# Pushing soil with combined aggregate spherical disc and burial of stem

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**Abstract**. As an object of research, the technological process of cutting the roots of the stalks of the pine tree with the soil and placing them on the side together with the spherical disk in the combined aggregate implementation was accepted.
In our republic's cotton cultivation field, the world's latest innovations, including minimal, resource-saving, Strip-till, No-till technologies of soil cultivation and drip irrigation methods, are gradually being introduced. Combined aggregates produced abroad and in our country, designed to perform several technological processes at once, are being supported and introduced by cotton growing clusters. We found it necessary to bring a combined aggregate that prepares new sedges and sedges in the fields with sedges. During the movement of the aggregate in the sedge field, the sedges of the sedge are first tilted to the side of the sedge, and the roots are trimmed with soil and placed at the bottom of the sedge. Then, the lower layer of the bush is divided into two parts, it is turned over the stalks laid on the sides, and new bushes are formed in that place. And in the place of existing puss, new furrows are formed. The research was carried out using methods and tools for measuring angles and distances and optimizing parameters using the mathematical planning method of multifactorial experiments. The study's results determined that the diameter of the spherical disk is 510 mm, the radius of curvature is 540 mm, and the installation angles relative to the direction of movement and the vertical should be 30-32° and 20°, respectively. The research results showed that it is possible to perform the technological processes of cutting the layer of the pistachio root with spherical disks and throwing it to the middle of the side.

## 1 Introduction

The object of research consists of the technological process of cutting the roots of the stalks bent to the side of the field with the soil and placing them on this side and the spherical disk in the combined aggregate that implements it.

On average, 45 percent of the total 1.1 million hectares of cotton area in our republic is planted with cotton, and cotton is cultivated. Cotton cultivation has been going on in these

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areas for the past 100 years. Attitudes towards cotton growing technology and soil fertility have been changing positively for the last 15-20 years by farmers and cluster leaders. Minimum tillage, Strip-till, and No-till technologies, and drip irrigation methods are gradually being introduced. The products of the grown crops are harvested, the remaining part is crushed as much as possible, buried in the soil, and attention is paid to the possibilities of developing and implementing technical solutions based on local conditions. In this regard, the researches devoted to forming new egat and pushts and burying them for the use of cotton as organic fertilizer after picking cotton are relevant. In Russia, European countries, the United States of America, and several other countries, plant residues are widely used as organic fertilizers by burying them in the soil [1-10].

The issue of reusing cotton bolls as organic fertilizer began in 1913 in the cotton industry of Uzbekistan. A.E.Vyalovsky, D.A.Sabinin, F.A.Skryabin, E.Ya.Yasheva, G.I.Yarovenko, and A.G.Shalimov studied the length, depth of burial, rotting process, and factors affecting it [8-15].

Studies have shown that the yield of cultivated cotton increased by 4.1 centners, and the soil density in the fields where cotton was buried decreased by 30-40% when measured after three years [5-6]. Studies have recommended burying the stalks by crushing them, spreading them over the field, and then plowing them in with plows [1-15].

In the practice of foreign countries engaged in the cotton field, there are technologies for burying whole and crushed cotton stalks in one pass through the fields with cotton stalks and the technical means for their implementation [12-15]. According to the results of the literature analysis, the peduncles in the pust were buried, and new pusts were formed on them. Still, there is no information about their opening in the place of existing egats [15-20].

In world practice, the technologies of burying the stalks under the new bushes at the same time as creating new bushes and hedges at the same time as passing through the field with stalks and the technical means to implement it have been developed, and they are protected by patents of inventions [10-21].

## 2 Methods

The proposed technology is intended to cut 20-26 cm wide and 13-17 cm deep from the middle part of the bush where the stem root is located and throw it to the side (Figure 1).

Technological processes performed by tillage bodies were studied and analyzed, and a working hypothesis was formed that this process could be performed with a spherical disc.

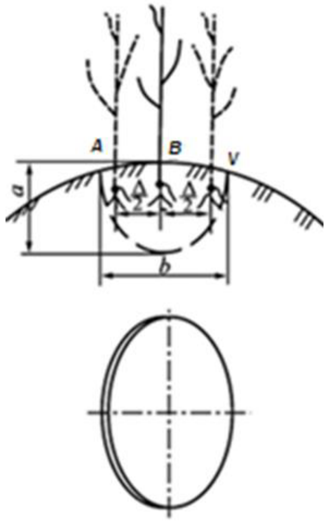


**Fig. 1.** Spherical disc layout for cottonwood soil and shearing

The goal was to establish the parameters of the spherical disc, which will cut the stem where the cotton root is located from the middle of the bush and throw it to the side, and the following tasks were set to achieve it.

- based on the absolute velocity of soil particles thrown from a spherical disk and the effect of disk parameters
- justifying the distance of throwing the blade to the side depending on the angle of installation and deviation of the disk relative to the vertical.

One of the requirements for the operation of a spherical disk is that the main part of the root ball thrown from it should fall in the middle of the side edge. Then it is considered to be done qualitatively by placing the stalks in the bush at the bottom of the side edge and along its axis of symmetry. The scheme of the combined unit, which implements the proposed technology and includes a spherical disk, is presented in figure 2. Urama 1, suspension device 2, bender 3, spherical disk 4, scraper 5, spherical disk adjustment screw 6, flat disk 7, pusher 8, and its entry angle adjustment screw 9 are included.

The working process of the combined unit is as follows: bender 3 bends the stalks of the brush forward along the side edge, the spherical disk 4 cuts the root of the bent stalk and the soil on it and throws it to the bottom of this edge, the brush remover 8 separates the remaining bottom layer of the brush into strips from the middle and separates them accordingly on the left and right sides. It rolls over the branches on the right side and forms new shoots.

Flat discs 7 provide stable movement of the unit in the horizontal plane. The soil adhering to the working surface of the spherical disc is cleaned with a scraper 5. Changing the angle of installation of the spherical disk concerning the direction of movement of the unit is done by screw 6, and changing the angle of installation of the pusher concerning the horizontal is done by screw 9.

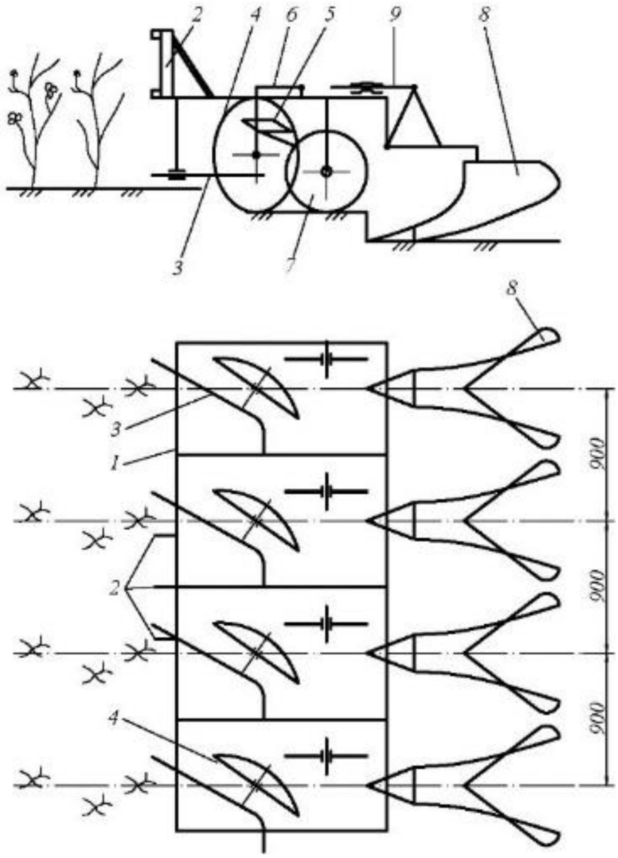


**Fig. 2.** The scheme of the combined unit: 1 is frame; 2 is suspension device; 3 is bender; 4 is spherical disc; 5 is scraper; 6 is adjustment screw of the spherical disc; 7 is flat disk; 8 is push-button; 9 is the screw of adjustment of the pusher

Spherical discs freely mounted on the axis of rotation can work in three different modes during operation: rolling without slipping and chattering; to slide and roll; to roll around.

In this theoretical study on the movement of soil particles on the working surface of a spherical disk, we accept the following condition

– the spherical disk rolls without slipping or chattering during operation.

In addition, we note that in the course of work, the disc cuts the soil layer with a width of 20–26 cm and a thickness of 13–17 cm, where the root system of the stem is located and throws it to the bottom of the side along with the stem.

Since the spherical disc is in forwarding and rotational motion during the work process, the soil particles move along with it in rotation (extraction) and relative movement along its working surface.

## 3 Results and Discussion

It is known that the absolute speed of a soil particle located at point $M$ of the working surface of a spherical disk (Figure 3) is equal to the sum of its displacement $V_k$ and relative speeds $V_n$ at this point, i.e.,

$$V_a = \sqrt{V_1^{\,2} + V_2^{\,2} + 2V_1V_2\cos\varepsilon_c}\,, \tag{1}$$

where $\varepsilon_c$ – $V_1$ and $V_2$ are angles between velocity vectors, degrees

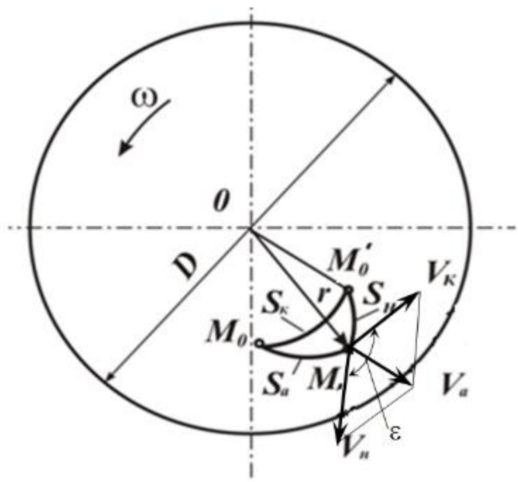


**Fig. 3.** The scheme for determining the absolute speed of a soil particle on the working surface of a spherical disk

The displacement speed of the soil particle

$$V_1 = \omega_c r \tag{2}$$

where $\omega_c$ is angular velocity of the spherical disc, rad/s, $r$ is radial distance from the axis of rotation of the disk to the observed soil particle, m.

According to the accepted condition

$$\omega_c = \frac{2V_3 cos\alpha}{D} \tag{3}$$

where $V_3$ is the speed of movement of the spherical disk together with the aggregate, m/s; $V_3 cos\alpha$ – $\overline{V}_3$ is the projection of a vector in the direction of aggregate motion; $\alpha$ is the installation angle of the spherical disk relative to the aggregate movement direction, degrees

so,

$$V_1 = \frac{2V_3 r\cos\alpha}{D}\,. \tag{4}$$

To determine the relative speed $V_2$, we construct the differential equation of the relative motion of the saw $M_3$ on the surface of a spherical disk [1-20].

A particle $M$ of soil is in relative motion along an arc formed by the radius of curvature of a spherical disk and is acted upon by forces: gravity $G = mg$; centrifugal inertia force generated by the rotation of a spherical disk $F^I$; centrifugal inertial force resulting from the relative movement of a soil particle along an arc formed by a spherical disk radius of curvature R is $F^{II}$; additional compressive strength exerted by the taproot $P^b$; normal force acting on the soil particle by the working surface of the spherical disc *N*; friction force *F*; Coriolis force $F^{III}$ formed by rotation of the soil particle along the radius of curvature of the spherical disc with relative and angular velocity $\omega_c$

When the stem is bent, the additional compressive force $P^b$ exerted by the root on the soil particle is

$$P^b = \frac{EJ_0(1-\lambda h)^4}{S}, \tag{5}$$

where *S* is the surface of the cross-section of the plant in which the root system of the bent stem is located, m$^2$; $EJ(z)=EJ_0(1-\lambda z)^4$ ва $0<z<h$, $\lambda=K_k/D$; $K_k$ is the taper of the cotton stem; $D_0$ is diameter of the stem neck, m *d* is the diameter of the end of the stem of a cotton plant, m; *H* is the distance between the sections of the stem, m; *E* is the modulus of elasticity of the cotton stem, Pa; $J_0$ is the moment of inertia in section *O* of the stem, m$^4$. *h* is the distance between the surface of the pad and the bender.

In determining this force, we assume that the bending force acts on the stem at a height h above the surface of the bush and that the stem does not deform at this distance (FIGURE 4).

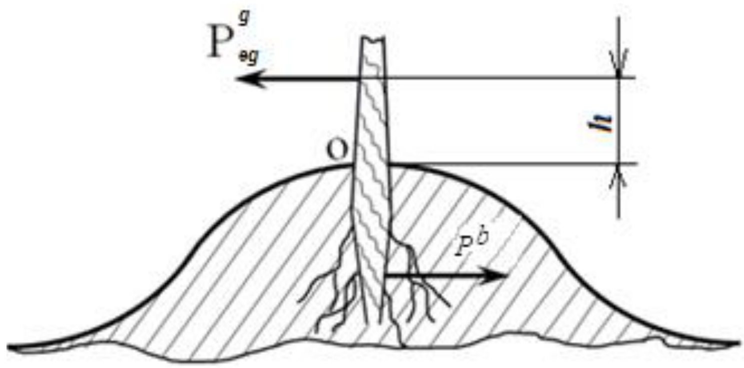


**Fig. 4.** The scheme of forces acting on the tree

Taking into account the applied forces and the assumed conditions, the differential equation of the soil particle $S_n$ moving relative to the arc of the spherical disc working surface can be expressed as follows

$$\frac{mdV_2}{dt} = mg\cos(\xi+\beta)\cos\tau + m\omega^2 R\sin\xi\cos\xi -$$
$$-f\left[\frac{mV_2^2}{R} + mg\sin(\xi+\beta)\cos\tau + m\omega^2 R\sin^2\xi - P^b\cos(\xi+\beta)\right]. \tag{6}$$

Performing mathematical operations, the following expression was obtained to determine the relative velocity of soil particles thrown from a spherical disc.

$$V_2=\left\{-\frac{1}{e^{2f(\arcsin\frac{D}{2R}-\xi_0)}}\left[\frac{2Rf(3g\cos\tau-2EJ_0\frac{(1-\lambda h)^4}{mS})}{1+4f^2}\cos(\xi_0+\beta)+\right.\right.$$

$$\left.+\frac{2R\left[g\cos\tau(1-2f^2)-EJ_0\frac{(1-\lambda h)^4}{mS}\right]}{1+4f^2}\sin(\xi_0+\beta)+\frac{4R^2V_3^2\cos^2\alpha(\sin 2\xi_0-f\sin^2\xi_0)}{fD^2}\right]+$$

$$+\left[\frac{2fR(3g\cos\tau-2EJ_0\frac{(1-\lambda h)^4}{mS})}{1+4f^2}\cos(\arcsin\frac{D}{2R}+\beta)+\frac{2R\left[g\cos\tau(1-2f^2)-EJ_0\frac{(1-\lambda h)^4}{mS}\right]}{1+4f^2}\right.\mathrm{x}$$

$$\left.\mathrm{x}\sin(\arcsin\frac{D}{2R}+\beta)+\frac{V_3^2\cos^2\alpha(4D\sqrt{R^2-(0{,}5D)^2}-fD^2)}{fD^2}\right\}^{\frac{1}{2}}.$$

4) $V_1$ and (6) by putting the values of $V_2$ in expression (1) and also taking into account that when ε $2V_1V_2\cos 90°=0$ we determine the velocity $V_a$

$$V_a=\left\{\left(\frac{2\cdot r\cdot V_3}{\mathrm{D}}\cos\alpha\sin\xi\right)^2+\left\{-\frac{1}{e^{2f(\arcsin\frac{D}{2R}-\xi_0)}}\left[\frac{2Rf(3g\cos\tau-2EJ_0\frac{(1-\lambda h)^4}{mS}}{1+4f^2}\cos(\xi_0+\beta)+\right.\right.\right.$$

$$\left.+\frac{2R\left[g\cos\tau(1-2f^2)-2EJ_0\frac{(1-\lambda h)^4}{mS}\right]}{1+4f^2}\times\sin(\xi_0+\beta)+\frac{4R^2V_3^2\cos^2\alpha(\sin 2\xi_0-f\sin^2\xi_0)}{fD^2}\right]+$$

$$+\left[\frac{2fR(3g\cos\tau-2k)}{1+4f^2}\cos(\arcsin\frac{D_{c.\partial}}{2R_э}+\beta)+\frac{2R\left[g\cos\tau(1-2f^2)-K\right]}{1+4f^2}\right.\times$$

$$\left.\left.\left.\times\sin(\arcsin\frac{D}{2R}+\beta)+\frac{\vartheta_3^2\cos^2\alpha(4D\sqrt{R^2-(0{,}5D)^2}-fD^2)}{fD^2}\right\}\right\}^{\frac{1}{2}}. \quad (7)$$

After reversing $V_a$ speed,

$$V_a=\left\{\left(V_3\cos\alpha\right)^2+\left\{-\frac{1}{e^{2f(\arcsin\frac{D}{2R}-\xi_0)}}\left[\frac{2Rf(3g\cos\tau-2f\cdot EJ_0\frac{(1-\lambda h)^4}{mS})}{1+4f^2}\cos(\xi_0+\beta)+\right.\right.\right.$$

$$\left.+\frac{2R\left[g\cos\tau(1-2f^2)-f\cdot EJ_0\frac{(1-\lambda h)^4}{mS}\right]}{1+4f^2}\sin(\xi_0+\beta)+\frac{4R^2V_3^2\cos^2\alpha(\sin 2\xi_0-f\sin^2\xi_0)}{fD^2}\right]+$$

$$+\left[\frac{2fR(3g\cos\tau-2f\cdot EJ_0\frac{(1-\lambda h)^4}{mS})}{1+4f^2}\cos(\arcsin\frac{D}{2R}+\beta)+\frac{2R\left[g\cos\tau(1-2f^2)-f\cdot EJ_0\frac{(1-\lambda h)^4}{mS}\right]}{1+4f^2}\right.\times$$

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$$\times \sin(\arcsin\frac{D}{2R}+\beta)+\frac{V_3^2\cos^2\alpha(4D\sqrt{R^2-(0{,}5D)^2}-fD^2)}{fD^2}\Bigg]\Bigg]\Bigg\}^{\frac{1}{2}}. \qquad (8)$$

where $V_3$ is the speed of movement of the spherical disk together with the aggregate m/s; $V_3 cos\alpha - \overline{V}_3$ is the projection of a vector in the direction of aggregate motion; $\alpha$ is the installation angle of the spherical disk relative to the aggregate movement direction, degrees; $f$ is coefficient of friction of a piece of soil moving on a spherical disc working surface; $D$ is spherical disc diameterм; $m$ is mass of soil particles, kg; $\xi_0$ is half of the central angle of the spherical disk, degrees; $R$ is radius of curvature of the spherical disk, m; $g$ is acceleration of free fall, m/s$^2$; $\tau$ is the angle of rotation of the spherical disk relative to the vertical axis, degrees; $\beta$ is the angle of installation of the spherical disk relative to the vertical, degrees.

The resulting expressions allow for determining the relative, relative and absolute speeds of soil particles on the surface of a spherical disk, depending on the operating conditions of the disk and its parameters.

Figures 5-8 show changes in the absolute speed of soil particles thrown by a spherical disk according to expression (8) depending on its direction of movement and installation angles relative to the vertical, aggregate speed, disk diameter, and radius of curvature.

When constructing the graphs of the absolute speed of a soil particle thrown from a spherical disc, which is presented in Figure 5, as a function of its installation angle, the following was adopted: $\beta$=18º, $\xi_0$=10º, $\tau$=90º, $E$=5.2·10$^9$ Pa, $J_0$=6.7·10$^{-8}$ m$^4$, $\lambda$=1 m$^{-1}$ ва $h$=0.15 m, $m$=1 kg, $S$=0.02 m$^2$, $V_3$=1.8 m/s, $D$=0,51 m, and $R$=0.54 m, g=9.81 m/s$^2$.

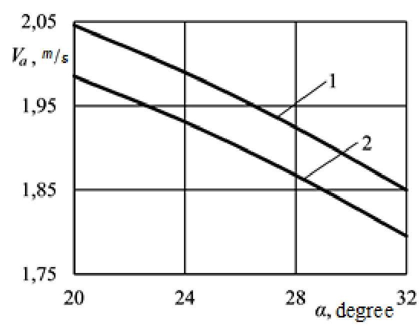



**Fig. 5.** Graphs of changes in the absolute speed of a soil particle thrown from a spherical disc depending on its angle of installation 1 is $f$=0.5; 2 is $f$=0.6

As can be seen from the graph, increasing the angle of installation of the spherical disk α from 20º to 32º leads to a decrease in the absolute speed. When the friction coefficient is equal to $f$=0,5, the absolute speed of the soil particle on the spherical disk decreases depending on the angle of its installation. When the friction coefficient is f=0.6, the increase in the installation angle from *20º* to *24º* has no significant effect on the rate of decrease in speed; the further increase in the angle leads to a linear decrease in speed. This relationship can be explained as follows. With an increase in the installation angle, the normal pressure of the disc on the ground increases, which causes an increase in the friction force and a corresponding decrease in the relative speed. When constructing graphs of changes in the absolute speed of a soil particle thrown from a spherical disc as a function of its angle of installation with respect to the vertical, shown in Fig. 6, the following was adopted: $\xi_0$=10º, $\tau$ =90º, $E$=5,2·10$^9$ Pa, $J_0$=6.7·10$^{-8}$ m$^4$, $\lambda$=1 m$^{-1}$ ва $h$=0.15 m, $m$=1 kg, $S$=0.02 m$^2$, $V_3$=1.8 m/s, $D$=0.51m, and $R$=0.54 m, $\alpha$=25º.

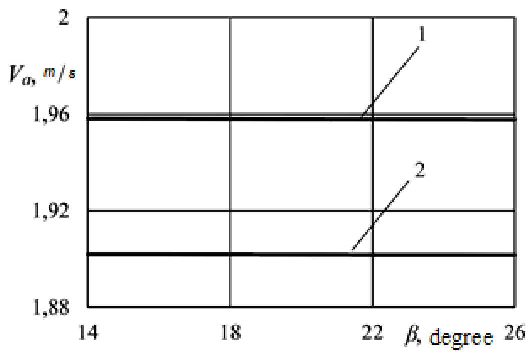



**Fig. 6.** Graphs of changes in the absolute speed of a soil particle thrown from a spherical disc as a function of its angle of installation relative to the vertical 1 is $f$=0.5; 2 is $f$=0.6

As seen from the graph in Figure 6, the spherical disk installation angle relative to the vertical does not significantly affect the absolute velocity of the soil particles.

When constructing graphs of changes in the absolute speed of a soil particle thrown from a spherical disc as a function of the aggregate speed presented in figure 7, the following was adopted: $\alpha$=25º, $\beta$=14º, $m$=1 kg, $S$=0.02 m$^2$, $h$=0.10 m, $D$=0.51 m, $R$=0.54 As can be seen from the graphs constructed in m values, the absolute speed of the soil particle increased sharply according to the straight line pattern with the increase of the aggregate speed.

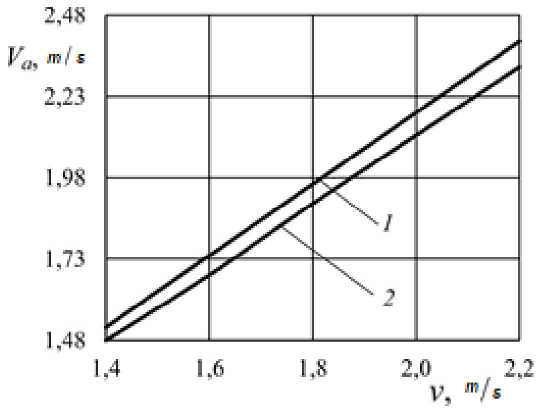



**Fig. 7.** Graphs of change of absolute speed of soil particles thrown from a spherical disc as a function of aggregate speed 1 is $f$=0.5; 2 is $f$=0.6

Since the spherical disc rotates without slipping or shearing, the rotational speed of the disc and, accordingly, the absolute velocity of the soil particle varies with the aggregate velocity.

When constructing the graphs in FIGURE 8 $\xi_0$=10º, $\tau$ =90º, $E$=5.2·10$^9$ Pa, $J_0$=6.7·10$^{-8}$ m$^4$, $\lambda$=1 m$^{-1}$, $h$=0.10 m, $m$=1 kg, $S$=0.02 m$^2$, $V_3$=1.8 m/s, $\alpha$=25º, $\beta$=14º, $S$=0.02 m$^2$, $R$=0.54 m is accepted.

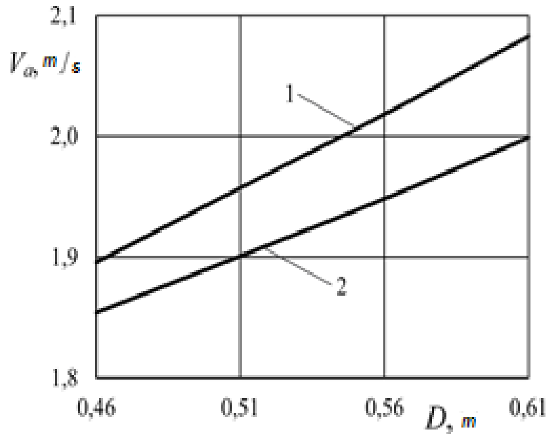



**Fig. 8.** Graphs of variation of soil particle absolute velocity as a function of spherical disc diameter 1 is $f$=0.5; 2 is $f$=0.6

As the graphs show, the soil particle's absolute speed increases in a straight line with the increasing diameter of the disk. For example, when the disk diameter increased from 0.46 m to 0.61 m at $f$=0.6, the speed of the soil particle increased from 1.85 m/s to 2 m/s.

The distance of the soil particles falling from the spherical disc in the transverse direction affects the angular orientation of the stems along the axis. In addition, the placement of the flat disk to the left relative to the spherical disk depends on the lateral throw distance of the soil particles.

We determine the throwing distance of the soil particles falling from the spherical disc according to the following expression [10-16]

$$X_m = \frac{v_a \cos(\alpha+\xi)\left[v_a \sin(\alpha+\xi) + \sqrt{v_a^2 \sin(\alpha+\xi) + 2gh_n}\right]}{g}, \tag{9}$$

where $h_n$ is available push height, m.

Cross throw distance $X_k$ of the soil particles falling from the spherical disk (FIGURE 9).

$$X_K = \left\{\frac{v_a \cos(\alpha+\xi)\left[v_a \sin(\alpha+\xi) + \sqrt{v_a^2 \sin(\alpha+\xi) + 2gh_n}\right]}{g}\right\} \sin\alpha + \frac{b_d}{2}. \tag{10}$$

(10) it can be seen from the expression that the transverse throw distance of a soil particle falling from a spherical disc depends on its absolute speed, the angle of fall, the height of the available ridges, and the working width of the disc.

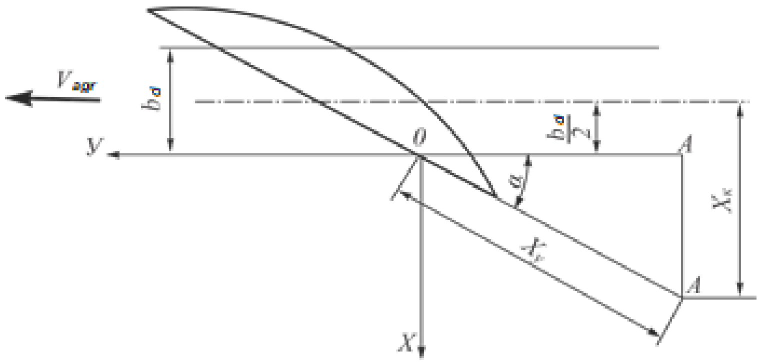
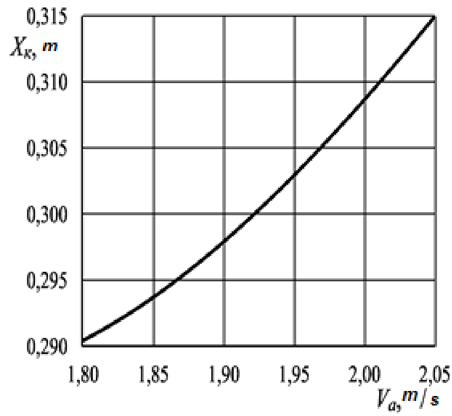
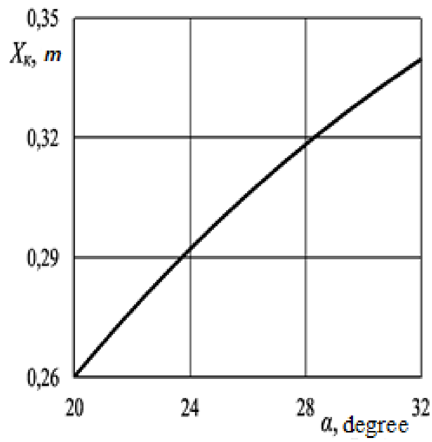



**Fig. 9.** The scheme for determining the lateral throw distance of soil particles falling from a spherical disk

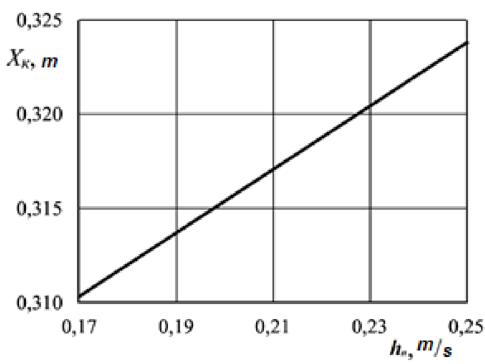
(10) According to the expression, the distance of the soil particle from the disc, the absolute speed of the soil particle is $V_a$, and the change graphs depending on the installation angle of the spherical disc *α,* and the height hp are presented in figure 10, *a, b, v*.




*a*) $\alpha$=28º; $\xi$=30º; $g$=9.8 m/s$^2$;
$h_n$=0.19 m; $b_∂$=0.2 m

*b*) $V_a$=2,0 m/s; $\xi$=30º; $g$=9.8 m/s$^2$;
$h_n$=0.19 m; $b_∂$=0.2 m




*v*) $V_a$=2.0 m/s; $\xi$=30º; $g$=9.8 m/s$^2$; $\alpha$=28º; $b_d$=0.2 m

**Fig. 10**. Graphs of variation of $X_k$ as a function of $V_a$, *α,* and $h_n$

As can be seen from the graphs presented in FIGURE 10, the transverse throwing distance of the soil particles increased according to the concave parabola with the increase of their absolute speed, the bubble parabola with the increase of the installation angle, and the straight line relationship with the increase of the height of the existing pile.

Analysis of the graphs showed that the speed of movement of the spherical disk is 1.95–2.05 m/s, the installation angle is 28–32º, and the available height of the pile is in the range of 19–21 cm to place the thrown soil particles along the lateral axis.

A special device for two-row processing was developed to conduct experimental studies, and its pilot copy was prepared (Figure 11).

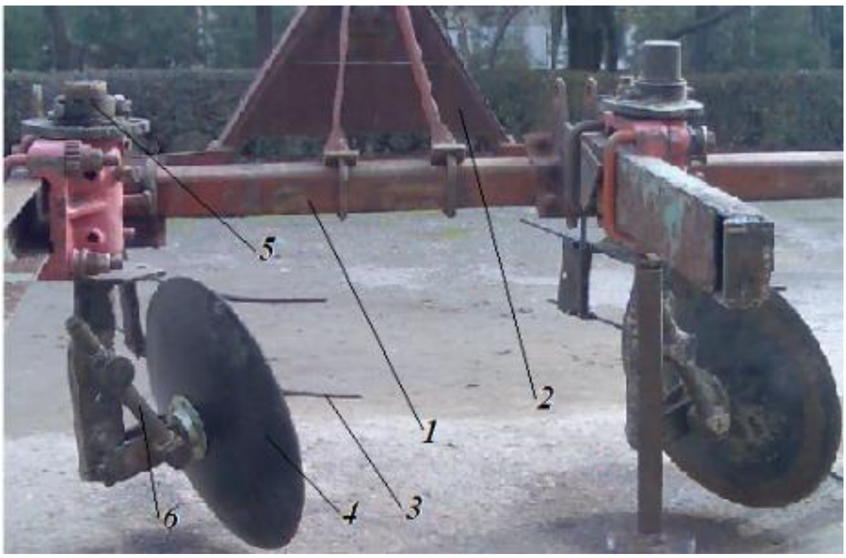



**Fig. 11.** The experiment device

The device consists of a transverse frame 1, a suspension device 2, a tilter 3, a spherical disc 4, and an adjuster 5 for the angle of its installation relative to the direction of movement and an adjuster 6 for the angle of backward deviation relative to the vertical.

A spherical disk with a diameter of 510 mm was selected based on the conducted theoretical studies. First of all, in the experiments, the change of the angle of laying the stalks concerning the axis of the egat was studied depending on the angle of installation concerning the direction of movement of the spherical disc.

Experiments were carried out at velocities of 1.72 and 1.94 m/s by installing spherical discs with a diameter of 510 mm at a depth of 15 sm. In the experiments, the installation angle of the spherical disc concerning the direction of aggregate movement was changed from 200 to 35º with an interval of 5º.

The results of the experiments are presented in Figure 12.

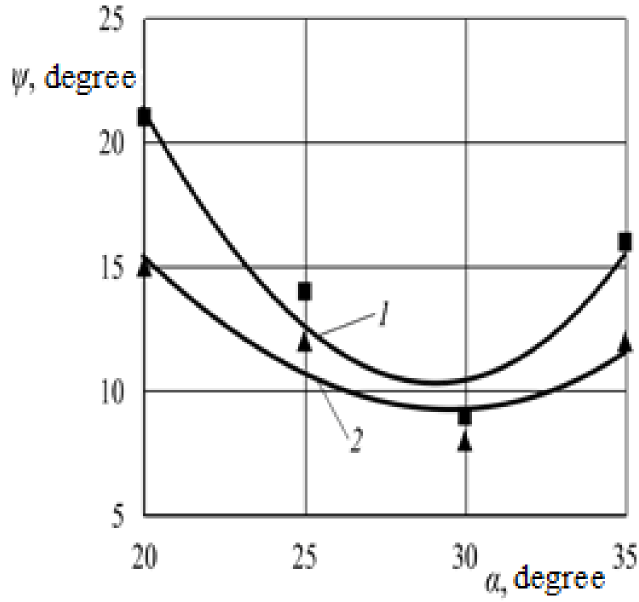



**Fig. 12.** Dependence of the bearing angle of the stalks relative to the axis of the spherical disk relative to the direction of movement of the spherical disk 1 is 1.72 m/s; 2 is 1.94 m/s

As can be seen from the obtained results, with the increase of the installation angle of the spherical disc concerning the direction of movement, the angle of laying of the rods concerning the edge of the stalks first decreases to the smallest value according to the law of parabola, and then increases.

The aggregate speed was 1.72 m/s, and when the spherical disk was set at 30º, the angle of laying of the stalks concerning the axis of the egate was the smallest, i.e., 8º, and when it was set at 20, 25, and 35º, it was 21º, 12º, and 16º, respectively.

When the unit speed is 1.94 m/s, and the spherical disc is set at 30º, it was observed that the angle of laying the stems concerning the ground is 8º, and when it is set at 20, 25 and 35º, it is 15º, 12º and 16º, respectively.

In this situation, when the spherical disc is set at an angle smaller than 30º, the plant's stem with root soil is thrown along the edge relative to the initial position; as a result, the root system falls to the side of the plant. When the spherical disc is set at an angle greater than 30º, the stalk is thrown to the center of the egate, but it falls to the side of the egate before reaching the center of the egate.

Because at large installation angles on the working surface of the spherical disc, the friction forces of the stem and the soil on the disc increase, which leads to a decrease in their throwing speed.

https://doi.org/10.1051/e3sconf/202336504023

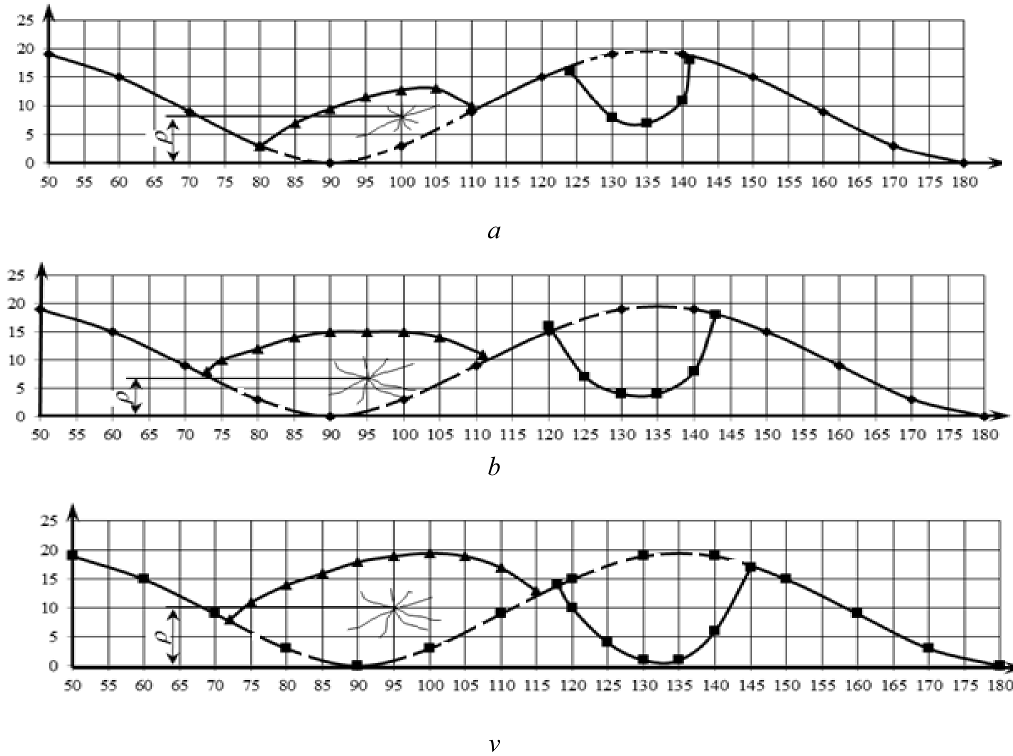



**Fig. 13.** Dependence of the distance of laying the stalks to the bottom of the egate on the depth of processing of the spherical disc *a, b* and v are processing depth 12.15 and 18 cm

When studying the processing depth of the spherical disc, experiments were carried out with it set to a processing depth of 12, 15, and 18 sm, and as an evaluation criterion, the distance of the cotton stalks to the bottom of the cone was accepted. v is given in the pictures.

When the processing depth of the spherical disc was 12 cm, the distance from the neck of the stems to the bottom of the stem was 8 sm (Figure 13, a).

13, As can be seen from the picture b, the distance from the neck of the stem to the bottom of the stem was 6 cm when the processing depth was 15 sm.

When the spherical disk worked to a depth of *18 cm* and pushed the rooted cotton soil to the edge, the distance from the neck of the stalks to the bottom of the edge was *r = 10.6 sm* (13,*v*– расм). Because the amount of soil cut by the spherical disc has increased, the density of the soil is greater than that of the roots, so the roots are thicker due to the roots going to the bottom of the soil. So, working with a spherical disc at a depth of 12 and 15 sm provides the minimum value of the distance of laying the stalks to the bottom of the edge, but the working width of the spherical disc at 12 sm is also small. Therefore, the processing depth of the spherical disk was 15 sm.

Multifactorial experiments were conducted using the method of mathematical planning of experiments to determine the joint optimal values of the parameters studied in the theoretical studies of the spherical disk and the one-factor experiments.

**Table 1.** Conditional designation of factors, range, and levels of change

| Naming of factors | Unit of measure | Designation | Change interval | Levels of factors | | |
|---|---|---|---|---|---|---|
| | | | | -1 | 0 | +1 |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Installation angle relative to the direction of movement$\alpha$ | *degree* | $X_1$ | 5 | 25 | 30 | 35 |
| The angle of deviation relative to the vertical $\beta$ | *degree* | $X_2$ | 5 | 10 | 15 | 20 |
| Processing depth, *a* | *cm* | $X_3$ | 3 | 12 | 15 | 18 |
| Movement speed, *V* | *m/s* | $X_4$ | 0,22 | 1.50 | 1.72 | 1.94 |

When conducting multi-factor experiments, the angle ($U_1$) and the height ($U_2$) of the stalks concerning the bottom of the plant were taken as evaluation criteria. After processing the experimental results, the following regression equations that adequately describe the evaluation criteria were obtained.

The angle of laying the stalks relative to the axis of the tree, degrees

$$Y_1=9.198-0.350X_1-1.333X_2-2.233X_3-4.500X_4+2.390X_1^2-0.78X_1X_2- -1.083X_1X_4+1.491X_2^2+0.917X_2X_3+5.324X_3^2+2.657X_4^2 \quad (11)$$

the height of the placement of the stems relative to the bottom of the plant, cm

$$Y_2=6.784-1.307X_1+1.0963X_2-0.8633X_3+1.065X_4+2.1599X_1^2+ +0.265X_1X_2+0.553X_2^2+1.299X_3^2-0.957X_3X_4-0.7261X_4^2 \quad (12)$$

The installation of the spherical disk concerning the direction of movement and the angle of deviation relative to the vertical, as well as the increase in the depth of processing and the speed of aggregate movement, caused a decrease in the angle of laying the stalks concerning the axis of the tree.

The conditions were accepted that the angle ($U_1$) of the stalks should be at least 10 sm, and the height ($U_2$) of the stalks should be less than 10 sm.

**Table 2.** Acceptable values of a spherical disc

| *V* ($X_4$), m/s | | $\alpha$ ($X_1$), degree | | *B* ($X_2$), degree | | *a* ($X_3$), sm | | $\psi$ ($Y_1$), degree | $\rho$ ($Y_2$), sm |
|---|---|---|---|---|---|---|---|---|---|
| Encoded | Real | Encoded | Real | Encoded | Real | Encoded | Real | | |
| -1 | 1.55 | 0.010 | 30º | 1 | 20º | 0.123 | 15.37 | 15º54<sup>I</sup> | 6.66 |
| 0 | 1.77 | 0.237 | 31º10<sup>I</sup> | 1 | 20º | 0.123 | 15.37 | 9º8<sup>I</sup> | 8.20 |
| +1 | 1.99 | 0.463 | 32º19<sup>I</sup> | 1 | 20º | 0.123 | 15.37 | 6º54<sup>I</sup> | 8.5 |

The results of the multi-factor experiment using the mathematical planning method show that the aggregate speed is 1.77–1.99 m/s, 30–32º relative to the direction of aggregate movement, and the angle of deviation relative to the vertical is 20º. ,0 cm high and at an angle of 6-10º to its axis.

This condition satisfies the set agrotechnical requirements.

A pilot-industrial copy of it was prepared based on theoretical and experimental studies of all working bodies in the combined aggregate. (Figure 14, *a, б*).

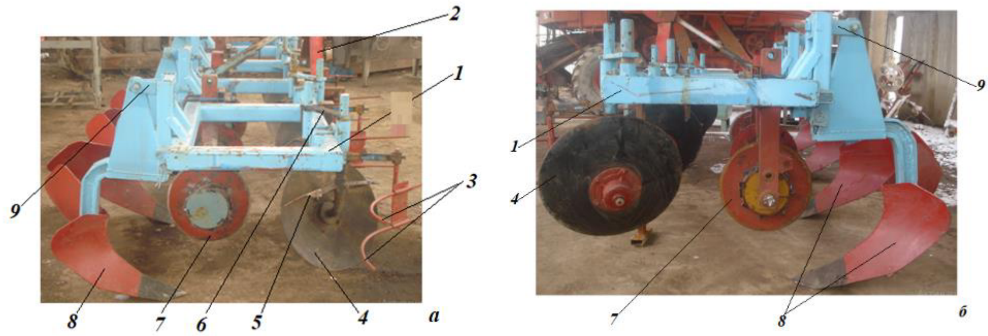



**Fig. 14.** Views of the combined aggregate: 1 is frame; 2 is suspension device; 3 is bender; 4 is spherical disc; 5 is scraper; 6 is adjustment screw of the spherical disk; 7 is flat disc; 8 is push-button; 9 is the screw of adjustment of the pusher

Field tests have been conducted with this combined unit for many years. The technology planned by the combined unit was successfully implemented.

However, there have been suggestions by several farmers that mulching is more effective. To provide positive solutions to the proposals, scientific research and construction works are carried out by crushing and burying the stalks.

## 4 Conclusions

The following conclusion was formed based on the results of theoretical and experimental research on the combined aggregate spherical disk

- spherical disc can perform the technological processes of cutting the stalks of the existing bush with the root soil and throwing them to the middle of the field.

-the diameter of the spherical disk is 510 mm, the working depth is 13–17 sm, the direction of movement and the installation angles relative to the vertical are 30–32° and 16–20°, respectively, and the radius of curvature is 54 mm.

- crushing the cotton stalks and then burying them under the new tussocks increases the effectiveness of the technology in preparing the fields for tussock planting.

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