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The Results of Determining of Working Depth Stability of the Universal Working Body and Width of Lateral Spread of Soil

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ABSTRACT: The article presents the results of determining of working depth stability of universal working body and width of the lateral spread of soil high-quality and energy-efficient cultivator universal working body for intercropping. When working between of cotton rows, it will be necessary to reduce the number of working bodies mounted on cultivator in order to increase productivity, reduce manual labour, energy and metal consuming. To do this, universal working body has been developed that performs all the technological operations that must be performed by a large number of working bodies mounted on existing cultivators without compromising their quality. It was fitted with a wide right and left blade to cultivate the middle of the cotton row, to cultivate slopes, and to cut weeds. The result is a constructive scheme of a universal working body, working parts of which are concentrated in one column, which allows to perform technological operations during different vegetative seasons.

KEYWORDS: universal operating element, chisel, operating depth, stability, row crop cultivator, soil.

I. INTRODUCTION

One of the important tasks in our country is the development of high-quality and energy-efficient cultivators for intercropping. In this regard, special attention is paid to the development of multifunctional universal working bodies for cultivators [1].
At present, research work is being carried out in agriculture aimed at the development of resource-saving technologies for intercropping and new technical means for their implementation. In particular, it is important for cultivators to develop universal working body and to justify the technological processes of working parts, to ensure resource efficiency [2,3,4].

II. RELEVANCE OF THE TOPIC

Keeping the top layer of soil loose reduces moisture evaporation and salinity in the bottom layer and improves air penetration into the bottom layer. This activates the microorganisms in soil and improves respiration of the plant. Loosening the soil between rows will increase its water permeability and allow deep opening of irrigation canals. This ensures efficient use of irrigation water, deep application of fertilizers to the soil, as well as gentle cultivating of soil, which fully retains moisture in it. Quality treatment between rows leads to an improvement in thermal regime of soil. It plays an important role in the first period of cotton vegetation.

III. RESEARCH RATIONALE AND METHODS

In order to ensure long-term retention of moisture in soil after irrigation, it is necessary to cultivate between rows in the optimum humidity and at the required depth. Experiments show that delayed intercropping increases the evaporation of moisture from the soil, damages plant roots and increases the risk of various diseases, delays growth and development by 10–15 days, and reduces yields by 4–5 ts/hec [5].

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It is known that after sowing seeds, the soil becomes compacted. In such soil's moisture escapes quickly, it is difficult to feed young seedlings, cotton grows poorly, suffers from disease [6, 7, 8]. Therefore, the first treatment between of cotton rows is carried out in order to prevent development of weeds with seed germination and to ensure the heating of the top layer of soil, and subsequent treatments are carried out in connection with fertilization of seedlings and vegetative irrigation [9, 10].

Based on the results of agro-technical studies, the depth of inter-row cultivation of cotton should be from 6–8 cm to 14–16 cm, depending on width of inter-rows and period of cultivation [11, 12]. In this case, the deviation of the processing depth from specified one should not exceed ± 1 cm.

Constructive scheme and basic parameters of the proposed universal working body. When working between of cotton rows, it will be necessary to reduce the number of working bodies mounted on cultivator in order to increase productivity, reduce manual labour, energy and metal consuming. To do this, a universal working body has been developed that performs all the technological operations that must be performed by a large number of working bodies mounted on existing cultivators without compromising their quality. It was fitted with a wide right and left blade to cultivate middle of the cotton row, to cultivate slopes, and to cut the weeds. In order to open irrigation canals, instead of the right and left blades, furrow-opening wings were installed. The result is a constructive scheme of universal working body, the working parts of which are concentrated in one column, which allows to perform technological operations during different vegetation seasons. As can be seen from diagram in Figure 1, the universal working body consists of a column 1, a chisel 2 mounted on it, right 3 and left 4 blades, as well as wings 5 and 6 [2, 4].

The following are the main parameters that affect the agrotechnical and energy performance of the universal working body:

b_1 – width of the chisel, m;

β_1 – angle of penetration (sinking) of chisel into the ground, degrees;

β_2 – grinding angle of blades, degrees;

γ_1 – angle of installation of the blade relative to the direction of the blade movement, degrees;

$2\gamma_2$ – opening angle of wings, degrees;

B – width of working body, m.

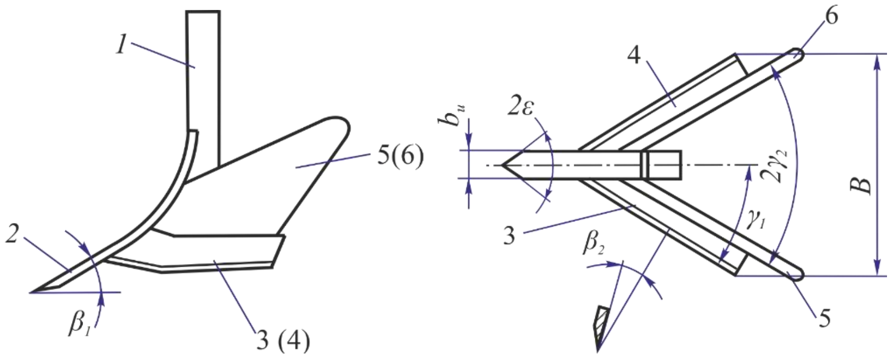

Fig 1. Constructive scheme of the universal working body proposed for cotton cultivator

The developed universal working body is multifunctional and performs technological operations such as cutting grass between cotton rows, loosening the soil and opening irrigation canals during different growing seasons.

IV. RESEARCH RESULTS

The stability of working depth of the universal working body is significantly affected by angle of penetration of the blade into soil and angle of blade grinding. During experiments, the change in stability of working depth depending on angle of penetration of blade into soil and grinding angles of the blade was studied. At the same time, the width of chisel was adjusted to 60 mm, the angle of installation relative to the direction of movement of the blade was adjusted to 30°, and experiments were conducted at operating speeds of the aggregate 4.8–6.5 km/h. The experimental data are presented in Table 1.

It can be seen from the table that when the angle of penetration of the universal working body chisel into soil increases from 23^o to 41^o, the value of standard deviation, which estimates its uniform travel along the working depth, from σ = ± 0.60 cm to ± 1.0 at speed 4.8 km/h, and at speed of 6.5 km/h from σ = ± 0.88 cm to ± 1.05 cm, and when the cutting angle of the blade varies from 22^o to 40^o, this value is ± 1.11 cm and ± 1.96 cm respectively. Ranged from 1.96 cm and

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from ± 1.10 cm to ± 2.19 cm. According to the results of the experiment, no change in depth of tillage was observed according to any regularity depending on the angles of penetration β_1 of the chisel into soil and β_2 of the blade, and the depth of tillage was in the range of 15–18 cm.

Table 1
The variation of the working depth plane of the universal working body depending on the angle of the grinding blade and penetration of the blade into soil

№	The name of corners of the working body	Values of the parameters	Processing depth unevenness indicators		
			The arithmetic value, M_{avr}, cm	An average square deviation, $\pm\sigma$, cm	Coefficient of variation, V, %
1.	The angle of entry of the chisel into soil, β_1	23 29 35 41	15,4/14,5 16,7/16,2 16,4/15,5 17,2/16,9	0,60/0,88 0,63/0,88 0,91/0,78 1,00/1,05	3,89/6,05 3,78/5,41 5,55/5,02 5,80/6,22
2.	The grinding angle of the workpiece blade, β_2	22 28 34 40	15,3/15,4 18,2/16,2 16,3/15,5 15,4/15,3	1,11/1,10 1,47/1,12 1,96/1,68 1,80/2,19	7,24/7,12 8,09/6,93 12,00/10,82 11,71/14,31
3.	Existing working bodies; 2 flat cutting knives, 2 cultivateing claws, 1 deep cultivateing claw		11,7/10,8	1,77/1,47	15,15/13,61

Note: The figure shows the speed of the aggregate at 4.8 km/h, and 6.5 km/h in denominator.

The universal working body, along with loosening the soil, moves it to the side, i.e. the soil is spread to the side under the influence of chisels and knives. The variation of the width of lateral spread of the soil depending on angles of penetration β_1 of the working body scan and the grinding β_2 of the blades is shown in Table 2 and Figure 2. The width of soil spread is directly related to the working depth of the working bodies and working speed of the aggregates. During experiments, working depth was adjusted to 14 cm, and the working speed was changed to 4.8 and 6.5 km/h.

Table 2
The lateral spread of loosened soil between the rows varies depending on angles of entry and crushing of the working body

№	Names of parameters	Values of parameters	Soil dispersion indicators		
			Average arithmetic value, M_{avr}, cm	Average square deviation, $\pm\sigma$, cm	Coefficient of variation, V, %
1.	The angle of entry of the working body into the ground, β_1	23 29 35 41	73,76/77,84 78,2/81,20 85,56/89,40 92,56/93,26	2,58/1,71 2,10/2,68 2,39/2,98 3,00/2,69	3,50/2,20 2,68/3,30 2,80/3,33 3,24/2,88
2.	Crushing angle of working body blades, β_2	22 28 34 40	72,68/76,36 76,65/78,32 74,66/75,96 74,40/75,72	1,84/1,31 1,52/1,31 2,77/2,56 2,16/2,91	2,53/1,72 2,09/1,67 3,71/3,37 2,90/3,91

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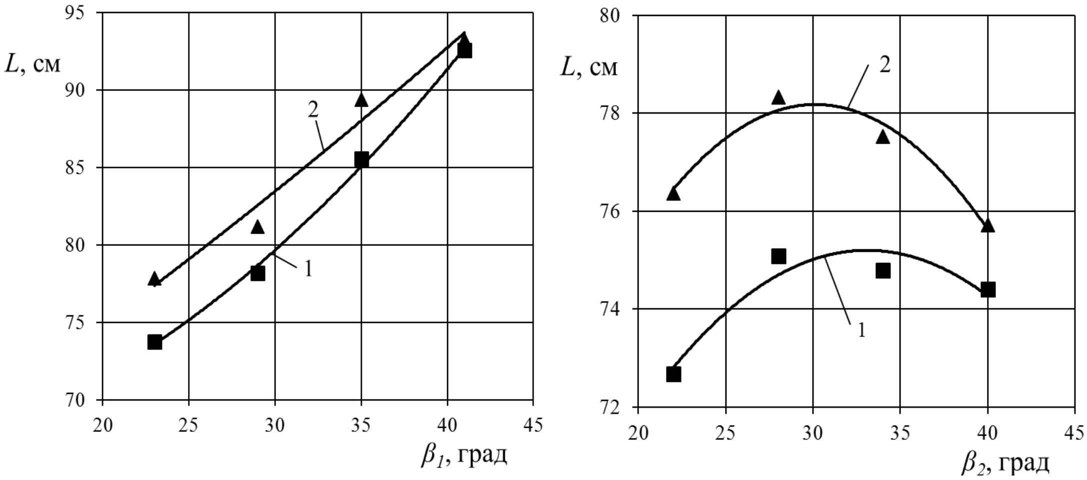

1 and 2 – when the aggregate speed is 4.8 and 6.5 km/h, respectively
Figure 2. Graphs of changes in width of soil lateral spread depending on angles β_1 and β_2

As can be seen from the graph and table, when the working speed of the aggregate was 4.8 km/h and angle of penetration of the working body into soil changed from 23^o to 41^o, the width of soil spread in both directions increased from 73.76 cm to 92.56 cm, the square deviation ranged from σ = ± 2.1 cm to ± 3.0 cm. When grinding angles of the blades increased from 22^o to 28^o, this figure increased from 72.68 cm to 76.65 cm, and when increased from 34^o to 40^o, slow decrease was observed from 74.66 cm to 74.40 cm. The mean square deviation decreased from σ = ± 1.84 cm to 1.52 cm and from 2.77 cm to 2.16 cm, respectively.

At a working speed of 6.5 km/h, when the angle of penetration of the working body into soil was changed from 23^o to 41^o, the width of the soil spread on both sides increased from 77.84 cm to 93.26 cm, the average square deviation ranged from σ = ± 1,71 cm to ± 2.98 cm. When grinding angles of blades increased from 22^o to 28^o, this figure increased from 76.36 cm to 78.32 cm, and when it increased from 34^o to 40^o, slow decrease was observed from 75.96 cm to 75.72 cm. The mean square deflection increased σ = ± 1.31 cm when grinding angles of blades increased from 22^o to 28^o and from 2.56 cm to 2.91 cm when increased from 34^o to 40^o.

It can be seen from this that the speed of the aggregate has a significant effect on lateral spread of soil but angle of entry of the working body shank into soil and grinding angles of blade play an important role in lateral spread of soil. When angle of penetration of the chisel into soil was in range of 29^o–41^o, the width of crushed soil in both directions was equal to width of the row spacing (90 cm) and more. However, as the bending angles of blades increased from 28^o to 34^o, this was the case, i.e. the width of soil spread did not exceed 78.32 cm.

IV. CONCLUSION

Therefore, it was found that the angle of penetration of the blade into soil should be in range of 29o–35o and grinding angles of blades should be in range of 28o–34o.

Due to their large number and small coverage width when existing working bodies were used, the soil spread width was much less than that of universal working bodies and was around 66.55-68.22 cm. Because one-sided cutting flat blades push the soil to the middle of the edge, not to the side.

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