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Selecting a rational distance between rows of loosening working bodies and the height of the stand

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ABSTRACT: This article provides a theoretical basis for the height of the working elements of the tiller and the longitudinal distances between them of a combined machine for cultivating and planting grain on sloping fields. The distance between the rows of flat-cutting working bodies is one of the main technological parameters that determine the reliability of the technological process and its energy consumption. In addition, this parameter determines the length of the tool and its material consumption. A compromise solution to this problem is based on finding the minimum distance between the rows of working bodies that ensures free passage of the processed layer without forming a soil rampart. Depending on the distance along the surface of the soil, the height of the working elements, as well as the transverse distance between them, was determined, taking into account the size of the existing plant residues. At operating speeds of the unit of 2.0-2.5 m/s, the calculated minimum distance between rows of flat-cutting working bodies should be 0.74-0.87 m, and the minimum height of the stand should be 0.82-0.96 m.

KEY WORDS: Combined machine, soil, loosener, height of the stand, distance, chisels.

I. INTRODUCTION

Today, the world's area of cultivated fields is 1.4 billion hectares. In Uzbekistan, the area of cultivated fields with sloping lands is 734 thousand hectares, including a large part of the area under cereal crops. The food industry of our country requires 120-150 thousand tons of durum wheat per year. 30 thousand tons of the required durum wheat fall on the lands of Kashkadarya and Surkhandarya regions.Currently, the yield of cereal crops grown on fallow lands is 7-15 quintals per hectare. However, experiments have proven that if agrotechnical measures are applied correctly, 15-25 quintals of grain can be obtained from each hectare of land. So, although there is a possibility of obtaining high yields from fallow lands, the productivity in production is very low. The analysis shows the need to develop technologies and special tools for soilless tillage in Uzbekistan [1].

Researchers have developed loosenings that have different sized working bodies of the Chisel type. When treating slopes with this type of loosening, ridges are formed at the bottom and topsoil at the top of the softened layer, which contributes to water retention and accumulation in the soil, resulting in water erosion prevention [2, 3].

Taking into account the above, it is necessary to develop a machine that can cultivate and plant grain crops in one pass in the cultivation of cereals in the fallow fields, as well as to correctly select its optimal parameters when developing the machine.

II. SIGNIFICANCE OF THE SYSTEM

The study of literature survey is presented in section III, methodology is explained in section IV, section V covers the experimental results of the study, and section VI discusses the future study and conclusion.

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III. LITERATURE SURVEY

Scientists of the Regional Fund "Agrarian University Complex" have developed various designs of deep-smoothing working bodies [2, 3]. The ability of the tiller to remain free from soil and plant residues depends on the distance from the support plane of the tiller to the lower plane of the frame [4]. According to previous studies, when the distance from the lower plane of the frame to the surface of the uncoated soil is 0.3 m, the working process of the working body is reliable and it does not become clogged with soil and plant residues [5]. The maximum height of the uncoated soil is 1/4 of the working depth [6].

The longitudinal distance between the first and second row of softening paws is determined from the condition that the soil deformation zone processed by the second row of softening paws does not touch the blade of the previous row of softening paws. Otherwise, the technological process will be disrupted, and the softening paws may become clogged with soil and plant residues [7]. Accordingly, it was determined that with a tillage depth of 25 cm, the longitudinal distance between the first and second rows of softeners should be at least 47.5 cm [8].

IV. METHODOLOGY

In the studies applied methods of theoretical mechanics and agricultural mechanics. Two- and three-sided piles were used to substantiate the loosening parameters, and the processes of soil deformation and disintegration under their influence were considered [9, 10]. The main criterion for substantiating the optimal values of the loosening parameters is the quality of soil compaction, the absence of a dense layer at the bottom of the loosening layer. The main parameters of the loosening working body are its crumbling angle, solution angle and working width.

The distance between the rows of flat-cutting working bodies is one of the main technological parameters that determine the reliability of the technological process and its energy consumption. In addition, this parameter determines the length of the tool and its material consumption. A compromise solution to this problem is based on finding the minimum distance between the rows of working bodies that ensures free passage of the processed layer without forming a soil rampart.

V. EXPERIMENTAL RESULTS

The minimum distance is determined by the zone of propagation of the deformation of the layer on the soil surface relative to the working bodies [11, 12] and by the expression:

$$L_{min} = H \cdot tg\varphi + l \tag{1}$$

where L_{min} – in is the minimum distance between the rows of flat-cutting working bodies, m;

φ – is the shearing angle in the longitudinal-vertical plane, degree;

l – is the distance from the rack to the front face of the wedge, m.

Calculations using expression (1) give satisfactory results at relatively low travel speeds of 0.5-1.0 m/s. With an increase in travel speed above 1.5 m/s, it is recommended to increase the minimum distance, since this increases the role of the dynamic factor of pressure of the soil layer coming off the ploughshare of the working element of the front row [13]. However, there are no specific recommendations for choosing the minimum distance between the working elements of the front and rear rows.

It is known that soil unloading or the formation of a ridge does not occur in the case when the soil flows created by the working bodies of the front and rear rows move towards each other at different speeds, but do not collide.

To assess the influence of the speed of movement of the tool and to determine the minimum distance between the rows of flat-cutting working bodies, we will use the calculation scheme (Fig. 1), assuming that the mass of the soil layer cut by the ploughshare is concentrated in its center of mass, and the movement of the layer coming off the ploughshare occurs at a constant speed.

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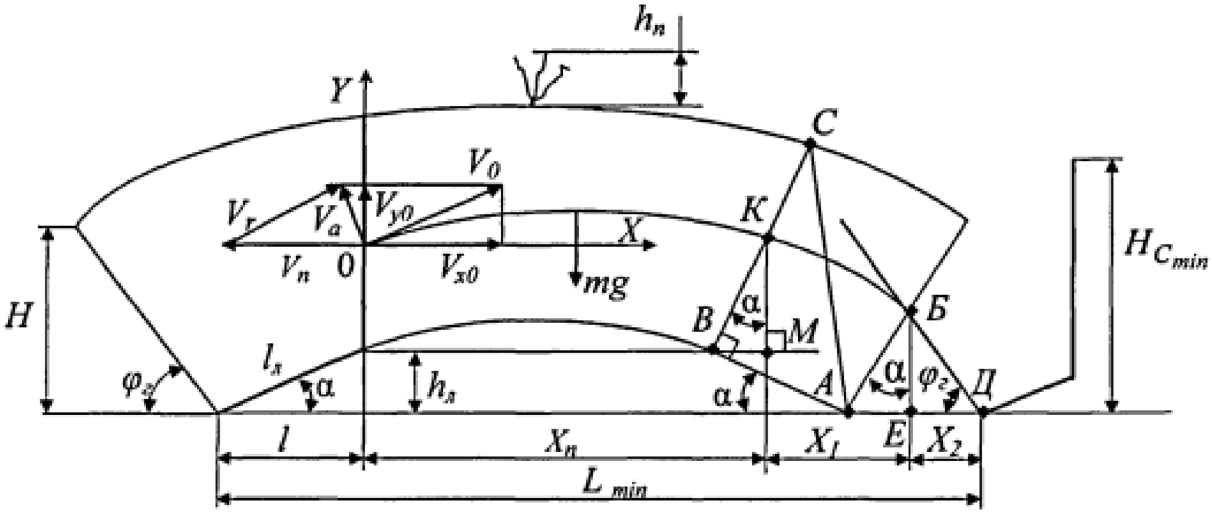

Fig. 1. Calculation scheme for determining the minimum distance between the paws in the direction of travel

Taking into account the accepted assumptions, the movement of the soil layer can be considered as the movement of a solid body thrown at an angle α to the horizon with a speed Vo under the action of the weight force. In this case, the forces of resistance to movement are neglected due to the relatively low speed of movement. The origin of the coordinate axes is placed at the point where the center of mass leaves the ploughshare, then the initial conditions of the body's movement are

$$t = 0;\ x_o = 0;\ y_o = 0;$$
$$x_0' = V_0 cos\alpha; \quad y_0' = V_0 sin\alpha.$$

Only one force is applied to the center of mass of the soil layer - its weight. Therefore, the differential equations of motion of the center of mass of the layer on the x and y axes have the form:

$$mx'' = 0; \qquad my'' = -mg. \tag{2}$$

After carrying out the transformations, the differential equations (2) can be written:

$$x'' = 0; \qquad y'' = -g.. \tag{3}$$

The solution of differential equations (3) using initial conditions has the following form:

$$x = V_0 \cdot t \cdot cos\alpha. \tag{4}$$
$$y = V_0 \cdot t \cdot sin\alpha - (gt^2)/2. \tag{5}$$

Equation of the trajectory of the center of mass of the formation

$$y = x \cdot tg\alpha - (gx^2)/(2V_n^2 \cdot cos^2\alpha). \tag{6}$$

Taking y = 0, we determine the flight range of the center of mass of the formation:

$$x_n = (V_n^2 \cdot sin2\alpha)/g. \tag{7}$$

Maximum height of rise of the center of mass of the formation:

$$y_{max} = [V_n^2 \cdot tg\alpha(1 + cos2\alpha)]/g. \tag{8}$$

The soil layer, cut by the ploughshare, having moved along a parabola, will descend to the bottom of the furrow at point A (Fig. 1). In this case, the centre of mass of the layer will occupy the position at point B, since the soil layer has descended to the bottom of the furrow and no further movement occurs, then at points A and B the speed of movement of the soil layer along the x axis will be equal to zero. Consequently, the plane of shearing of the flat-cutting working element of the rear row must pass through point B, thereby ensuring

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the condition of free passage of the layer without the formation of a soil rampart. Then the minimum distance between the working elements of the first and second rows, taking into account expressions (1) and (7)

$$L_{min} = 1.5H \cdot tg\varphi + l_l \cdot cos\alpha + (V_n^2 \cdot sin2\alpha \cdot cos\alpha)/g, \quad (9)$$

where l_l – is the length of the ploughshare, m;
V_n – is the forward speed of the unit, m/s.

When processing dry and compacted soils with a flat wedge with an angle of 25 degrees to the bottom of the furrow, the angle of inclination of the cutting plane to the horizon is in the range from 34 to 40 degrees [13].

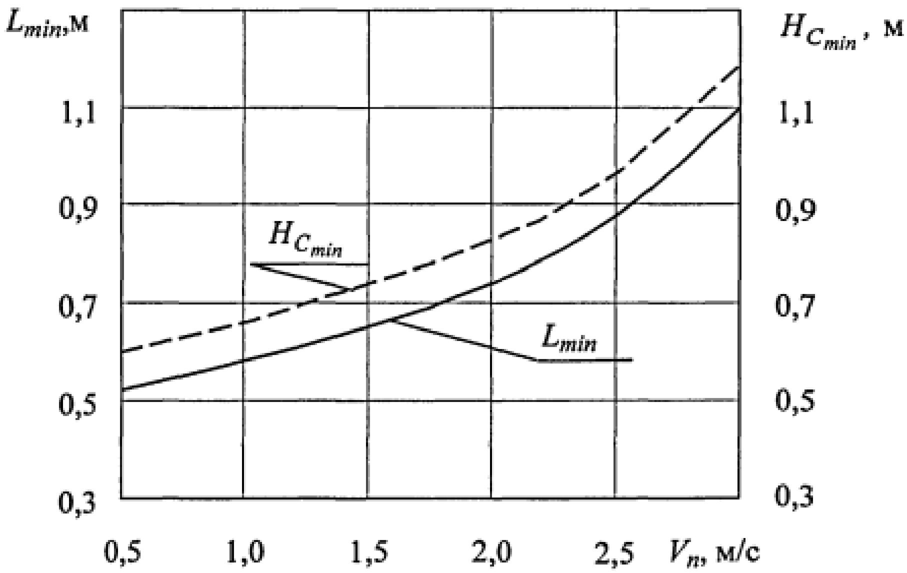

Fig. 2. The influence of the speed of the unit V_n on the minimum distance between the rows of flat-cutting working bodies L_{min} and the minimum height of the stand H_{Cmin}

The height of the stand of the flat-cutting working element must ensure free passage of the soil layer, taking into account its lifting by the ploughshare, lifting due to the dynamic pressure of the layer, the depth of processing, the height of crop residues and is determined by the expression:

$$H_{Cmin} = H + l_l sin\alpha + (V_n^2 \cdot tg\alpha(1 + cos2\alpha)cos\alpha)/g + h_n, \quad (10)$$

where h_n – is the height of crop residues, m.

Calculations performed using expressions (9) and (10) for angles of inclination of the cutting plane to the horizon pg equal to 34, 38 and 40 degrees, with a ploughshare length of 0.15 m, a processing depth of 0.3 m, a crumbling angle of 25 degrees, and a height of crop residues of 0.1 m, showed that with an increase in the speed of movement V_n and the cutting angle in the longitudinal-vertical plane φ the minimum distance between the rows of flat-cutting working bodies and the minimum height of the rack must be increased (Fig. 2).

IV. CONCLUSION

At operating speeds of the unit of 2.0-2.5 m/s, the calculated minimum distance between rows of flat-cutting working bodies should be 0.74-0.87 m, and the minimum height of the stand should be 0.82-0.96 m.

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