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Substantiation Of Loosening The Soil With A Subsoiler During Soil Processing For Sowing Melons And Gourds Under A Closed Film Tunnel

Farmon Mamatov, Khayriddin Fayzullayev, Dilmurod Irgashev, Sodiq Mustapaqulov, Matluba Nurmanova and Lola Hamrayeva

Karshi Engineering Economic Institute, 180100, Karshi, Uzbekistan, fmamatov_50@mail.ru

Abstract – This article presents the results of experimental studies to substantiate the arrangement of deep-rippers on the frame of a combined machine for preparing soil for sowing melons under a closed tunnel film.

Keywords – Machine, Soil, Melons, Pit, Frame, Traction Resistance, Working Speed, Working Depth, Scan, Soil Properties, Plug, Frontal Scheme, Coverage Width, Constructive Scheme.

I. Introduction

The development and application of energy-saving and high-productivity tillage and preparation machines for planting is a world leader in the world. "Globally, the area under tillage before planting melons and vegetables is estimated at 600 million hectares. One of the most important tasks is the development of machines for high-quality and productive work", as well as energy-saving soil preparation and preparation for planting.

II. Literature Review

A new energy-saving method of soil preparation for planting melons under a closed tunnel film proposed by the authors is surface softening of the soil in the middle part of the tunnel-wide strip, deep softening of the right and left sides of the surface-softened strip without overturning, along the axis of symmetry prepares the row for planting in the fall [1-11]. To implement this method, a constructive scheme of the combined machine was developed.

III. Materials and methods

The aim of the study was to substantiate the optimal scheme placement and parameters of the combined machine working bodies in the frame to ensure quality soil preparation when planting melons under a closed tunnel film.

IV. Research results

The parameters that determine the effectiveness of pitchers include their depth of tillage, the quality of soil softening, the width of the trace of the working bodies.

The surface of the soil loosened area affects, firstly, the quality of loosening, and secondly - the energy consumption in tillage.

Therefore, when selecting the scheme of mutual placement of working bodies bent to the right and left, it is necessary to study the effect of soil softening on the completeness, resistance to gravity and between the tracks.

When the softening completeness is determined, we assume that the width of the scales of both pairs of working bodies and the height of the sloping part are the same and that the sloping part of the working bodies moves along the fracture line of the soil.

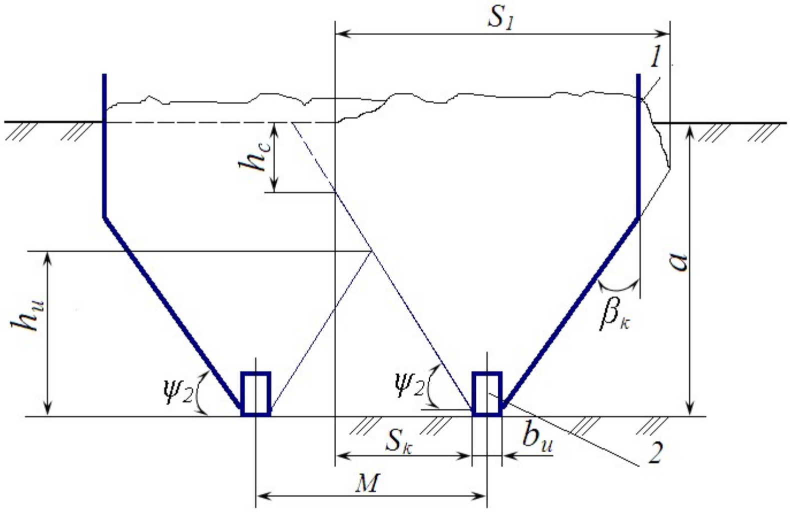

Figure 1. Scheme of softening the sludge with plungers

As can be seen from Figure 1, in the process of loosening the soil with plowshares, the zones of distribution of soil deformations intersect with each other in the zone treated by the left and right working bodies scans.

The result is a high ridge h_u beneath the drive layer.

It is known that [5;6], the quality of soil softening is evaluated by the completeness of softening, η with the softening coefficient, which is expressed in the ratio of the surface area of the softened area in the plane perpendicular to the direction of movement of the softeners bent to the right and left.

$$\eta = \frac{S_1 + S_2}{S}, \qquad (1)$$

where S_1 – is the surface of the layer softened by the working body of the first row, m^2;

S_2 – the surface of the layer softened by the working body of the second row, m^2;

S – the total surface area of the cross-sections of the layers to be softened by the working bodies of the first and second rows, m^2.

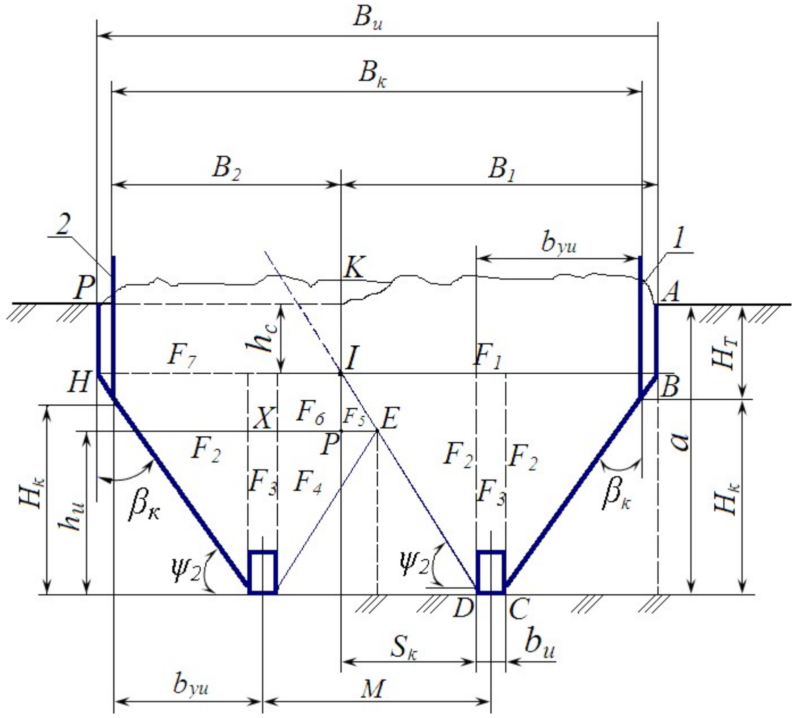

Figure 2. Scheme for determining the completeness of soil loosening with dredgers

1 – working body bent to the right; 2 – working organ bent to the left

The surface of the softened layer with the working body of the first row (Fig. 1)

$$S_1 = F_1 + 2F_2 + F_3 \tag{2}$$

The surface of the layer softened by the working body of the second row

$$S_2 = F_2 + F_3 + F_4 + F_5 + F_6 + F_7 \tag{3}$$

According to Figure 2

$$F_1 = [2(a - h_c)ctg\psi_2 + b_u]h_c; \tag{4}$$

$$F_2 = \frac{1}{2}(a - h_c)^2 ctg\psi_2; \tag{5}$$

$$F_3 = b_u(a - h_c); \tag{6}$$

$$F_4 = h_u^2 ctg\psi_2; \tag{7}$$

$$F_5 = \frac{1}{2}[(a - h_c) - h_u]^2 ctg\psi_2; \tag{8}$$

$$F_6 = [2h_u ctg\psi_2 - (a - h_c)ctg\psi_2](a - h_c - h_u);$$

$$\eta = \frac{(a^2 - h_c^2)ctg\psi_2 + ab_u}{a[2(a-h_c)ctg\psi_2 + B_k - 2H_k ctg\psi_2} +$$

$$+\frac{(a-h_c)^2 ctg\psi_2 + b_n(a-h_c) + \frac{3}{2}h_u^2 ctg\psi_2 - (a-h_c)h_u ctg\psi_2}{a[2(a-h_c)ctg\psi_2 + B_k - 2H_k ctg\psi_2} +$$

$$+\frac{(2h_u - a + h_c)(a-h_c-h_u)ctg\psi_2 + (B_k + 2H_k ctg\beta_k - b_u)h_c}{a[2(a-h_c)ctg\psi_2 + B_k - 2H_k ctg\psi_2}, \quad \textbf{(17)}$$

$$F_7 = Mh_c - \frac{1}{2}h_c cg\psi_2 \quad \textbf{(9)}$$

where M – is the distance between the traces of the working bodies, m

From Figure 2

$$M = B_k - 2H_k ctg\beta_k - b_u, \quad \textbf{(10)}$$

where β_k – the angle of inclination in the transverse vertical plane of the transducer handle, degrees.

(3) – (9) Substituting the values of F_1, F_2, F_3, F_4, F_5, F_6 and F_7 into (2) and (3), we obtain

$$S_1 = (a^2 - h_c^2)ctg\psi_2 + ab_u, \quad \textbf{(11)}$$

$$S_2 = (a-h_c)^2 ctg\psi_2 + b_n(a-h_c) + \frac{3}{2}h_u^2 ctg\psi_2 - (a-h_c)h_u ctg\psi_2 +$$
$$+(2h_u - a + h_c)(a-h_c-h_u)ctg\psi_2 + (B_k + 2H_k ctg\beta_k - b_u)h_c. \quad \textbf{(12)}$$

We determine the total surface area of the layer to be smoothed by the working bodies of the first and second rows according to the following formula

$$S = B_u a, \quad \textbf{(13)}$$

where B_u – the width of the working coverage of the working bodies, m.

From Figure 2

$$B_u = 2(a-h_c)ctg\psi_2 + b_u + M \quad \textbf{(14)}$$

Substituting the value of M in expression (10) into (13) and (14), we obtain the following results

$$B_u = 2(a-h_c)ctg\psi_2 + B_к - 2H_k ctg\psi_2. \quad \textbf{(15)}$$

$$S = [2(a-h_c)ctg\psi_2 + B_к - 2H_k ctg\psi_2]a. \quad \textbf{(16)}$$

Substituting the values of S_1, S and S into (16), we obtain the following relationship to determine the softening coefficient η:

From the obtained expression (17) it can be seen that the coefficient of soil softening with opposite working bodies depends on the parameters of the pits, the physical and mechanical properties of the soil and the transverse distance between the working bodies and the working depth.

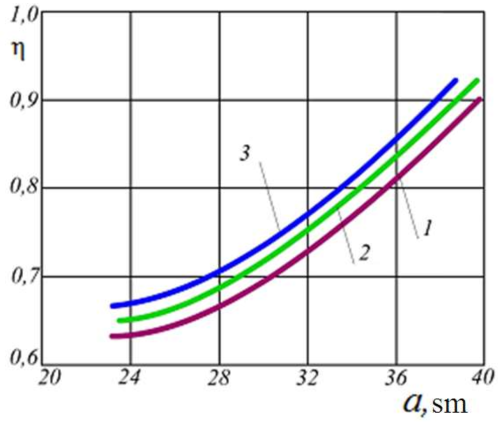

Figure 3. Graphs of change of softening coefficient depending on processing depth

1 – Bk =60 sm; 2 – Bk =70 sm; 3 – Bk =80 sm;

Assuming β_k=45º and ψ_2=45º and b_u=5 sm graph of the variation of the softening coefficient according to expression (17) in Figure 2 (17) is constructed depending on the transverse distance between the working bodies and the machining depth.

It can be seen that as the transverse distance between the working bodies and the machining depth increase, the softening coefficient increases. The main reason for this is that as the working depth and the transverse distance between the working bodies increase, the surface to be machined by the second row of working bodies increases sharply. However, the value of the softening coefficient in all options does not differ much from each other. Therefore, it is advisable to adopt the transverse distance and working depth between the working bodies based on the agrotechnical requirements for the proposed technology.

The height of the ridge formed at the bottom of the ridge in the softened layer is also one of the main agro-technical indicators, according to Figure (3) above

$$h_u = \frac{M - b_u}{2} tg\psi_2. \tag{18}$$

We can set the value of M to (18) according to expression (10)

$$h_u = \frac{B_k - 2H_k ctg\beta_k - 2b_u}{2} tg\psi_2. \tag{19}$$

It is known that during the tillage process, the upper edge of the ridge is broken, resulting in a decrease in its height. In this case, the actual height of the hump is determined by the following formula [7].

$$h_{ux} = K_u h_u, \tag{20}$$

where K_u – is the coefficient that takes into account the distortion of the hump.

Considering (20), formula (19) has the following form

$$h_u = K_u \frac{B_k - 2H_k ctg\beta_k - 2b_u}{2} tg\psi_2. \tag{21}$$

The value of K_u is in the range of 0.49-0.61 [7].

It can be seen from the obtained expression (21) that the height of the ridge formed at the bottom of the ridge depends on the transverse distance between the oppositely mounted working bodies, the height of the sloping part of the working bodies, the width of the screed and the physical and mechanical properties of the soil.

V. CONCLUSIONS

Combined machine pits that prepare the soil for planting melons under a closed tonnage film are bent to the right and left, their working surfaces and bent parts are oriented to each other and shifted relative to each other in the longitudinal plane the height of the slope of the working bodies, the width of the screed and the physical and mechanical properties of the soil allow to ensure the required level of work with low energy consumption.

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