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DETERMINING SOIL DEFORMATION ZONES AND PLACING THE LOOSENING SHAWLS ON THE CULTIVATOR FRAME

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Abstract

Targeted scientific research is being conducted around the world to create resource-saving technologies for preparing fields for sowing before sowing seeds of agricultural crops and new models of technical means for their implementation, to develop scientific and technical foundations for improving existing ones, and to ensure resource efficiency in the work process. Development of agrotechnical demonstrators of existing chisel cultivators and the development of material and energy efficiency savings methods and, in this regard, the development of a construction scheme for chisel cultivation

Keywords: chisel cultivators, zone, soil, deformation, draw

Introduction

The main purpose of ensuring that the working bodies of chisel cultivators fully cover the soil is to improve its quality of loosening and prevent the formation of large clods. This is especially important for chisel cultivators, as ensuring adequate soil loosening is the most important and basic agrotechnical requirement when cultivating land before planting.

In an improved chisel-cultivator, the working elements in the first row act on the solid soil, i.e., they work in closed cutting conditions, while the working elements in the second and third rows act on the soil layers with softened zones formed by the working elements in the first row on the sides, i.e., they work in open cutting conditions.

The zone of deformation of soil with plastic properties is not limited to the zone of contact with the working element, but extends forward and to the sides over a considerable distance. The soil layer moving along the working surface of the paw is subject to the normal force N (Fig. 1) and the friction force F_{max}, which

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together give the resultant $\overline{R}=\overline{N}+\overline{F}_{max}$, deviated from the normal by the friction angle φ of the soil on the paw.

According to the theory of the greatest tangential stresses, the directions of the planes H_1 and H_2, along which the layer can be destroyed as a result of shearing (cracks are formed), are located symmetrically relative to the resultant R at an angle θ. The value of the angle θ depends on the properties of the soil and its condition. The soil deformation zone extends forward from the bottom of the furrow to the surface of the field (Fig. 2) at a distance from the toe

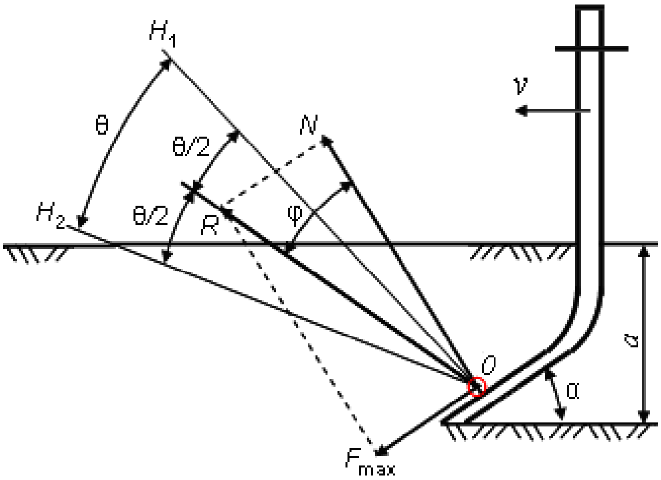

Fig. 1. Acting forces and planes of shearing of the soil layer in the longitudinal-vertical plane

The width of the soil deformation zone b_p by a loosening paw in the plane of shearing is considered the width of the grip of this paw.

$$l = a\mathrm{tg}(\alpha + \varphi) \quad (1)$$

According to the diagram (Fig. 2), the width of the deformation zone (capture) of the paw will be

$$b_p = b_o + \frac{2a\mathrm{tg}(\theta/2)}{\cos(\alpha + \varphi)}, \quad (2)$$

where bo is the design width of the paw, mm; a is the depth of processing, mm; θ is the angle between the planes limiting the area of soil deformation, deg.; α is the angle of entry of the paw into the soil.

Paw spacing step, (3)

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$$t = b_o + \frac{2h\mathrm{tg}(\theta/2)}{\cos(\alpha+\varphi)} \quad (3)$$

The width of the ripper paw grip can be determined graphically. The arrangement of the ripper paws on the beam is carried out taking into account the overlap of the soil deformation zones in width so that the height of the untreated ridges is $h \le 2/3a$ (Fig. 2). At $h = 2/3a$, the spacing of the paws is

$$t = b_0 + \frac{1{,}333a\mathrm{tg}(\theta/2)}{\cos(\alpha+\varphi)}, \quad . (4)$$

in this case, the overlap of deformation zones

$$\Delta b_p \ge \frac{0{,}667a\mathrm{tg}(\theta/2)}{\cos(\alpha+\varphi)} \quad . (5)$$

When the paws are arranged in 2 rows or more, the degree of clogging with plant residues and soil is reduced.

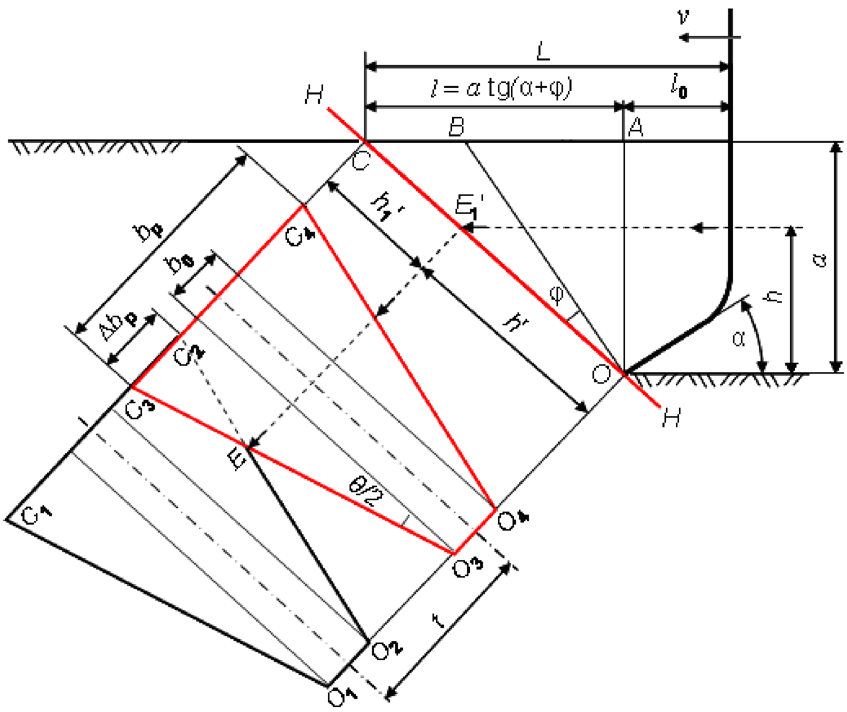

Fig. 2. Zones of soil deformation by cultivator paws in the plane of shearing H – H.

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Contents of the report: summary of the work, necessary calculations and constructions: deformation zones and placement of paws (according to Fig. 2 and 3), conclusion. Designation: B — cultivator grip width; a — processing depth; bo — structural width of the loosening paw; α — angle of paw entry into the soil; φ — angle of soil friction on the paw material; θ — angle between planes limiting the area of soil deformation; lo — paw tip extension relative to the stand; f — coefficient of soil friction on the paw.

The distance between the rows of loosening paws consists of the longitudinal deformation zone l and the extension of the paw tip relative to the stand lo, that is:

$$L \geq l_o + a \cdot \mathrm{tg}(\alpha + \varphi), \quad (6)$$

The number of paws is determined by the width B of the cultivator's grip, that is:

$$z = \frac{B}{t} = \frac{B}{(b_p - \Delta b_p)}, \quad (7)$$

When installing paws in two rows, their total number must be odd, and in the second row one more paw is installed than in the first. Determine the width of the loosening paw grip, spacing, overlap, number of paws and distance between rows of paws when they are arranged in 2 rows or more. Graphically determine the soil deformation zone of the loosening paws (compare with the calculated data) and their arrangement.

Determine graphically the width bp of the soil deformation zone by a loosening paw, the spacing of the paws t in the transverse direction and the overlap value Δb_p of the deformation zones by adjacent paws, compare them with the calculated values.

Draw the soil deformation in the H – H shear plane (Fig. 2), for which:

– draw two horizontal lines at a distance a (the surface of the field and the bottom of the furrow), mark a point O (the position of the toe of the paw on the bottom of the furrow), draw two vertical lines: OA and at a distance lo and the line of the position of the paw stand; then lines: at an angle α to the bottom of the furrow (the line of the position of the paw in the furrow), perpendicular to it straight line OB and at an angle φ to it straight line OC (soil shear lines);

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– construct a zone of transverse soil deformation with a paw in the H–H plane of the location of the straight line OC: draw straight lines perpendicular to OC, mark a point O_4 at some distance from point O and at a distance bo (the design width of the paw) mark a point O_3, from points O_3 and O_4 draw lines parallel to the straight line OC to the level of the field surface, from the same points at an angle θ/2 to them – lines O_4C_4 and O_3C_3, then from the construction the distance $C_3C_4= b_p$ is the zone of soil deformation;

b) on the longitudinal-vertical projection of soil deformation, set aside from the bottom of the furrow the permissible height of unprocessed ridges, equal to the height h=2/3a, at the intersection with line OC, mark point E'1. Draw a line through point E'1 (indicated by arrows) to the intersection with line O_3C_3 and determine the position of point E;

c) by analogy, construct the soil deformation zone with the adjacent paw;

Determine the required number of loosening paws, rounding the obtained values to a larger whole number when arranged in one row, to a larger whole odd number when arranged in two rows, and specify the spacing step t of the arrangement and the overlap Δbp of the paws based on the adopted number of paws.

Construct a diagram of the arrangement of loosening paws and deformation zones in the horizontal plane during continuous processing, similar to the diagram in Fig. 3:

a) when arranging in one row from the centre line of the cultivator with an odd number of paws, draw the centre lines of the paws at a distance equal to the pitch of the paws – the specified value t, with an even number of paws – at a distance equal to half the pitch of the paws, i.e. ½ t, and then draw the centre lines of the paws at a distance t;

b) when installing paws in two or more rows, draw a smaller number of paws in the first row and a larger number in the second; place the second row of paws from the first and subsequent ones at a distance of L between them.

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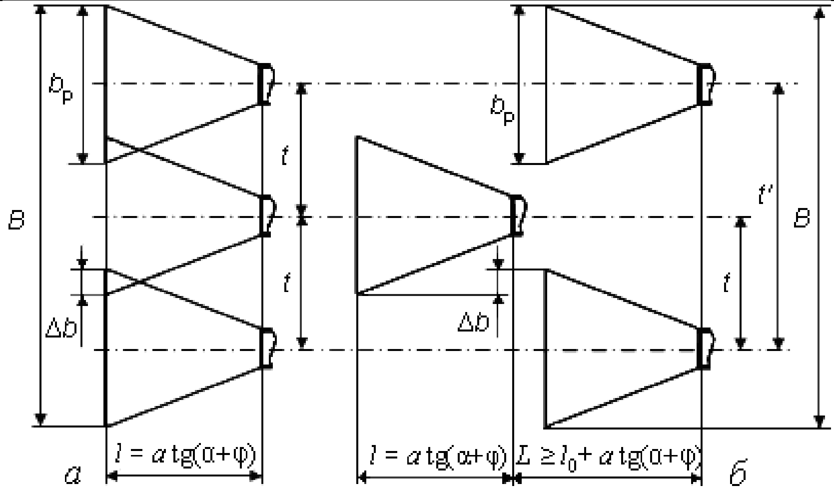

Fig. 3. Arrangement of cultivator loosening paws in one row (a) and in two rows (b), as well as soil deformation zones in the horizontal plane during continuous tillage.

When the ratio of the working hours of the working organs in the second and third quarters of the improved chisel-cultivator to the total working hours is 0.5, that is, the working bodies in the second and third quarters of the chisel-cultivation working group are equal. When processing a layer, high work quality is achieved with a low energy-intensive hand.The cultivation depth of the second row of working elements of the improved chisel-cultivator is adjusted to ensure the required values of the quality of soil loosening and the height of the unevenness formed on the field surface and the bottom of the cultivated layer with low energy consumption.

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