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Conditions for bending cotton stalks of a combined aggregation bender and their implementation

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Abstract. As the object of the research, the cotton stalk and its physical and mechanical properties, the elastic of the combined aggregate and the spherical disk were accepted. Like many other European countries, our country has also developed minimal, resource-saving and zero technologies for the cultivation of agricultural products, and their technical solutions are being supported and implemented by farmers and clusters. In particular, in the preparation of cotton fields for sowing for the next year in one pass of machinery in cotton growing, the research was conducted on the development of a minimum technology and a combined unit that implements it. In the implementation of this technology, the cotton stalks are tilted to the side furrow in the direction of movement of the aggregate, and the root is laid on the bottom of the furrow with the soil. The bottom layer of the existing pile is then divided into two parts, each of which is rolled over the cotton stalks on the side edges on both sides, where a new pile is formed. Once the aggregate has passed, the existing ridges are replaced by ridges with cotton stalks buried under them, and ridges are formed in place of the existing ridges.

In the study, the angle of the axis of symmetry was determined by the angle of the stalks, and in the laboratory, the amount of force required to bend the stalks was determined using a specially prepared stand.

In the study, the width of the flexible cover is 45 cm, the mounting angle of the straight part of the flexible relative to the direction of movement is 35-450, the radius of curvature should be 100 mm, the mounting height relative to the ridge should be 15 cm, and the shape was determined.

Bending of cotton stalks standing on the ridge in the direction of aggregate movement to the side ridge, digging them with root soil, longitudinal laying at the bottom of this ridge can be done using a spherical disk.

1 Introduction

The object of the research is the physical and mechanical properties of the cotton stalk, the parameters of the bender and the height of its installation relative to the surface of the stalk. 118 million over the world, in our country, 450,000 hectares of land are planted with cotton and cultivated. Soil degradation protection, resource-saving, minimal and zero technologies

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and their implementation techniques have been introduced, which allow reducing the cost of crops grown by an average of 25% while maintaining soil fertility. In this regard, research on the burial of cotton stalks under new stalks is relevant in the formation of new stalks and branches in cotton fields for use as organic fertilizer [1-11].

There are technologies to prepare cotton stalks for the next year in one pass, forming stalks and stalks. [12-15]. However, their construction is complex, the metal volume is high, and the mass of the aggregate is heavy. Therefore, there is a need to develop minimal technologies suitable for the country's climatic and soil conditions and the combined units that implement them. Because the current technology of land preparation for sowing in the cotton industry of the republic is designed to perform each technological process separately and sequentially. As a result, the number and type of equipment performing technological processes are increasing, and their entry and exit into the field correspondingly increase. This leads to compaction and deterioration of the structure of the soil, in addition to not meeting the requirements of resource conservation [16-21].

Based on the above, when combining the aggregate in the cotton fields, burying the cotton stalks under a new ridge that is identical to the existing field location is all back to the existing technology of opening new fields and continuing to implement it. The combined unit consists of a series of flexible blades, spherical and flat discs, as well as bump generators. This article presents materials devoted to the parameters of the bender.

According to this technology, four rows of cotton stalks are processed. The technology is implemented in the cotton fields, where cotton is harvested in the fall. In the implementation of the technology, the stalks standing upright on the ridge are bent in the direction of movement of the aggregate to the forward side edge using bends 3, while the spherical discs 4 cut their root with the soil and throw it in the middle of this edge. The bottom layer of the existing pile is then divided into two parts by means of pile forming 5, each of which is rolled over the cotton stalks on the side edges on both sides, where a new pile is formed. Once the aggregate has passed, the existing ridges are replaced by ridges with cotton stalks buried under them, and ridges are formed in place of the existing ridges. The aggregate forms 3 completely new buds and branches when the row spacing is 90 cm and 4 when the row spacing is 60 cm.

The flat discs 7 ensure stable movement of the unit in the horizontal plane. The spherical disc is cleaned with a soil scraper 5 attached to the working surface. Changing the mounting angle of the spherical disk relative to the direction of movement of the unit is done by screw 6, and changing the mounting angle of the spindle relative to the horizontal is done by screw 9.

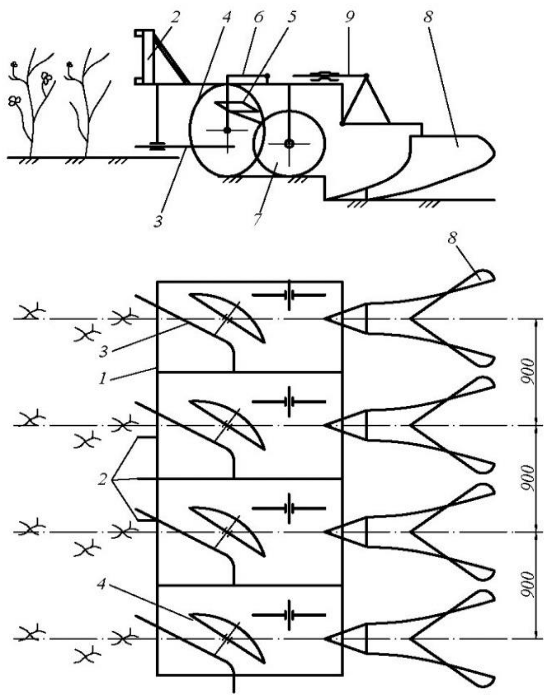

Fig. 1. Scheme of the combined aggregate: 1 is Frame; 2 is hanging device; 3 is flexible; 4 is spherical disk; 5 is Scraper; 6 is adjusting screw of a spherical disk; 7 is flat disc; 8 is furrow-taking; 9 is push adjustment screw.

Parameters of the combined aggregate cotton stalk: the shape of the bender, the width of the coverage, the angle of installation relative to the direction of movement of the right part of the binder, the radius of curvature, the height of the installation relative to the bend. Theoretical and experimental studies are aimed at substantiating these parameters.

2 Methods

Theoretical research was carried out using theoretical mechanics, agricultural mechanics, and experimental research using the laws and rules of mathematical statistics, methods of mathematical planning of experiments and methods specified in existing regulations (Tst 63.03.2001, Rh 63.03-98, GOST 28218-2016). The angle of inclination of the stalks relative to the axis was measured using a specially designed conveyor (Figure 2).

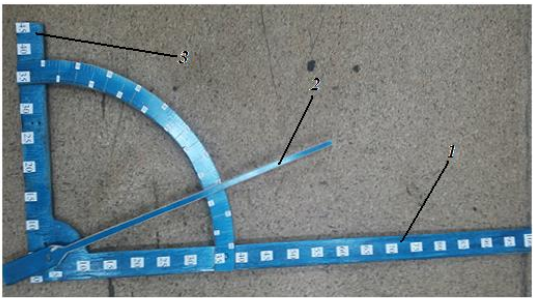

Fig. 2. A device for measuring the angles of incidence of cotton stalks relative to the axis of rotation: 1 is longitudinal bar; 2 is moving indicator; 3 is transverse bar.

3 Results and Discussion

The cotton stalk consists of three parts: the first, i.e. the main part of the stalk E_0C_0 the appearance of a straight line at an acute angle to the direction of movement, the second, i.e. the middle part B_0C_0 The last part, in the form of a curved line A_0B_0 while it has the appearance of a straight line perpendicular to the direction of motion (Figure 3).

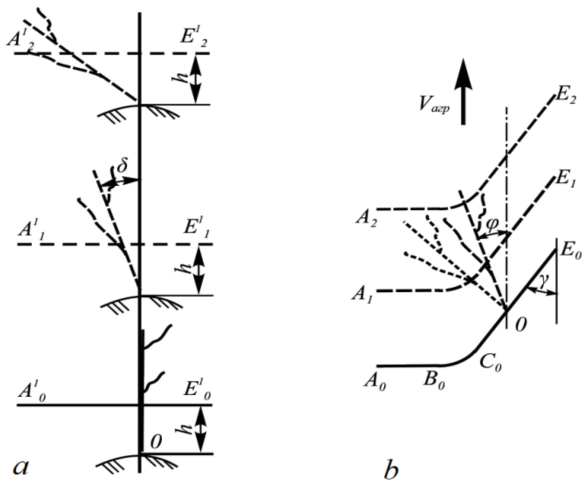

Fig. 3. Scheme for substantiating the shape of the inverter: a is the transverse vertical plane; b is the horizontal plane

The process of placing the cotton stalks on edge under the influence of a flexible and spherical disk is carried out as follows. The head of the grinder E_0C_0 under the influence the stalks are bent in a lateral vertical plane in a transverse vertical plane sliding along the bender Of the inverter E_0C_0 slipping from part of it B_0C_0, and the cotton stalks in front of this part are partially bent to the side and hold them in place during the displacement of the spherical disc cotton stalk soil into the stalk.

Of the inverter B_0C_0 under the influence of the part and the spherical disk, the stalks are laid in the middle of the stalk in the direction of movement of the aggregate. The end of the grinder A_0B_0 part serves to fully lay the stalks on the stalk. Based on the above, we substantiate the parameters of the bender parts.

Let's say a flexor is moving along a horizontal plane C_1 interact with the stalk at the point (Figure 4). In this case, normal $N_г$ and friction F forces act on the cotton stalk by the bender. We divide the normal $N_г$ force into N_v forces directed along the direction of motion of the aggregate and N_τ forces directed along the bender.

The force N_τ tends to move the stalk along the working surface of the bender, to which the friction force F resists.

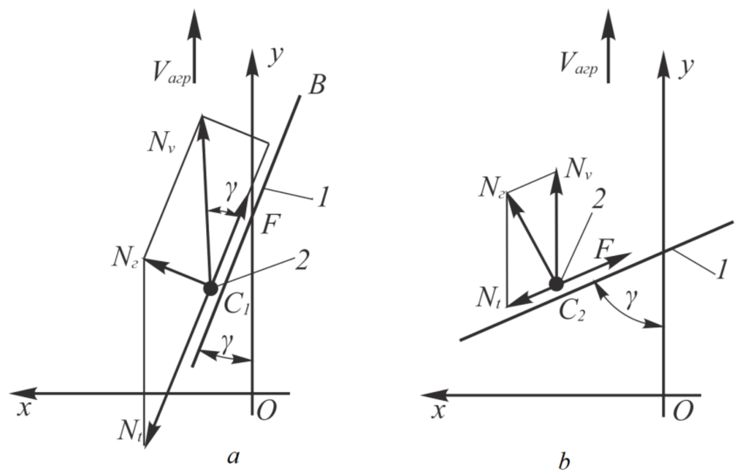

Fig. 4. Schematic of the forces acting on the stalk by the head part (*a*) and the middle part (*b*) of the twister: 1 is flexible; 2 is cotton stalks.

The following condition must be met for the cotton stalk to slide on the bender [4-7]

$$N_\tau = N_g tg\gamma > F = N_g tg\phi. \qquad (1)$$

From this

$$\gamma < \frac{\pi}{2} - \phi \qquad (2)$$

where φ *is* angle of friction on the cotton bender, degrees.

If $\gamma > \pi/2 - \varphi$ is, the cotton stalk does not slip on the bender, and it bends in the direction of motion N_v force, ie only the aggregate. The ratio of the forces N_τ and F is as follows (Fig. 4, b)

$$N_\tau = N_g \cdot ctg\gamma < F = N_g tg\phi \qquad (3)$$

or

$$\gamma > \frac{\pi}{2} - \phi . \qquad (4)$$

(4) if the condition is met, the cotton stalk cannot slide along the working surface of the bender, and under its influence, the aggregate bends in the direction of movement.

Therefore, for the quality execution of the specified technological work, the values of the mounting angle of the bending head should be taken into account the expression (2) and the middle part (4).

The last part of the bender serves to bend and press the stalks forward in the direction of movement. Therefore, it should be installed perpendicular to the direction of movement.

The number of stalks that interact with the grinder at the same time is one of the factors influencing the course of the technological process. The number of stalks bent depends on the mounting angle g of the bender and the number of stalks on the stalk. This is because the smaller the bend's angle relative to the axis of symmetry and the shorter the distance between the bubbles in the bend, the greater the number of bends under the bending effect. To simplify the determination of the number of stalks to be collected in all parts of the bender, the middle part of it was also adopted as a straight line. Then the bender is in the form of $A_0B_0C_0E_0$ (Figure 5).

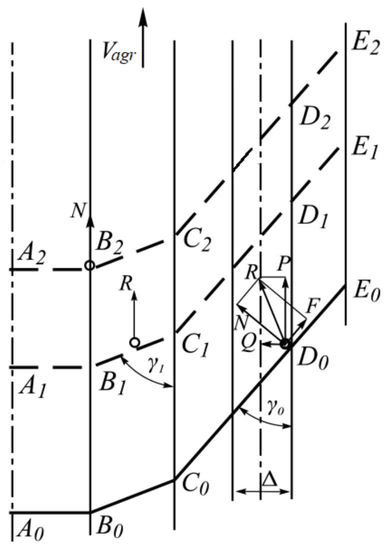

Fig. 5. Schematic of the change of forces acting on the stalk at the beginning, middle and end parts of the bender

In this case, the beginning of the bender is C_0E_0, the middle part is C_0B_0, and the last part is B_0A_0. Suppose that the C_0E_0 part of the bender is set at an angle γ_0 to the direction of motion.

The condition $\gamma_0<90^o–\varphi$ –according to expression (2) must be fulfilled for the cotton stalk to slip and bend. In this case, the cotton stalk bends in the direction of the force R, which deviates from the normal force N in the direction of motion at an angle φ

An equally effective reaction force R can be thought of as the sum of the longitudinal R and transverse Q forces [11 - 15], that is

$$\frac{P}{R} = \cos\left[90^0 - \left(\phi + \gamma\right)\right] = \sin(\phi + \gamma) \qquad (5)$$

and

$$\frac{F}{N} = tg\phi = f \;; \qquad \frac{N}{R} = \cos\phi$$

Because

$$P = Rsin\,(\varphi + \gamma) = R\,sin\varphi\,cos\gamma + Rsin\gamma cos\varphi = N(sin\gamma_0 + f\,cos\gamma_0 \qquad (6)$$

$$Q = \,Rcos\,(\varphi + \gamma) = Rcos\varphi cos\gamma – Rsin\varphi sin\gamma = N(cos\gamma_0 – f\,sin\gamma_0) \qquad (7)$$

It is known that the friction angle of the cotton stalk on the bender is in the range of φ=16–28º [16]. In this case, when γ_0<62º, the cotton stalk slides along the bend from E_0 to

C_0 and bends to the side.

Since the middle part of the bender is designed to bend the C_1B_1 stalks and keep them in this position, the stalks on it should bend in the direction of non-slip movement. To do this, the condition $\gamma_1>90^o - \varphi$ must be met. According to this condition, when $\varphi=16 - 28^o$, it should be $\gamma_0>62^o$.

In this case, the direction of the reaction force R acting on the cotton by the bender is the same as the direction of movement of the bender.

In part A_1B_1 of the bender, the direction of the normal reaction forces N and R is the same as the direction of movement of the bender.

To determine how many stalks the cultivator will be exposed to simultaneously, studies were performed on stalks located at a width of Δ=12 (Figure 6).

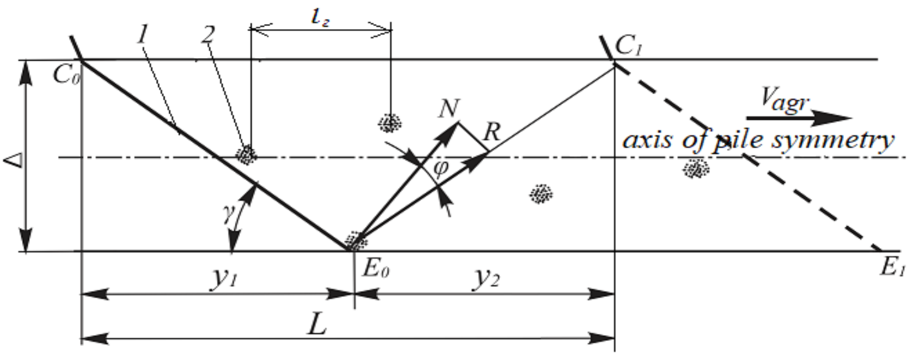

Fig. 6. Scheme for determining the number of bending stalks at the inlet of the bender**:** 1 is flexible; 2 is cotton stalks.

During the movement of the aggregate, the stalks at point E_0 of the bending part E_0C_0 begin to slip and bend in the direction of the force R. This process continues to point C_0. During this period, the bender passes through L. The stalks located on the surface of the triangle $E_0C_0C_1$ are bent under the influence of the bender and pass into the middle of it. The triangular stalks $E_0C_1E_1$, on the other hand, are in a state of sliding and bending along the bend [14].

During this period, the bender travels a distance y_1+y_2 and assumes the position E_1C_1. The number of bent cotton stalks n during displacement y_1+y_2 can be determined as follows [18-20].

$$n = \frac{y_1 + y_2}{l_g} \qquad (8)$$

where l_z is the distance between the stalks in a row, m.
From figure 5 we determine the distances y_1 and y_2

$$\frac{\Delta}{y_2} = tg\left[90^\circ - \left(\phi + \gamma\right)\right] = ctg\left(\phi + \gamma\right)$$

because

$$y_1 = \Delta ctg\gamma, \; y_2 = \Delta tg(\gamma + \phi). \qquad (9)$$

Given that $L=y_1+y_2$=14.25+22.56=36.81 cm and l_e≈10 cm, it was found that there were n=3–4 cotton stalks at the inlet of the flexible.

Experimental studies were conducted in cotton-harvested cotton fields.

A special device scheme for processing two lines was developed for experimental research, and an experimental copy of it was made (Figure 7).

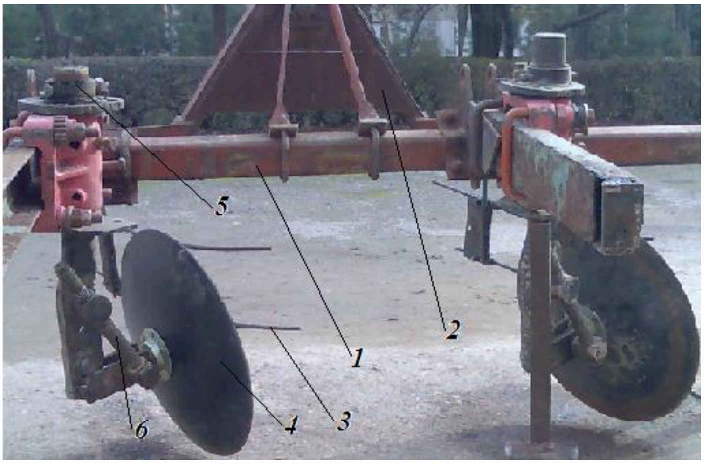

Fig. 7. Experimental device

The device consists of a transverse frame 1, a suspension meniscus 2, flexible 3, spherical discs 4 and an adjustment angle 5 in the direction of its movement and an angle adjustment 6 in the vertical direction. A special bracket column has been developed to change the mounting angle and height of the grinder and the distances from it to the spherical disc. Benders with different radii of curvature were prepared (Figures 8 and 9).

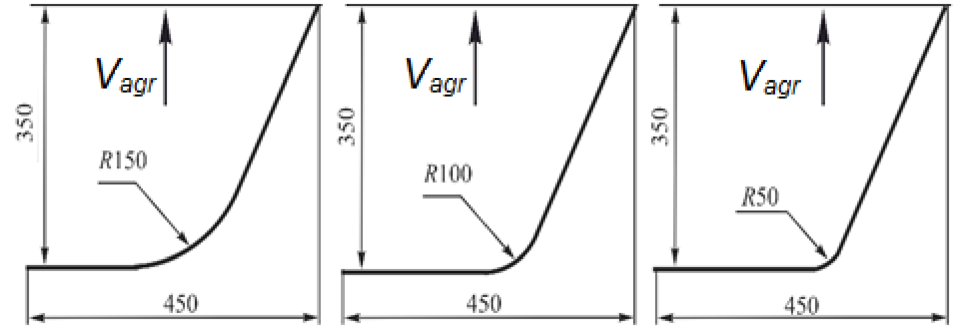

Fig. 8. Scheme of benders with different radii of curvature

Fig. 9. Flexibles with different radii of curvature

The main evaluation criterion in the experiments was the angle of inclination of the stalks relative to the axis of the stalk. Experiments were carried out at three depths of spherical disc processing a=12, 15 and 18 cm to determine the deposition of cotton stalks at the bottom of the ridge. After the bender and the spherical disc had passed through the marked location, the ridge profile was opened in the transverse vertical plane, and the distances r from the stalk neck to the bottom of the ridge were measured (Figure 10). The experiments were repeated 5 times. Measurements were made to the nearest 0.1 cm.

In these experiments, a curve with a radius of curvature of 100 mm was used, which was set at the height of 0.15 m from the ridge surface and at an angle of 35^0 to the direction of movement.

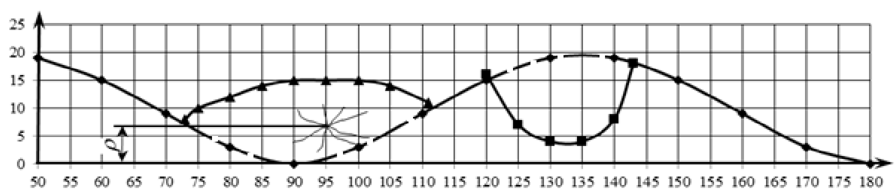

Fig. 10. Scheme of laying the stalks at the bottom of the lateral ridge with the root soil

As can be seen from figure 10, the distance from the neck of the stalk to the bottom of the stalk at a depth of 15 cm with a spherical disk ρ =6 cm.

Thus, processing with a spherical disk at a depth of 15 cm provides a minimum value of the distance of laying the stalks at the bottom of the ridge. Thus, the processing depth of the spherical disk is assumed to be 15 cm.

4 Conclusions

Bending the cotton stalks along the working surface of the bender to the side edge, the width of the bender is 40–45 cm, the installation angle relative to the direction of movement is 35–43°, the height of the installation relative to the surface of the ridge is 15 cm, then their longitudinal laying with the root soil at the bottom of the ridge provides a rational value of the working depth of the spherical disk 13–17 cm.

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