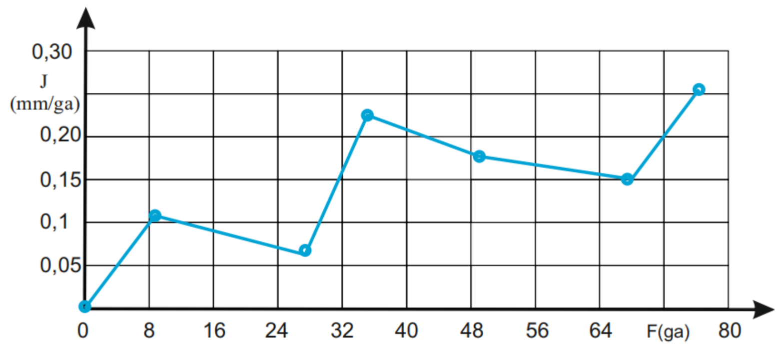


Figure 6. The wear rate of the coverage width of the composite working body

Data representing the thickness changes at the end of the sharpening angle of the blades of the composite working body are shown in Figure 4.16. Composite working body In the study of the thickness of the blade blades at the end of the sharpening chamfer, micrometer measurements were taken from three parts of the parallelogram-shaped module, its middle part and tail parts. Since there were two parallelogram-shaped modules and their positions were changed after processing an area of 35.5 ha, the arithmetic mean of the measurements taken from 12 places was taken.

The thickness of the "soil-cultivating composite working body" was initially 6 mm, but during the cultivation of 8.5 hectares of land, the thickness of the nose decreased by an average of 0.55 mm.

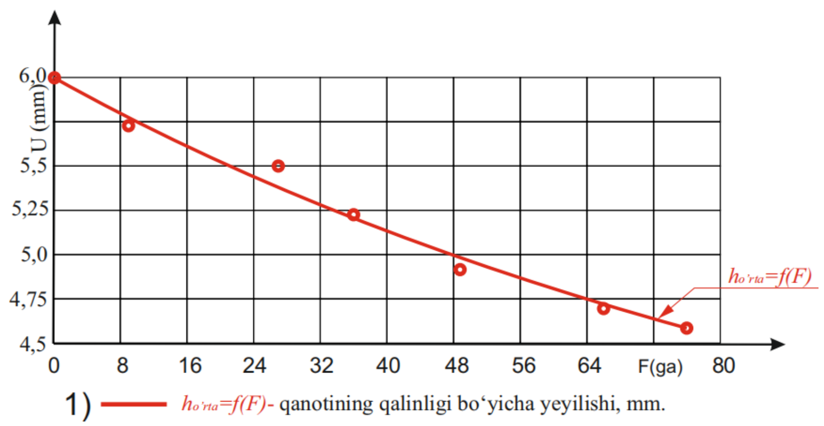


Figure 7. Dynamics of wear of the coverage width of the working body of the aggregate

1) Assembled working body Eating according to the thickness of the wing

$$U = 242{,}85 F^2 - 2967{,}8 F - 9062{,}78, \qquad (2)$$

Later, after processing an area of 76.5 hectares, the thickness of the blades of the working body of the combine at the end of the sharpening angle was 1.4 mm.

New assembly working body The thickness of the blade edge at the end of the cutting edge was 6 mm, the same as the thickness of the 65G steel sheet. The thickness of the blade edge at the end of the cutting edge decreased from 6 mm to 4.6 mm during the processing of 76.5 hectares.

Figure 8. shows the assembled working body The wear rate of the wing blades at the end of the sharpening chamfer increased to a maximum of 0.67 mm/ha during the processing from 0 to 12 ha, and then decreased to 0.27 mm/ha during the processing from 12 to 27.5 ha. The reason for the sharp change in wear rate from 0 to 12 ha is that four arrow-shaped pawls (except for the one between the rear wheels out of a total of 5 arrow-shaped pawls in the unit) were rotated clockwise around the unit and exchanged their positions every time the measurement was taken, so the wear rate was higher on the pawls that fell into the large wheel tracks. Due to this, the wear rate increased to a maximum of 0.67 mm/ha during the processing, After the blades of the parallelogram-shaped modules were adjusted, that is, from 48 ha to 76.5 ha, the intensity of the plowing did not change much.

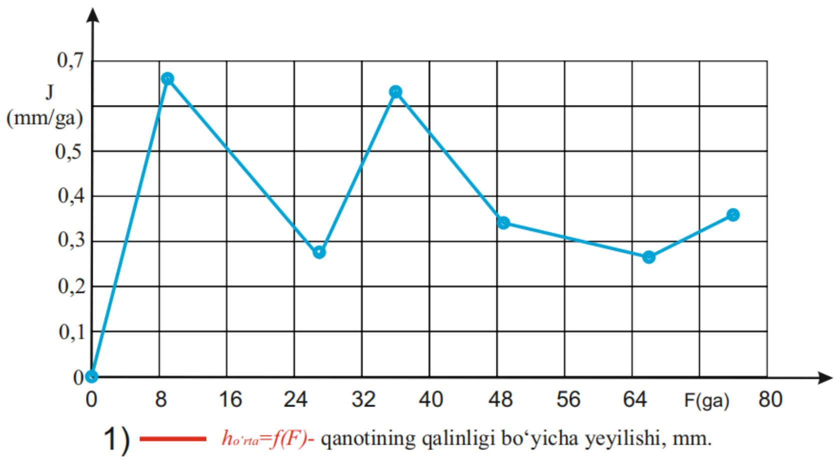


Figure 8. Assembled working body Wear rate of wing blades according to their thickness at the end of the sharpening face

That the sharpening angles of the blades of the parallelogram-shaped modules of the combined working body, at the beginning of the work, were 23°16 / and during the processing of an area of 76.5 hectares, they sometimes varied between 21°54 / due to self-sharpening.

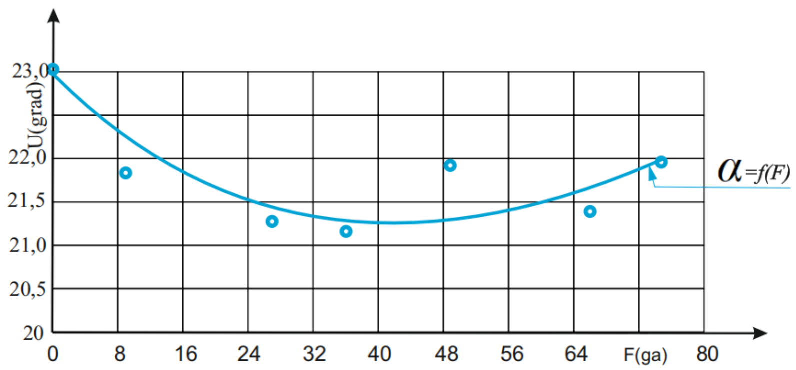


Figure 9. Dynamics of the non-transition of the sharpening angle of the blade of the working body of the aggregate

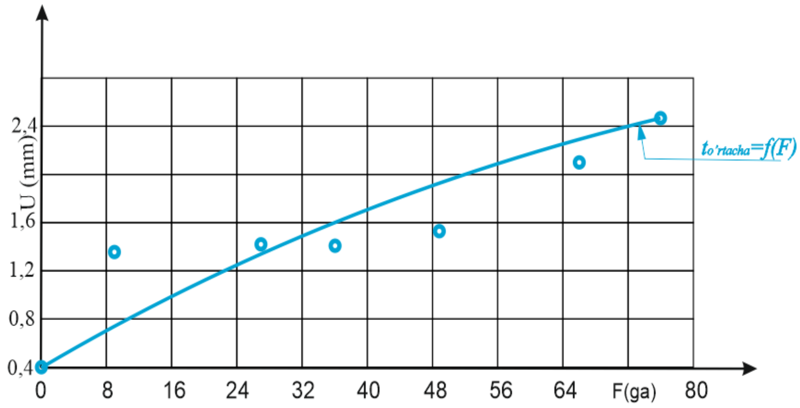


Figure 10. Wear dynamics of the blades of the assembled working body modules according to the thickness

The thickness of the blades of the parallelogram-shaped modules of the assembled working body, at the time of the start of work, is 1 mm. and during the cultivation of 76.5 hectares, it sometimes thickened up to 2.1 mm due to self-sharpening, as shown in Figure 10.

The conducted research revealed that the shortcomings of the existing arrow-shaped paws were almost eliminated in the utility model called "Soil-tillage-type working body". That is, the existing arrow-shaped paws were not exhausted on their two wings, but were rendered unusable due to the exhaustion of the nose part in the "Soil-tillage-type working body". As a technical solution to this problem, the blades of two parallelogram-shaped modules were used to rotate and the reserve was solved in a remarkable way due to the surfaces. The research revealed that it has a resource of 1.8-2.0 times more than the existing arrow-shaped paws

3. Conclusions

The conducted field and analytical studies have shown that the newly developed "Soil-Tillage Composite Working Organ" demonstrates significantly improved wear resistance and operational efficiency compared to conventional arrow-shaped tines used in KXU-4M cultivator units.

1. Field experiments covering 76.5 hectares revealed that the linear wear of the working organ's coverage width did not exceed 3.2 mm, remaining within acceptable agro-technical standards.
2. The thickness of the blade edges decreased from 6.0 mm to 4.6 mm after extensive operation, while the sharpening angle varied only slightly within the range of 21°–23°, indicating stable self-sharpening properties.
3. The wear intensity decreased progressively after 12 hectares of field work, showing that the parallelogram-shaped modules adapt to soil contact conditions and ensure uniform abrasion.
4. The design solution — implementing two interchangeable parallelogram modules — successfully eliminates the main drawback of standard tines, allowing both cutting edges to be utilized sequentially.
5. Comparative analysis showed that the new working organ has 1.8–2.0 times longer service life and higher reliability than the conventional arrow-shaped tine.

Overall, the "Soil-Tillage Composite Working Organ" can be recommended for large-scale application in soil-tillage machinery to enhance operational durability, reduce replacement frequency, and improve the energy efficiency of agricultural cultivation processes.

ACKNOWLEDGEMENTS

The authors would like to extend their heartfelt appreciation to the administration and research team of the Jizzakh Polytechnic Institute for their continuous support and valuable guidance throughout the experimental and analytical phases of this study. Special thanks are extended to the "Yorqin Said Khojakbar" farming enterprise in the Zafarobod district of Jizzakh region for providing field conditions and technical assistance in conducting the soil-tillage experiments.

The authors also acknowledge the contribution of the "BMKB-Agromash" Joint Stock Company for manufacturing the prototype of the "Soil-Tillage Composite Working Organ" and ensuring its readiness for field testing.

This work was carried out as part of the applied research on improving the wear resistance and operational reliability of soil-tillage machinery in the agricultural sector of the Republic of Uzbekistan.

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