DESIGN JUSTIFICATIONS FOR A ROTARY TILLAGE MACHINE IMPLEMENT

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Abstract:
It has been proposed to carry out strip-tillage for sowing cucurbitaceous crops. Plough working tools of frontal plough are used for main tillage and loosening-levelling device for strip-tillage in the sowing area is installed by the hulls.

Keywords: soil, gourds, irrigation furrow, knife curvature radius.

The cucurbits are among the most common crops cultivated in regions with warm and hot climates. Their ability to produce high yields in semi-desert conditions, where other crops are problematic, has ensured their widespread popularity. At present, melons are cultivated in more than 130 countries of the world [1,2].

When preparing the soil for melons, a number of technological operations are carried out in a certain sequence. All of them are carried out during solid tillage of the field. Studying the peculiarities of cucurbits cultivation, it can be noted that solid tillage of the field is not required. Working the whole field, we have a large cost of labor and energy. To reduce the cost there and energy is proposed to produce a strip-till the field. In this case, we do not violate the technological requirements for the cultivation of melons. Strip tillage should be carried out in the zone of crop rows and formation of irrigation furrows between them.

To perform a full set of works on soil preparation it is necessary to carry out the following technological operations: plowing to a depth of 22...27 cm; pre-sowing tillage; formation of an irrigation furrow [3,4].

As part of a combined tillage unit for pre-sowing tillage it is proposed to use rotary working tools with spherical knife elements. For effective operation of such a working body it is necessary to justify its design and technological parameters. Their choice cannot be made arbitrarily, because there are rational limits of their variation, and geometric elements of design are linked by functional relationships.

In the modern stage of disc tillage machines solid or notched discs with a constant curvature of their surface are used. Working tools with variable surface curvature are usually not used. In this connection we also use knife elements with constant curvature of the blades. The tool is mounted with a zero angle of attack. In order to increase the processed surface of the field, the blade elements are installed on the disc with the curvature directed in different directions from the plane of their attachment. The blades are sharpened on the outer and inner sides of the knife elements. Recommended blade sharpening angle i=15…200. The thickness of the knife elements can be determined by the following empirical relationship [5]:

$$\delta = 0{,}008\, D, \qquad (1)$$

where D - diameter of the tool, mm.

The results of the interaction of the implement with the soil depend on the size and curvature of the blade elements, the operating speed of the machine, and the properties of the processed medium. The diameter of the rotary tool largely determines the quality of the operation. An excessive increase in its value is undesirable, as the vertical component of soil resistance, tending to push the tool out of the soil, increases. Depending on the working conditions, the smallest diameter among the permissible values should be chosen, because the load required for penetrating the tool increases sharply as the diameter of the tool increases. The diameter therefore depends on the working depth and can be determined as follows [6]:

$$D = ka, \qquad (2)$$

where k - coefficient equal to (4 ... 6); a -the processing depth, cm.

Soil crumbling during cultivation is largely determined by the curvature of the blade tools. The greater the curvature of the knife, the more crumbly the soil is when using it. Nevertheless, the determination of its curvature radius depends on the diameter of the tool, the angle of blade sharpening and the working depth. The diameter and radius of curvature of the blade are interrelated parameters. Depending on the diameter, the radius of curvature of the blade element can be determined by the expression

$$R = \frac{D}{2sin\varphi} \qquad (3)$$

where 2φ – angle at the apex of the sector (fig. 1).

Half of the central angle of the spherical sector φ for the huskers is - φ = 26 ...320, harrows - φ = 22 ...260. The radius of curvature of the blade element is a constant value. We take its value for our case to be 260.

The basic geometric parameters of the spherical knife working body include its diameter, the radius of curvature, half of the angle at the top of the disc sector. By additional, the angle of the sharpening taper ω and the sharpening angle i. We define them as follows. According to the expression 2 for k=5 and a working depth of 8 cm we have a blade diameter of 400 mm. From dependence 3, the radius of curvature of the knife element is 455 mm. The thickness of the blade element according to formula 1 is 3.2 mm. Taking into account the safety margin, we accept δ = 4 mm. The width of the knife element in terms of its strength is taken 40 mm.

In connection with the installation of knife elements on the disk with the curvature directed alternately in different directions from the plane of their mounting on the flange, the width of capture of such a working device will be 10 cm. It is possible to locate 12 blade elements on the flange of the working device taking into account their geometrical dimensions and fastening. In this case, 6 of them will be directed by the curvature in different directions (fig.1).

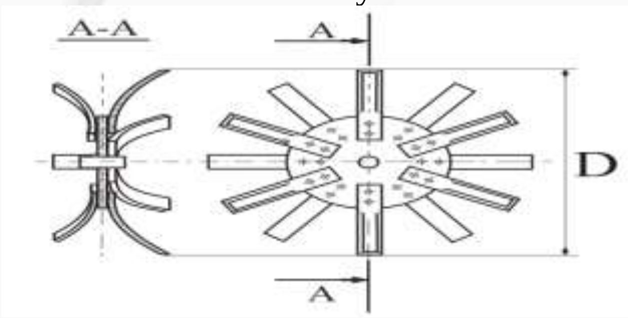

Fig. 1. Rotary tillage implement

If it is necessary to perform strip tillage in the zone of sowing 30 cm wide, it is necessary to combine three such rotary working bodies into batteries.

Conclusions. The use of a combined tool for strip-tillage under cucurbitaceous crops allows reducing the time of work, preserving moisture in the soil, protecting the field surface from compaction by reducing the number of machine passes and ensuring high quality of technological operations.

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