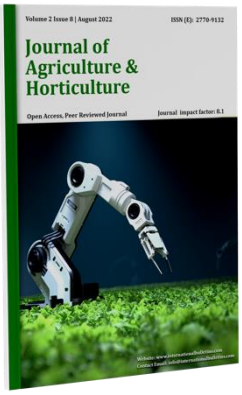

SUBSTANTIATION THE DISC RIPPER PARAMETERS OF THE PLOWING UNIT

Tukhtakuziev A.
Doctor of Technical Sciences, Professor,
Nurmanov S.S.
PhD basic doctoral student,
Ergashev M.M.
PhD in Technical sciences, Senior Researcher,
Usarov M.M.
Head of the machine and mechanism design department.
Research Institute of Agriculture Mechanization
Tashkent Region, Uzbekistan
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Abstract

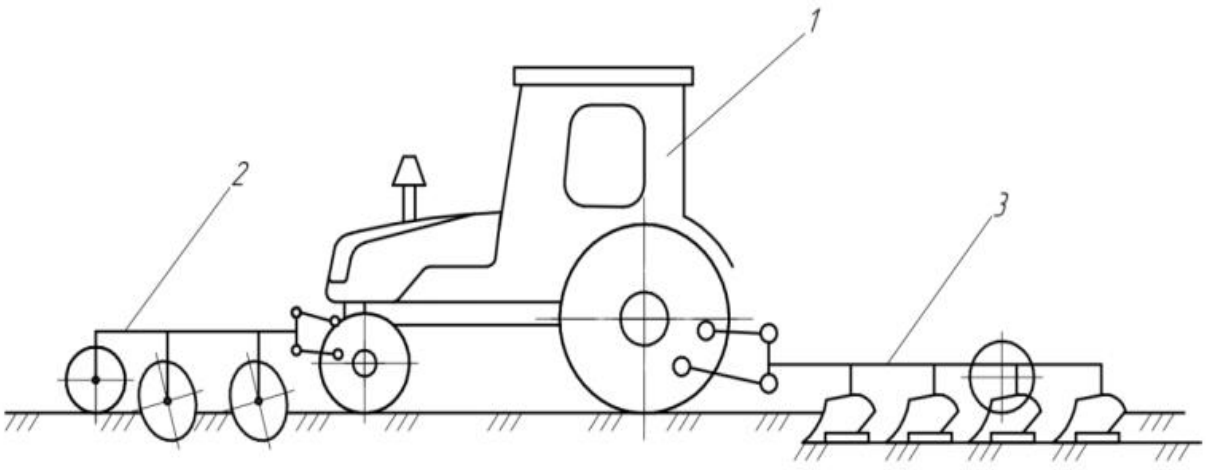
The information about the unit and technological process of the developed combined plowable unit , consisting of disc ripper and plow and mounted appropriately in front and behind the tractor are specified in the article. The results of theoretical studies to substantiate the installation angles to direction of movement and vertical, diameter and radius of curvature of the working surface of discs of its disc ripper and transverse and longitudinal distances between them are mentioned as well.

Keywords: combined plowable unit, disc ripper, plow, tractor, technological process of operation, parameters of the disc ripper, results of theoretical researches.

Introduction

In the Republic of Uzbekistan, the agricultural crops are cultivated on irrigated lands. At the same time, vegetation watering is carried out along furrows at the depth down to 20 cm. Therefore, fields surface after harvesting crops, i.e. before plowing, have irregularities in the form of furrows and ridges. In addition, after harvesting, large number of uncollected and unpolluted plant residues remain on the field surface. All this worsens the uniformity of the plowing depth (its deviation from the set one exceeds the permissible limit (± 2 cm) by 4-6 times), leads to incomplete and shallow sealing of plant residues, plow faces.

Based on above, there have been developed a combined plowable unit [1] consisting of the disc ripper and plough mounted on tractor, accordingly, in front and behind (Figure 1). It combines the technological processes of t the field surface for plowing and in plowing.



1-tractor; 2-disc ripper; 3-plough

Fig.1. Scheme of the combined plowable unit

Disc ripper consists of frame with hinged device and support wheels mounted on it in two rows of operating elements in the form of spherical disks.

During the operation process of combined plowable unit, the operating elements in the form of spherical disks (*hereinafter disks*) of the disk ripper align the irregularities on the surface of the field by moving the soil ridges into irrigation furrows and grind the plant residues remaining on the surface of the field and thereby create favorable conditions for the uniformity of the plow stroke in depth, complete and deep sealing of plant residues, it is excluded plough faces, which helps to improve the quality of operation and labor productivity.

It should be noted that the discs of the disk ripper placed in the first row, cut the soil and crushed plant residues are moved along the unit to left, and discs of the second row move them to the right side. This helps to increase the quality of leveling the field surface and good mixing of soil and plant residues.

Materials and methods of Research

This article describes the results of theoretical studies to substantiate the disk ripper parameters of the combined plowing unit, implemented by applying the basic principles of agricultural mechanics.

Research results and their discussions

The following are the main parameters of the disk ripper of combined plowable unit (Figure 2): α, β-respectively the installation angles of discs to the movement direction of and vertical side; *D*-diameter of the discs; *R*- curvature radius of the working surface of the discs; *l*-the transverse distance between disks of the first and second rows; *m* - the transverse distance between discs installed in one row; *L* - the longitudinal distance between disks of the first and second rows.

Installation angles of discs to the direction of movement and vertical side have significant impact on quality of soil crumbling, the ridges of field surface and bottom of the furrow, the depth of sealing and degree of plant residues grinding, and based on previous studies [2-4], their values are assumed to be within 25-30 ° and 15-20 °, appropriately.

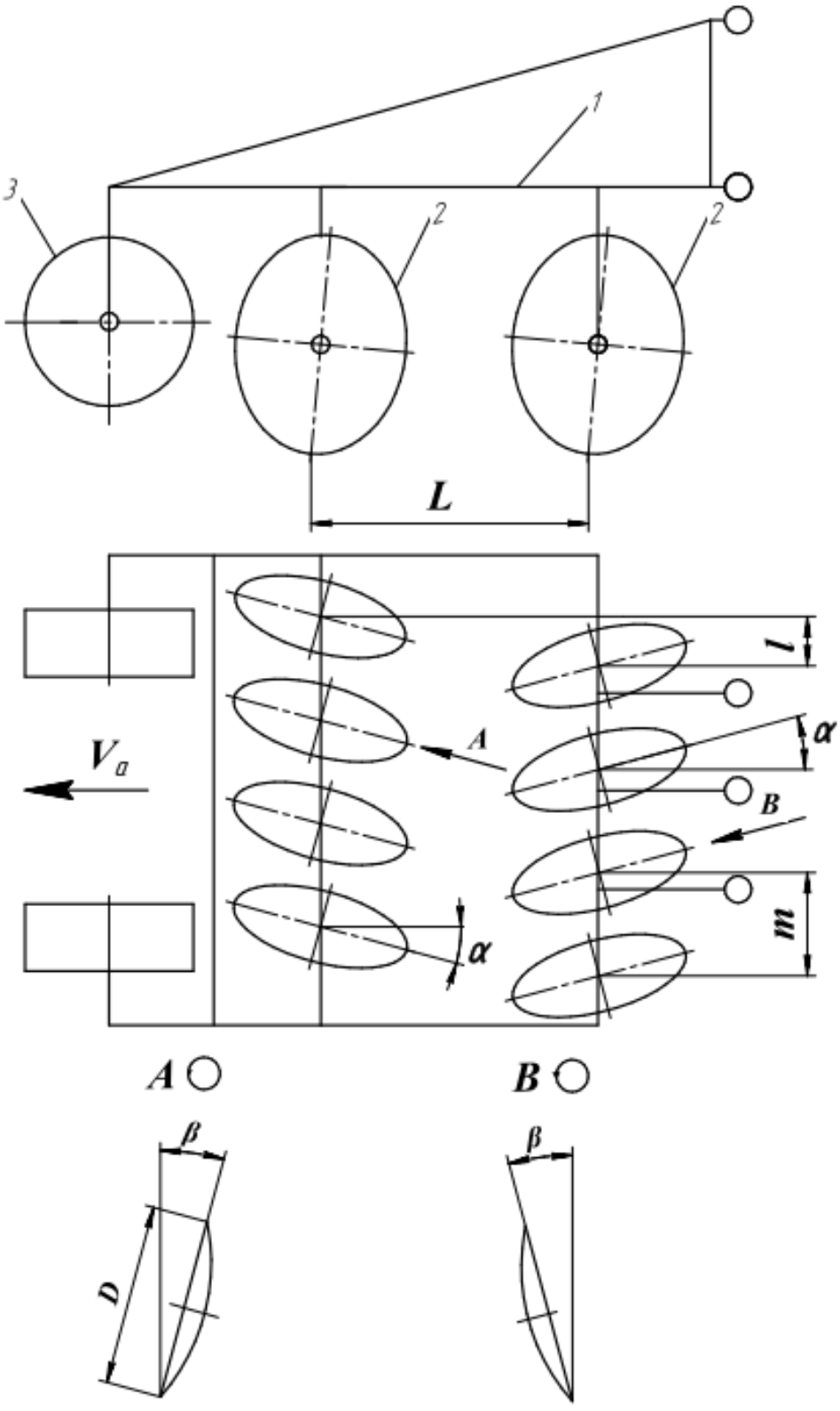
Discs diameter is determined base on terms of pressing into the soil of plant residues located on the soil surface, or cutting them by discs' blades and in order for its determination, considering the diameter of plant residues, their friction angles on the disc blade and on the soil surface, tillage depth installation angle of the disks to vertical side, the following formulas are obtained:

$$D \geq \frac{d\left[1+\left(\cos\varphi_1+\cos\varphi_2\right)\right]\cos\beta+2h}{\left[1-\cos\left(\varphi_1+\varphi_2\right)\right]\cos\beta}, \qquad (1)$$

where *d* – the plant residues diameter on soil surface, m;

φ_{1p}, φ_{2p} – the friction angles of plant residues on disc blade and on the soil surface, appropriately, º;

h – the processing depth of disc ripper, mm.



1-frame with hinged device; 2-spherical disk; 3-supporting wheel

Fig.2. Scheme and main parameters of the disk ripper of combined plowable unit

Curvature radius of the discs' working surface is determined by known value of their dimeter as per the following formula [5]:

$$R \geq \frac{D}{2\sin\varphi_э} \qquad (2)$$

either considering (1)

$$R \geq \frac{d\left[1+\cos\left(\varphi_{1ў}+\varphi_{2ў}\right)\right]+\frac{2h}{\cos\beta}}{2\left[1-\cos\left(\varphi_{1ў}+\varphi_{2ў}\right)\right]\sin\varphi_э}, \qquad (3)$$

where $\varphi_э$ – the central angle in the disk equatorial section, º.

Transverse distance between disks of the first and second rows was determined by the following formulas obtained base on terms that height of untreated longitudinal ridges formed between them at the furrow bottom did not exceed the permissible value [Δh] [6], т.е.

$$l \geq \frac{1}{c}\left\{b\left\{\frac{\sqrt{d}}{2a}\left[b^2\sqrt{\frac{1}{\left(4ac-b^2\right)c}}+\sqrt{\left(4a-\frac{b^2}{c}\right)}\right]-\left[\Delta h\right]\right\}-\right.$$

$$\left.-\left\{4cd-\left(4ac-b^2\right)\left\{\frac{\sqrt{d}}{2a}\left[b^2\sqrt{\frac{1}{\left(4ac-b^2\right)c}}+\sqrt{\left(4a-\frac{b^2}{c}\right)}\right]-\left[\Delta h\right]\right\}^2\right\}^{\frac{1}{2}}\right\} \qquad (4)$$

where $c=\cos^2\varphi+\sin^2\varphi\cos^2\beta\sin^2\alpha$;

$b=\sin 2\varphi(1-\cos^2\beta\cos^2\alpha)$;

$d=0{,}25D^2\cos^2\beta\sin^2\alpha$;

$a=\sin^2\varphi+\cos^2\varphi\cos^2\beta\sin^2\alpha$.

Transverse distance between the discs mounted in one row was determined from the condition of ensuring complete plowing of the layer they processed according to below formula

$$m \leq D\sin arctg\left(\frac{tg\beta}{\cos\alpha}\right)-l+h\cos\left(\alpha+\varphi_1\right):$$

$$:\left[\cos\varphi_1\cos\frac{1}{2}\left(90°-\arccos\frac{\sqrt{R^2-\left(0,5D\right)^2}}{R}-\beta+\varphi_1+\varphi_2\right)\right] \qquad (5)$$

either considering (4)

$$m \le D \sin arctg\left(\frac{tg\beta}{\cos\alpha}\right) - \frac{1}{c}\left\{b\left\{\left[\frac{\sqrt{d}}{2a}b^2\sqrt{\frac{1}{(4ac-b^2)c}} + \right.\right.\right.$$

$$\left.\left.\left. + \sqrt{\left(4a - \frac{b^2}{c}\right)}\right] - [\Delta h]\right\} - \left\{4cd - (4ac - b^2)\left\{\frac{\sqrt{d}}{2a} \times \right.\right.\right.$$

$$\left.\left.\left. \times \left[b^2\sqrt{\frac{1}{(4ac-b^2)c}} + \sqrt{\left(4a - \frac{b^2}{c}\right)}\right] - [\Delta h]\right\}^2\right\}^{\frac{1}{2}}\right\} + h\cos(\alpha + \varphi_1):$$

$$: \left[\cos\varphi_1 \cos\frac{1}{2}\left(90° - \arccos\frac{\sqrt{R^2 - (0,5D)^2}}{R} - \beta + \varphi_1 + \varphi_2\right)\right], \qquad (6)$$

where φ_1, φ_2 – angles of the external and internal friction of soil, º.

Longitudinal distance between the disks of the first and second rows was determined from terms that the propagation zone of soil deformation under influence of disks of the second row in the longitudinal direction did not reach disks of the first row, because otherwise there is clogging of soil, plant residues and weeds between the disks of the first and second rows, which leads to disruption of technological process of the disk ripper and increase its traction resistance. In this case, the following formulas are obtained

$$L \geq 2\sqrt{\frac{h}{\cos\beta}\left(D-\frac{h}{\cos\beta}\right)}\cos\alpha+\left\{\left\{D\sin arctg\left(\frac{tg\beta}{\cos\alpha}\right)+\right.\right.$$

$$+h\cos(\alpha+\varphi_1):\left[\cos\varphi_1\cos\frac{1}{2}\times\right.$$

$$\left.\left.\times\left(90^\circ-\arccos\frac{\sqrt{R^2-(0,5D)^2}}{R}-\beta+\varphi_1+\varphi_2\right)\right]\right\}-$$

$$-2\left(0,5D-\frac{h}{\cos\beta}\right)\sin\beta\cos\alpha\Big\}tg(\alpha+\varphi_1)+$$

$$+\left(0,5D-\frac{h}{\cos\beta}\right)\sin\beta tg\alpha. \qquad (7)$$

Performed calculations base on formulas (1)-(7) in the event if d=3 cm, φ_{1p}=30º, φ_{2p} = 40º, h = 10 cm, β =15º, $\varphi_э$= 25º, α = 30º, Δh=2,0 cm, φ_1 = 30º and φ_2 = 40º showed that disk diameter of the disk ripper must be at least 380 mm, the curvature radius of its working surface must be at least 445 mm, the transverse distance between disks of the first and second rows must be at least 65 mm, transverse distance between the disks installed in one row must not exceed 300 mm, and longitudinal distance between the disks of the first and second rows– at least 835 mm.

Conclusions

Thus it is prescribed in effort to provide the preset technological process of operation, i.e. to level the unevenness of the field surface and to crush the plant residues existing on it, the installation angles to movement direction and vertical side of disks of the disk ripper of the combined plowable unit should be accordingly within 25-30º and 15-20º, the disks diameter - not less than 380 mm, the curvature radius of their working surface - not less than 445 mm, the transverse distance between disks of the first and second rows - not less than 65 mm, the transverse distance between disks of the first and second rows - not less than 65 mm, the transverse distance between the disks of the second rows - not less than 65 mm, the transverse distance between the disks of the first and second rows - not less than 65 mm.

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