Determining the depth of immersion of combined machine ridge harvesters and the dimensions of the ridges produced by them

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Abstract. The article discusses the outcomes of theoretical research focused on determining the optimal depth of immersion for combined machine cultivators used in preparing garden and vine rows for monoculture planting, along with the corresponding dimensions of the cultivators they form. The study specifically addresses the planting of vegetable crops between these rows, with a standard width of 70 cm. Considering the typical growth pattern of these crops in bush form, with heights ranging from 10-15 cm and widths of 33-37 cm at the top, it was concluded that the immersion depth of the combined machine's bushes should be adjusted within the range of 8.5-14.9 cm to meet agrotechnical requirements effectively.

1 Introduction

Within the soil-climatic conditions of the Republic of Uzbekistan, vegetables, rice, and other inter-row crops are planted and developed between recently built-up gardens and vine lines for 6-8 a long time [1-2].

Currently, agrotechnical activities are being carried out separately on agricultural machines and devices in preparing the garden and vine rows for planting in the spring. This causes increased labor, energy, and fuel consumption, soil macro-microstructure disruption and excessive compaction, and soil moisture loss. In addition, agricultural machines and weapons created 50-60 years ago and imported from the CIS countries are used to implement the above activities. A large amount of material costs are spent on the use of these machines and their repair [3-6].

Based on the above, Scientific-research institute of agricultural mechanization (SRIAM) has developed a design of a combined machine that prepares garden and electric train plots for planting together (Figure 1).

The combined machine is prepared with a suspension gadget and comprises of a outline 1, a conditioner 2, a rotational working body 3 that shapes a delicate soil layer, a leveler 4, a heap picker 5, a compactor 6 that compacts the beat layer of heaps and slants.

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The operational process of the combined machine, responsible for preparing cultivated and vineyard rows for single-crop planting, unfolds as follows: as the unit traverses the field, its conditioner loosens the soil between the plant rows, while the rotating working element pulverizes the softened soil from the conditioner, creating a fine soil layer. Subsequently, a leveler smoothes the surface of the area where the fine soil layer has been loosened to meet agrotechnical standards. Following this, a furrow is formed using a furrow opener, and then its upper layer and slopes are compacted to the required agrotechnical level with a compactor, preparing the soil for crop planting.

This article presents the results of theoretical studies on the determination of the depth of plowing of combined machine plows and the size of plows formed by them.

2 Materials and methods

In the process of research, the basic laws and rules of higher mathematics, analytical geometry and agricultural mechanics were used.

We determine the problem using the scheme presented in Figure 2. In this case, it is considered that the distance between the edges of the bush $B_e$ and the height of the bush $h_b$ or the width of the top of the bush $b_t$ are given.

First, let us consider the case where $B_e$ and $h_b$ are given. In this case, according to the known values of $B_e$ and $h_b$, we determine the width of the top of the pile $b_t$, the depth of the pile receiver into the soil $h_p$, the width of the pile at the level of the field surface $b_d$ and the thickness of the soil spread over the top of the pile $h_u$.

Fig. 1. Constructive diagram of the combined machine that prepares the plows of the field and the current row for sowing.
1 – the profile before removing ridges between all rows; 2 – the profile after removing ridges between all rows

Fig. 2. The scheme for determining the depth of immersion of the pusher into the soil.

3 Results and discussion

According to the scheme presented in Figure 2:

\[ b_t = B_e - 2h_b \tan \gamma \]

where \( \gamma \) – the angle of natural fall of the soil (35-38°) [7-10], °.

Now, to determine \( h_p, b_d \) and \( h_u \), we make the following equations according to the scheme presented in Figure 2

\[ kh_p^2 \tan \gamma = \left(b_t - h_p\right) \left(\frac{b_t + b_d}{2}\right); \]

\[ b_d = b_t + 2\left(b_t - h_p\right) \tan \gamma; \]

\[ \frac{b_t + b_d}{2} = B_e - \left(h_t + h_p\right) \tan \gamma; \]

and

\[ h_u = \left(b_t - h_p\right), \]

where \( k \) – the soil softening coefficient by the tiller.

Solving equations (2)-(5) together, we get the following expressions to determine \( h_p, b_d \) and \( h_u \)

\[ h_p = \frac{1}{2} \left(k - 1\right)^{-1}\left[-B_e + \sqrt{B_e^2 + 4\left(k - 1\right)\left(B_e - h_b \tan \gamma\right)h_b \tan \gamma}\right] \tan \gamma; \]

\[ b_d = B_e - 2h_b \tan \gamma + 2\left[h_p - \frac{1}{2} \left(k - 1\right)^{-1}\left[-B_e + \sqrt{B_e^2 + 4\left(k - 1\right)\left(B_e - h_b \tan \gamma\right)h_b \tan \gamma}\right]\right]; \]

\[ h_u = h_b - \frac{1}{2} \left(k - 1\right)^{-1}\left[-B_e + \sqrt{B_e^2 + 4\left(k - 1\right)\left(B_e - h_b \tan \gamma\right)h_b \tan \gamma}\right] \tan \gamma. \]

\( B_e \) and \( b_t \) given their given values \( h_b, h_p, b_d \) and \( h_u \) are determined. In this case, the following expressions were obtained to determine them according to the scheme in Figure 2:

\[ h_b = \frac{1}{2} \left(B_e - b_t\right) \tan \gamma; \]

\[ h_p = \frac{-B_e + \sqrt{B_e^2 + 4\left(k - 1\right)\left(B_e - B_p\right)\tan \gamma}}{2\left(k - 1\right)} \tan \gamma; \]

\[ h_u = \frac{1}{2} \left[B_e - b_t + \frac{B_e - \sqrt{B_e^2 + 4\left(k - 1\right)\left(B_e - B_p\right)\tan \gamma}}{\left(k - 1\right)}\right] \tan \gamma; \]

\[ b_d = B_e + \frac{B_e - \sqrt{B_e^2 + 4\left(k - 1\right)\left(B_e - B_p\right)\tan \gamma}}{\left(k - 1\right)}. \]
Figure 3 shows that taking $B_e = 70$ and $90$ cm and $\psi = 38^\circ$ and $k = 1.1$, according to expressions (1) and (6)-(8), $b_t$, $h_p$, $b_d$ and $h_u$ to $h_b$, 4-and in the figure, graphs of changes depending on $h_b$, $h_p$, $b_d$ and $h_u$ ni $b_t$ were constructed according to expressions (9)-(12). It can be seen from them that an increase in $h_b$ leads to a decrease in $b_t$, and $b_d$ an increase in $h_p$, and $h_u$ (Figure 3), and an increase in $b_t$ leads to a decrease in $h_b$, $h_p$ and $h_u$ and an increase in $b_d$ (Figure 4) leads to.

![Graphs](image)

1 – $B_e = 70$ cm when; 2 – $B_e = 90$ cm when

**Fig. 3.** $b_t$ (a), $h_p$ (b), $b_d$ (v) and $h_u$ (g) is $h_b$ change graphs depending on.
4 Conclusion

The graphs constructed according to the expressions (9)-(12) above show that when the height of the paddy field increased, the width of the paddy top and the width of the paddy field at the level of the field surface decreased, and the depth of the paddy receiver to the soil and the thickness of the soil spread over the paddy increased. All the mentioned indicators increased when the distance between the fringes increased from 70 cm to 90 cm.

As the width of the top of the paddy field increased, the height of the paddy field, the depth of immersion in the soil, and the thickness of the soil spread on the top of the paddy field decreased, while the width of the paddy field at the level of the field surface increased. In this case, when the distance between the fringes increased from 70 cm to 90 cm, all the indicated indicators increased.

According to the existing agrotechnical requirements, vegetable crops are grown in beds with a width of 70 cm between the edges, a height of 10-15 cm and a width of 33-37 cm at the top. Putting these values in the expressions (6) and (10), we determine that the depth of immersion of the combined machine tillers into the soil should be adjustable in the range of 8.5-14.9 cm.

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