Development of a machine for preparing the soil for sowing melons under the film

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Abstract. The purpose of the study is to substantiate the design scheme and substantiate the parameters of the working bodies of the machine for preparing the soil for sowing melons and gourds under a tunnel-type film. The authors proposed a new technology of soil preparation for sowing melons under a tunnel-type film and a combined machine for its implementation. The basic principles and methods of classical mechanics, mathematical analysis and statistics were used in this study. It has been established that the most optimal design of the proposed combined machine is considered to be a scheme with a sequential installation of screw bodies with backplows equipped with counter shares, a roller, spherical discs and a furrow cutter with a leveler. According to the results of the research, it was found that with a width of capture of the bodies and a transverse distance between their field edges of 45 cm, a combined machine for preparing the soil for sowing melons under a film using a new technology, a width of capture of counter shares 35 cm, a height of a body share relative to its blade 10 cm, installation angles to the horizon and direction of movement, respectively 34° and 40°, provides an increase in the quality of work and productivity, and with a roller width of 1.35 m, a diameter of 340 mm, an angle of inclination of the slats of the extreme and middle sections of 32°, a height of 4 cm, the number 8 strips of extreme sections and 11 middle sections, longitudinal distance from the nose of the body share to the roller axis 1.4 m, the transverse distance from the nose of the body share to the center of the support wheel 75 cm, the longitudinal distance between the roller and the furrow cutter 35 cm, the height of the furrow cutter 45 cm, length 70 cm, wing opening angle within 30º, leveler height 10 cm, setting angle to the direction of travel 30º is achieved to form the required irrigation furrow with minimal energy consumption.

1. Introduction

High-quality soil preparation with minimal energy consumption for the cultivation of melons and gourds is an urgent task. In the Republic of Uzbekistan, the technology of soil preparation for sowing melons and gourds provides for the performance of several operations for multiple passes of machines, which leads to soil compaction, a decrease in labor productivity, an increase in fuel and resource consumption, a delay in soil preparation, which entails a decrease in yield [1-8]. The problems of soil...
preparation for sowing melons and gourds are considered in many scientific works [9-16]. Research on the development of soil preparation technologies for sowing melons and gourds, substantiation of machine designs and parameters of their working bodies were carried out by F.Mamatov [1-8; 11-12;26-29], B.Mirzaev [1-8; 13-14; 24-25], D.Chuyanov [20-22], U.Kodirov [17], X.Fayzullaev [18], Kh.Ravshanov [19], I.Ergashev [4; 9-10], V.I.Malyukov [30], V.G.Abezni [31], A.D.Em [32], V.N.Zhukov [32] and others. V.G.Abezni [31] substantiated and developed working bodies for presowing soil cultivation and sowing melons. The studies of A.D.Em and V.N.Zhukov [32] are aimed at developing machines for inter-row processing of melons. All these studies are aimed at improving technologies and technical means of processing for preparing the soil for sowing melons in open ground. These technical means cannot be used to prepare the soil for sowing melons under a tunnel-type film.

The aim of the study is to substantiate the design of a combined machine for preparing soil for sowing melons and gourds under a tunnel film and to substantiate the parameters of its working bodies.

2. Method
The basic principles and methods of classical mechanics, mathematical analysis and statistics were used in this study.

The authors proposed a new technology of soil preparation for sowing melons and gourds under a tunnel-type film, providing.

In the proposed technology, the extreme layers of ABCD and EFGH of the sowing zone are wrapped within its own furrow (Fig.1,a), and its middle part of the DCKE is loosened to a depth of a1 (Fig.1,b), the lumps of the upper layers of the dumped and loosened part of the field are crushed and leveled, form an irrigation furrow, the upper parts of the formed ridges are leveled and form special grooves (Fig.1,c) to cover the film.
Figure 1. Diagram of soil preparation technology for sowing melons crops under the film

The machine implemented by the proposed technology (Fig. 2) consists of a frame 1, disc knives 2, support wheels 3, right and left turning housings 4 and 5, ploughshare 6 and 7, counter shares 8 and 9, roller 10, furrow cutter 11, equalizers 12 and 13, spherical discs 14 and 15.
Figure 2. Structural diagram of a machine for preparing soil for sowing melons and gourds

During the operation of the machine, the circular knives 2 make vertical cuts to a depth of 12-13 cm and are separated from the array of layers with the width $b_n$ and $b_{a1}$. Right- and left-handed housings 4 and 5, together with plugs 6 and 7, wrap the $ABSD$ and $IKLM$ layers within their furrow, the counter shares 8 and 9, attached to the bodies 4 and 5, loosen the gaps between adjacent layers, the roller 10 crushes the upper layer of the treated parts, the furrow cutter 11 forms an irrigation furrow, the levelers 12 and 13 level the upper parts of the ridges of the formed furrow, the spherical discs 14 and 15 form special grooves for covering the film. Thus, the machine prepares the soil for sowing melons in one pass.

According to the proposed technology, the right- and left-handed hulls wrap the seams of the sowing zone 180° within their own furrow. From previous studies it is known that with the maximum value of the working depth $a_{max} = 26$ cm and the ratio of the width of the body to the maximum value of its depth of processing $k = 1.67$, the rational value of the width of the body is within 43.4-47.0 cm. From this, the grip width of the screw body is taken $b_c = 45$ cm, and the angles of installation of the
share to the wall of the furrow and to the bottom of the furrow, respectively, \( \gamma = 44^\circ \) and \( \varepsilon = 34^\circ \).

The parameters of the counter shares installed on the right and left turning bodies include the following (Fig.3): \( b_{tl} \) - the width of capture of the counter share, m; \( \gamma_{tl} \) and \( \varepsilon_{tl} \) - installation angles of the counter share to the direction of movement and to the bottom of the furrow, degrees; \( l_{tk} \) - is the longitudinal distance from the toe of the body share to the toe of the counter share, cm; \( h_{tl} \) - installation height of the counter share relative to the body share blade, cm; \( i_{tl} \) - is the angle of sharpening of the counter share blade, degree; \( t_{tl} \) - the thickness of the counter share, see Fig. 3.

![Figure 3. The main parameters of the body with a counter share: 1 – building; 2 – counter share](image)

To determine the width of capture \( b_t \) (Fig.4) of the counter-plow share, the following expression was obtained

\[
b_{mt} \leq \frac{1}{2} (b_{a1} - b_l),
\]

where \( b_{a1} \) – is the transverse distance between the field cuts of the right and left turning hulls, cm; \( b_l \) – is the lateral distance between the counter shares, see.

Based on the previous studies, as well as the parameters of the body share, the angle of installation of the counter share to the direction of movement and to the bottom of the furrow is taken respectively \( \gamma_d = 40^\circ \) and \( \varepsilon_d = 34^\circ \), the grip width is at least \( b_d = 17.5 \) cm, the longitudinal distance from the toe of the share to the toe of the counter share \( l_d = 12 \) cm, the installation height of the counter share relative to the body share blade \( h_d = 10 \) cm, the sharpening angle \( i_d = 25^\circ \) and the thickness \( t_d = 0.8 \) cm.

The main parameters of the furrow cutter are the following: \( \alpha \) – angle of entry into the soil, degree; \( \gamma_1 \) – wing opening angle, degree; \( b_{ae} \) – width of the bottom edge, mm; \( H_c \) – height, cm; \( L_c \) – length, cm and \( B_c \) – width of the wings, cm.

The depth of the furrow cutter was determined based on the condition for the formation of the furrow of the required depth
Figure 4. Scheme for determining the width of the counter shares

\[
a_a = 0.5 \left[ \frac{2(H_a \text{ctg} \varphi + b_2) + b_1}{1 + \sqrt{4(H_a + b_1 \text{ctg} \varphi)^2 \text{ctg}^2 \varphi + 4(H_a \text{ctg} \varphi + b_1 \text{ctg} \varphi)b_1 + b_1^2}} \right] \text{tg} \varphi, \tag{2}
\]

where \( H_a \) – is the depth of the furrow, cm; \( \varphi \) – is the angle of inclination of the furrow wall to the horizon, degree; \( b_2 \) – sowing zone width, cm; \( b_1 \) – is the lateral distance between the soles of the counter shares, see.

The height of the furrow cutter was determined taking into account the depth of the furrow by the following expression

\[
H_c = (1 + \mu_1) \frac{2H_a + b_1 \text{ctg} \varphi}{2}, \tag{3}
\]

where \( \mu_1 \) – is a coefficient that takes into account soil sludge before the furrow cutter.

The width of the wings along the upper edge of the furrow cutter was determined from the condition of equality of the distance between the upper edges of its irrigation furrows and the following expression was obtained

\[
B_c = b_{v2} + (2H_a + b_1 \text{ctg} \varphi) \text{ctg} \varphi, \tag{4}
\]

where \( b_{v2} \) – is the width of the lower edge of the blade, \( (b_{v2} = b_1) \) cm.

The blade length was determined by the following expression

\[
L_c = 0.5b_{v2} \text{ctg} \gamma_1 + \frac{(1 + \mu)(2H_a + b_1 \text{ctg} \varphi) \sqrt{f^2 + 1}}{2 \sin \varphi}, \tag{5}
\]

where \( \gamma_1 \) – is the opening angle of the dump wings, degree; \( f \) – coefficient of friction of soil against metal.
The lateral distance between the body and the support wheel was determined from the condition that the soil deformation zone by the body did not reach the structural elements of the support wheel:

\[ L_k \geq b_k + a \cdot \tan \psi_1 \cdot \cos \gamma, \quad (6) \]

where \( a \) – is the processing depth of the case, cm; \( \psi_1 \) – soil shear angle in the plane perpendicular to the share surface, degree.

The distance from the toe of the body share to the roller axis was determined by the following expression:

\[ L_{gm} \geq \mu \cdot \alpha \cdot t + \frac{D_g}{2} + \Delta, \quad (7) \]

where \( \mu \) – is the formation twisting factor; \( \alpha \) – depth of processing of the case, cm; \( ot \) – formation rotation angle, radians; \( D_g \) – roller diameter, cm; \( \Delta \) – longitudinal displacement of the roller, \( \Delta = 35-45 \) cm.

The longitudinal distance from the axis of rotation of the roller to the toe of the furrow cutter was determined from the condition of excluding reaching the deformed zone processed by the furrow cutter to the structural elements of the roller located in front of it according to the following expression:

\[ L_a \geq \sqrt{R_{gm}^2 - (R_{gm} - h_{gm})^2} + a \cdot \alpha \cdot \tan \psi_1, \quad (8) \]

\( h_{gm} \) – depth of immersion of the roller into the soil, m; \( R_{gm} \) – is the radius of the skating rink, m.

Calculations according to expressions (2) - (8) showed that the depth of the furrow cutter should be \( a_c = 15 \) cm, the body height \( H_c = 45 \) cm, the width of the wings along the upper edge of the furrow cutter \( B_c = 50 \) cm, the length of the furrow cutter \( L_c = 70 \) cm, the width of the lower dump edge \( b_{al} = 10 \) cm, the angle of entry of the furrow cutter into the soil \( \alpha = 60^\circ \), the opening angle of the dump wings \( \gamma_1 = 30^\circ \), the width of the equalizer capture \( b_d = 20 \) cm, the angle of installation to the direction of movement \( \theta = 30^\circ \), height \( h_d = 10 \) cm, the diameter of the spherical disk \( D_c = 45 \) cm, the transverse distance between the body and the support wheel \( L_c = 75 \) cm, the distance between the toe of the body share and the roller axis \( L_{gm} = 140 \) cm, the distance from the center of rotation of the roller to the toe of the furrow cutter \( L_a = 35 \) cm.

To determine the rational values of the above parameters, a special experimental setup was used. According to the results of the experimental studies, it was found that the required quality of the technology of soil preparation for sowing melons and gourds under a film with minimal energy consumption is provided with a width of capture of counter shares 35 cm, their width is 12 cm, as well as installation angles to the direction of movement and to the bottom of the furrow, respectively 40° and 34°, height of the furrow cutter body 45 cm, length 70 cm, angle of entry into the soil 60°, angle of opening of wings 30°, width of coverage of the equalizer 20 cm, angle of installation to the direction of travel 30°, height 10 cm and diameter of the spherical disc 45 cm.

3. Conclusions

The most optimal design of a combined machine for preparing the soil for sowing melons and gourds under a film using the new technology is considered to be a scheme with a sequential installation of screw bodies with back plows equipped with counter shares, a roller, spherical discs and a furrow cutter with a leveler, its use will allow to prepare the soil for sowing melons according to the requirements with minimal energy consumption.

Based on the results of theoretical and experimental studies, it was found that with a width of capture of bodies and a transverse distance between their field edges of 45 cm, a combined machine for preparing the soil for sowing melons under a film using a new technology, a width of capture of counter shares 35 cm, height of a body share with respect to its blade 10 cm, installation angles to the...
horizon and direction of movement 34° and 40°, respectively, provides an increase in the quality of work and productivity, and with a roller width of 1.35 m, a diameter of 340 mm, an angle of inclination of the slats of the extreme and middle sections of 32°, height of 4 cm, the number of strips of the outermost section is 8 pieces and the middle section is 11 pieces, high-quality preparation of the soil for sowing is provided with minimal energy consumption.

Based on the results of theoretical studies, it was found that with a longitudinal distance from the nose of the body share to the roller axis of 1.4 m of a combined machine for preparing the soil for sowing melons under the film using a new method, the transverse distance from the nose of the body share to the center of the support wheel cm, longitudinal distance between roller and furrow cutter 35 cm, furrow height 45 cm, length 70 cm, wing opening angle within 30°, equalizer height 10 cm, setting angle to direction of travel 30° is achieved to form the required irrigation furrow with minimal energy consumption.

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