Theoretical researches which are conducted on the precise dimensions of the furrow maker

1 Introduction

The agrotechnical measures for preparing the land for planting cotton in the cotton field are fertilizing, plowing, smoothing the unevenness caused by plowing, harrowing, threshing and cotton harvesting activities are carried out with separate aggregates, of which harrowing, harrowing and threshing activities are performed two or three times. Such multiple processing of aggregates leads to increase of labor, energy and fuel consumption, to damage of its structure and excessive densification.

2 Materials and methods

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Main working organs of the combined aggregate are: softener of the soil which does not plug the soil but softens, the device that fertilizes the softened layer in a ribbon-shaped method and the furrow maker forming beds on the fertilized layer.

The furrow maker of the combined aggregate plugs the soil remained after the previous season on the layer softened by the deep softener and makes new beds.

The analysis of the literature and the results of the carried comparative tests point out that utilization of spherical discs as tillage of the combined aggregate for forming qualitative beds by spending little energy show good results.

The furrow maker of combined aggregate (picture 1) consists of the column and spherical disc and make beds in the result of moving the soil in beds remained from the previous year onto the fertilized layer softened by the softener and fertilized by the help of fertilizers.

Here, every bed is formed by two discs placed opposite to each other (picture 2).

Main parameters of influencing the quality and energy working indices of the aggregate are tillage, crooked radius of the working surface of the disc \( R \), its diameter \( D \), the entrance corner relatively to the motion direction \( \beta \), the distance of settlement of the furrow maker to the softener \( L \).

Fig. 1. Working organ of the furrow maker of combined aggregate.
The scheme of forming a bed by the help of spherical discs

The main criteria for choosing the favorable values of furrow maker is the supply of making beds on the softened and fertilized layer which answer the demands by spending minimal energy.

In the technologic process of furrow making the discs cut soil blocks, raises them along the working surfaces, throws aside and makes beds. Resulting from these mentioned we will investigate cutting the soil blocks by discs, movement of the blocks on the disc surface and the process of making beds. We will make all these resulting from the results of investigations carried out by F.M. Kanarev, A. Tukhtakuziyev, A.A. Nasritdinov and others[6],[7].

3 Results and discussion
The part of soil blocks cut by disc knives are in the shape of ellipse and we can express it by the following equation:

\[
\frac{x^2}{R_d^2} + \frac{y^2}{R_d^2} = \beta
\]

Here, \(R_d\) – is the disc radius; \(x, y\) – are the coordinate arrows inserted into the center of disc rotation.

The width of horizontal cut of the soil block is characterized with \(b\), its thickness with \(\delta\) and the surface with \(S\). They can be found by the following expressions:

\[
h = \frac{D_h b d}{h_d} \]

\[
h = \delta
\]

\[
h = \int \left[ \pi \left( \frac{1}{4} \right) \left( \frac{1}{4} \right) \right] \sqrt{1 - \left( \frac{x}{R_d} \right)^2}
\]

Here, \(h\) – is the entrance depth of the spherical disc into the soil.

We can see from the following that, the shape and sizes of the soil block cut from the soil by the disc depend on the disc diameter (radius), settlement corner along the movement and the depth of soil entrance.

Determination of bed height and the depth of furrow maker entrance into the soil. On the basis of the references given in the carried investigations we will identify the height of beds which are made by furrow maker and the depth of their soil entrance by considering that lateral walls of beds are placed under the corner of natural fall of the soil (picture 3) relatively to horizontal flatness.

Fig. 4. Scheme of identifying the bed height and the depth of soil entrance of the furrow maker.

\[
h_n = \sqrt{\left( \frac{h_n}{5} \right)^2 - \left( h_d \right)^2}
\]

\[
\delta = \frac{h_n}{5,0}
\]

\[
B = \pi \left( \frac{1}{4} \right) \left( \frac{1}{4} \right) \left( \frac{1}{4} \right) \sqrt{1 - \left( \frac{x}{R_d} \right)^2}
\]

Thus, due to the expression (5) the bed height made the furrow maker depends on the the distance between beds and the corner of natural fall of the soil.

We can witness that by putting certain values (30 - 40 cm, [6], [7]) of \(\varepsilon\) in the expression (5) we can make 26 - 30 cm high beds in 90 cm interspaces.
In order to determine the entrance corner of the furrow maker into the soil we use the following equilateral made on the basis of the scheme in picture 4.

\[ \varepsilon = \frac{h}{k_\text{ю}} \left( \frac{1}{n} - \frac{1}{k_\text{ю}} \right) \varepsilon \]

Here, \( h \) – the depth of the soil entrance of the furrow maker; \( k_\text{ю} \) – softening coefficient of the soil.

We will have the following expression by solving the expression (6) relatively to \( h \).

\[ \frac{h}{k_\text{ю}} \geq \frac{1}{n} + \frac{1}{k_\text{ю}} + y + \frac{y}{m} \]

By putting the value of \( h_n \) on agro technical demands, by receiving \( h_n = 24 \pm 3 \) and \( k_\text{ю} = 1.1 \) [8] we will determine that the depth of soil entrance of the furrow maker is between 10.7 - 13.2 cm.

The settlement distance of the furrow maker in the round direction of the softener.

If the round distance between the softener and tillage is not enough, the soil will enter into the interspaces and this will result in the resistance of pulling the aggregate and the destruction of a technologic process. Having the distance more than that will result in the big size of the tool and increase of the metal size.

Due to the scheme given in picture 5, we can find the settlement distance of the furrow maker in the direction of the softener by the following expression.

\[ \frac{h}{k_\text{ю}} \geq \frac{1}{n} + \frac{1}{k_\text{ю}} + y + \frac{y}{m} \]
Fig. 5. The scheme of identifying the distance of furrow maker settlement in the direction of the softener. The palm fist of the softener is determined by the following expression:

\[ L_{yu.d} = b_{o.t.} \cos 0.5B \]

We will have the following by putting the value of the working surface of the softener by putting it in the expression (9) of determining the length \( L_{yu.d} \) of the working surface of the softener.

\[ (9) \]

Due to the scheme given in picture 6:

\[ \sin \beta = \frac{\sin \phi}{\cos \beta} \]

By considering (10) and (11) expressions the expression (8) will have the following form:

\[ \pi/2 + \phi_1 \]

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The distance between a softener and a cultivation device for its implementation, determined that the shape and dimensions of the furrow maker that the plow can cut from the soil depend on the diameter (radius) of the disc ridger, the angle of its penetration into the soil.

\[
\tau = \frac{r}{\sin(\alpha_0 + \varphi_x + \varphi_s)} + \frac{\pi - \varphi}{\sin(\alpha_0 - \varphi_x - \varphi_s)} \times \frac{\varphi + \varphi_x - \alpha_0}{\alpha_0 + \varphi + \varphi_s} \times \left(\frac{\alpha_0 + \varphi + \varphi_s}{\alpha_0 + \varphi - \alpha_0} \times \varphi \right)
\]

\[
+ \left\{ \frac{\varphi - \varphi_x}{\cos(\alpha_0 + \varphi + \varphi_s)} \right\} \frac{\beta + \varphi_s + \varphi_x}{\beta + \varphi_x + \varphi_s}
\]

4 Conclusion

In the results of the research, analytical links were obtained that allow determining the width of the interspaces between rows and the selection of the type and parameters of moldboard plow for combined tillage system processing machines and tools.

References


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