Justification of the parameters of the ripper of the harrowing unit

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Abstract. The following article describes the disadvantages of existing trailed harrowing units while preparing fields before sowing in early spring, such as: inconvenience in cleaning toothed harrows from weeds, attracting additional transport and labor when moving the trailed unit from one field to another, excessive labor costs, time losses, and eliminating these disadvantages by creating highly efficient wide-reach mounted units, as well as substantiating the parameters of working bodies based on theoretical and experimental studies. In addition, the article contains the results of scientific, theoretical and experimental studies on the operation of a highly efficient and easy-to-use wide-reach unit for high-quality soil preparation for planting.

1 Introduction

In our Republic, soil harrowing is carried out in two tracks per one pass of the tractor with BZSS-1.0, BZTS-1.0 or BZTH-1.0 harrows arranged in two rows. At the same time, heavy harrows BZTS-1.0 and BZTH-1.0 are used in fields that have received multiple washing, and in other cases – medium harrows BZSS-1.0 [1-3]

In cotton growing, aggregates are recommended to be made up of existing wide-reach couplings [1, 4]. However, these couplings do not meet the specific conditions of the zone, i.e. they do not fit into narrow field roads when moving from site to site.

In farms, harrowing aggregates are 6-8 m wide by attaching harrows in two tracks to a wooden or metal bar that is attached to a tractor. This type of aggregate also creates great inconveniences in operation.

The two-row arrangement of spike-tooth harrows when composing the harrowing unit causes a large metal - energy intensity of the unit. In addition, when moving from one field to another, the aggregate has to be disassembled and reassembled after transportation by means of a vehicle. According to the SITT, 5.4 people/hour are spent on this operation. In addition, to clean the teeth of the harrow from weeds and plant residues during operation, 2 maintenance workers are assigned to each harrowing aggregate. Moreover, to perform this operation, it is necessary to stop the aggregate and manually clean each link. Therefore, the cost of cleaning harrows is more than 30% of the shift time, and the reliability coefficient of the technological process is 0.61 [5].

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2 Materials and methods

It is known that the uniform harrow movement and the same penetration of its tines is possible when the line of traction force (traction line) passes through the center of resistance of the machine, i.e., through the point of application of all forces acting in the longitudinal-vertical plane. For existing harrows, the tines are sunk to the same value when the traction force is at an angle of 14-170 to the horizon [6-7]. Otherwise, there is a disturbing moment, under the influence of which the teeth of the front and rear rows of the harrow section penetrate into the soil unequally, the stability of its movement in the longitudinal-vertical plane deteriorates [8].

On the basis of the above-mentioned well-known position, let us consider the work of a harrow unit during two-track harrowing.

At two-track harrowing by harrows arranged in two rows, harrow links of the second row are attached to the rear part of the first row harrow by chains (Figure 1). As a result, the pulling force of the harrow located in the second row has almost horizontal direction and goes above its center of resistance O2. As a result, there is a disturbing moment under the influence of which the stability of the second row links is broken. At the same time the stability of the first row links is violated, as they are also affected by the disturbing moment tending to bury the teeth of the rear row more than the front one.

3 Results and Discussion

To create a harrow unit with higher productivity, good quality indicators of work with minimal energy costs, it is necessary to eliminate these disadvantages of the two-row harrow unit used in the farms of the zone. First of all, it is necessary to reduce the metal intensity of the machine and the labor intensity of its maintenance. One of the real ways to reduce the metal intensity of the harrow unit is to solve the issue of transition to one-track harrowing, which provides the same soil quality as the two-track harrowing. To reduce the labor intensity of cleaning the harrow from crop residues and transporting the unit from one area to another on narrow roads, the harrow unit must be mounted and consist of several articulated sections and a mechanism for lifting (folding) the side sections when moving the unit to the transport position.

Taking into account the initial requirements for harrowing and considering the tendency of development of wide-cut soil cultivating machines, we can formulate the general requirements for a harrowing unit:

- The harrow unit must be mounted and consist of separate sections hinged together.
- The harrow unit must be operated by one tractor driver and be converted from working to transport by means of the tractor hydraulic system.
For transferring the unit to the long-distance transport position from the working position and to the reverse position the lateral sections must be folded by the tractor operator with the help of the hydraulic system.

The arrangement of the harrow should allow accessible and convenient cleaning of the harrow from crop residues, adjustments and maintenance of the machine.

We have developed and manufactured a hinged coupling for making a wide-reach harrowing aggregate from tooth harrows. The coupling consists of a central section and two side wheels connected to it, support wheels and a mechanism for lifting the side sections into the transport position (Figure 2).

Rippers are installed on the front bars of all sections, in the form of a two-tiered harrow.

Fig. 2. Diagram of a harrowing unit made up of a hinged coupling: 1-support wheel; 2-suspension mechanism; 3-transverse beam; 4-frame; 5-ripping working bodies (ripper); 6-tooth harrow.

Due to this, tooth harrows without reducing the quality of tillage, it is enough to attach to the hitch in one row (track) instead of the traditional two-row (two-track). The attachment of the ripper and tooth harrows to the hitch bar separately (individually) ensures the stability of the stroke in depth of both the ripper and the tooth harrow [9].

During long-distance transportation or when moving the aggregate from one site to another along narrow field roads, the side sections are rotated into a vertical position with the help of lifting mechanisms and do not interfere with movement.

The width of the central section is 3 m, and the lateral sections are 2.75 m, the total width of the hitch is 8.5 m, in total 9 tooth harrows are attached to it.

The article presents the results of research to substantiate the parameters of the ripper installed on the hitch bars in front of the tooth harrows.

The main parameters of the ripper that affect its quality and energy indicators are (Figure 3): the width of the teeth spacing (a), the angles of their entry into the soil in the longitudinally vertical (γ) and transversely vertical (ε) planes, the width of the grip (B), the specific vertical load (Gp), the speed of movement (V), the type and parameters of its attachment.

Justification of the angle of entry of teeth into the soil in the longitudinal-vertical plane.

The teeth on the ripper can be installed vertically \( \gamma = \frac{\pi}{2} \), with a forward \( \gamma < \frac{\pi}{2} \) or backward tilt \( \gamma > \frac{\pi}{2} \) (Figure 4).
When installed vertically, the tooth acts on the soil particles with a force that coincides with the direction of velocity. Under the action of the force R, the soil particles move mainly in the horizontal direction, therefore, loosening of the soil with such a tooth occurs without significant mixing and removal of the lower wet layers to the surface. The teeth sink into the soil under the gravity of the ripper.

![Diagram of ripper teeth and forces](image1)

**Fig. 3.** The main investigated parameters of the ripper. 1-leveling bar; 2-tooth; 3-hitch mechanism.

![Setting of tines](image2)

**Fig. 4.** Setting the tines of the ripper a-vertical; b-inclined forward; c-inclined backward.

When installing the teeth with a forward tilt, i.e. $\gamma < \frac{\pi}{2}$ when the force R is deflected from the horizontal upwards, the soil particles under its action move not only forward, but also upwards. As a result, loosening of the soil occurs with the removal of the lower moist layers upwards, which is unacceptable according to agro-technical requirements. In addition, the strength of the soil reaction contributes to the deepening of the teeth into the soil, which affects the uniformity of the depth of tillage [10-14].

If the teeth are installed with a backward tilt $\left(\gamma > \frac{\pi}{2}\right)$, then the soil particles move downwards under the action of force R. The reaction of the soil prevents the teeth from deepening, as a result, the depth of its processing decreases. To ensure a given loosening depth, it is necessary to increase the weight of the ripper.

Thus, the vertical installation of the ripper teeth should be considered optimal.
4 Conclusion

- The best quality of tillage is provided by the vertical installation of the ripper teeth.
- It is reasonable how to set the angle of entry of the teeth into the soil in the longitudinal-vertical plane.
- When the harrow teeth are positioned at a fixed angle to the soil, the forces acting on them, along with the front of the soil layer, also affect the upper part of the layer, causing the soil layer to move.

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