

Parameters of slitter for embedding manure in soil for melon crops

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Abstract. The purpose of the study is the theoretical justification of the parameters of the slitter for embedding manure in the soil. A slitter has been developed for lifting the formation, forming a gap along the manure strip lying on the field's surface, pushing it into the gap, and leveling the gap with soil. The basic principles and methods of classical mechanics, mathematical analysis, and statistics were used in this study. The slitter includes a rack, large and small cheeks connected to a soil-supporting plate with an increasing slope from the bottom to the top towards the small cheek and adjacent to the soil-supporting plate. A window is made in the big cheek for the passage of manure. The large cheek is somewhat pushed forward relative to the soil-bearing plate, and its front face is pointed. It is established that when planting fertilizers, the following operations must be carried out: lifting the formation, forming a gap along the manure strip lying on the field's surface, pushing the latter into the gap, and leveling the gap with soil. The working bodies of the dump type are the most acceptable for lifting the formation and the formation of a gap. The following optimal values of the parameters of the slitter are established: the removal of the large cheek is 710 mm, the width is 200 mm, the length and height of the window are 550 and 250 mm, respectively, and the angle between the forming and field edge in the horizontal plane is 42°, the height of the small and large cheeks of the slitter is 300 and 250 mm, respectively.

1 Introduction

Currently, organic fertilizers are mainly applied for plowing by manure spreaders for all agricultural crops, including melons. However, concerning melon crops, such application technology is both irrational and uneconomical. This is explained by melon crops being cultivated on wide (from 1.8 to 4.0 m) aisles. Therefore, with a scattered (continuous) method of application, a significant part of the manure is not used by plants.

There is a lot of data in the literature regarding the fact that it is most rational to apply organic fertilizers for melon crops locally, which accelerates the formation of the root system, reduces the negative effect of the diversity of natural soil fertility, promotes the

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alignment of plant development, simultaneous and earlier fruit ripening, increases by 10-30% yield, by 1.0-1.5% sugar content in fruits and others [1-2]. However, this method is practically not used in production due to the lack of tools for the local application of organic fertilizers for melon crops.

The design of the crevice should be such that after the passage, as much of the soil as possible crumbles into the gap. To do this, it is necessary that when the soil interacts with the elements of the slitter, its vertical movement prevails. The well-known works, D. Chuyanov [1-2], F. Mamatov [3-27], B. Mirzaev [4-7, 12-19, 21, 23, 26], K. Ravshanov [9, 22, 25, 28, 33], U. Kodirov [1, 21, 28, 33], I. Temirov [9, 11, 33], on substantiating the parameters of plow hulls, are mainly aimed at studying the process of lifting and complete rotation of the formation, in which horizontal soil movement prevails. Studies of moving the soil along the oblique blade have been carried out.

Therefore, the theoretical justification of the parameters of the working bodies for embedding manure into the soil was carried out according to the basic provisions of known studies, but taking into account the technological features of the process of embedding manure for melon crops and the physical and mechanical properties and soils of the melon-growing zone of Uzbekistan.

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2 Methods

The basic principles and methods of classical mechanics, mathematical analysis, and statistics were used in this study. The main parameters of the slitter are calculated and selected from the conditions of manure embedding in the soil with a norm of up to 20 t/ha to a depth of up to 30 cm. Taking into account the fact that many elements of the slitter perform the technological process similarly to elements of widespread working bodies (plough housings, furrow cutters), the parameters of which are quite comprehensively and deeply justified, then we select the values of the parameters of these elements based on the work carried out earlier.

3 Results and discussion

The developed slitter is designed for lifting the formation, forming a gap along the manure strip lying on the field's surface, pushing it into the gap, and leveling the gap with soil. The slitter (Fig. 1) includes a rack 1, a large 2, and a small 5 cheeks connected to a soil-lifting plate 4, made with an increasing slope from the bottom to the top towards the small cheek and adjacent to the soil-supporting plate 6. A window for the passage of manure is made in the large cheek. The large cheek is somewhat pushed forward relative to the soil-bearing plate, and its front face is pointed. The angles between the generators and the field edge are horizontal. The working surface of the slitter differs from the surface of the dumps of general-purpose plows in that the angles between the generators and the field edge range and decrease from bottom to top, $\theta_0 - \theta_n = 9^\circ$. Such a change in angles contributes to the rise of the formation and intensive soil loosening [18]. In this case, the angle of inclination of the ploughshare blade to the field side should be $\theta_0 = 42^\circ$ [20].

The angle of inclination of the ploughshare to the bottom of the furrow in an orthogonal section (Fig. 2). The analysis of many studies shows that for a gradual formation rise along the working surface, the angle δ should be equal to 25° .

The angle of the ploughshare sharpening angle, based on the research of F.Mamatov [1-2], is assumed to be equal to $i_t = 15^\circ$.

Previously conducted studies [20] found that the rear cutting angle ϵ_1 should be at least 10° because, at lower values of this angle, the sinking ability of the working bodies deteriorates. At an angle $\delta=25^\circ$, the ploughshare should have a lower sharpening.

The height H_1 of the small cheek should ensure the preservation of the gap during the collision of organic fertilizers into it, i.e., it should be equal to $H_1=300$ mm.

The height of the H large cheek is equal to the sum of the depth of the slitter stroke and the height of the window:

$$H = h_{sl} + h_0. \tag{1}$$

According to the agrotechnical requirements for the depth of manure sealing, the maximum depth of the slitter stroke is 300 mm. The window's height is selected from the condition of passing through it, the maximum rate of manure mixed with soil. Experimental studies have established that $h_0=250$ mm.

In this regard, the height of the large cheek is $H=550$ mm.

The angle of the rear section of the large and small cheeks (Figure 1) is selected so that the lower plane does not touch the bottom of the furrow during operation. Prof. F.Mamatov [1-2, 5-8, 13-20] for plow hulls recommends taking it within $2-3^\circ$ [21]. To preserve the parameters of the slit, it is necessary that the angle of the rear section of the large and small cheeks be as small as possible. Therefore, we take $\epsilon_2=\epsilon_3=2^\circ$.

The working surface of the soil-lifting plate of the slitter is constructed according to the method of D. Chuyanov [1-2] G. Shodmonov [2], which consists in constructing working surfaces by moving a horizontal generator along two guiding parabolas, one of which is located in the plane of the slit wall, and the other in a parallel plane at a distance of the width of the slitter.

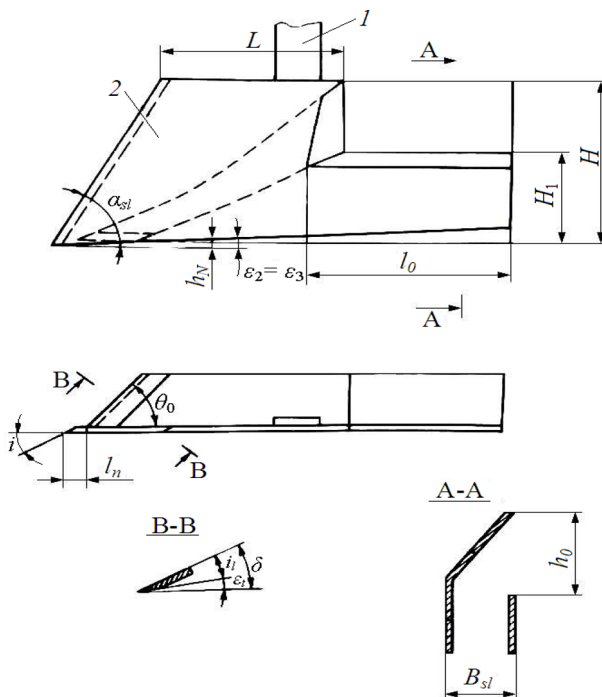


Fig. 1. Scheme of the experimental slitter

Fig. 1 shows the sequence of constructing the working surface of the soil-bearing plate of the slitter using this method; the parameters of the soil-bearing plate at a stroke depth of 30 cm are shown in Table 1. When constructing the contour of the working surface (profile projection) from point B at a distance from the field side, the BB' line is drawn, which is a furrow cut. Having set the height of the soil-bearing plate from the field side H and from the furrow side H_1 , they were connected by a straight line $A'B'$. To construct a horizontal projection from point A , which is the beginning of the first guiding parabola, a line AB is drawn at an angle to the field side. A line BB' parallel to the furrow side, which is a horizontal projection of the second guiding parabola with the beginning at point B , is drawn at a distance of B_{sl} .

Table 1. Parameters of the soil-lifting plate of the slitter

Parameters	Meaning
Width B_{sl} of the slot gripper, mm	200
Height H of the soil-lifting plate on the field side, mm	550
Height H_1 of the soil-bearing plate from the furrow side, mm	300
Angles between the guide parabolas and the bottom of the furrow α_1 and α_2 , deg	17
Angle θ_0 of the blade of the ploughshare to the field side, deg	42
The ratio of the departure to the height of the parabola:	
- first R/H	1.45
- second R_1/H_1	2.25

The guiding parabolas are constructed along lines tangent to them. According to the dimensions H and R (Table 1), the upper point L of the first parabola is found. To construct the first parabola, a tangent LK is drawn from point L , and a tangent at an angle α_1 to the horizon is drawn from point A . The parabola is constructed from point L to point P , located at a height of $h_p=0.04$ m. The segment AP is part of the tangent AK . For the soil to slide up the working surface without unloading, a tangent is drawn to the parabola at an angle of 40° to the height of the field cutoff H [15].

The angle α_2 between the lower tangent and the bottom of the furrow is assumed to be equal to the angle α_1 . According to the dimensions H_1 and R_1 , the upper point L' of the second parabola is found, and the tangent $L'T_0'$ is drawn. Thus, the second parabola is constructed from point L' to point P . Then point A' is connected to point B' (up to the height of the furrow cut H_1), and from this point B' , a tangent to the second parabola is drawn.

The rest of the construction of the contour of the horizontal and lateral projections of the soil-bearing plate is not difficult if we take as the starting points the intersection of the generators 1-1; 2-2; 3-3, etc., with guiding parabolas in the vertical plane (Fig. 2).

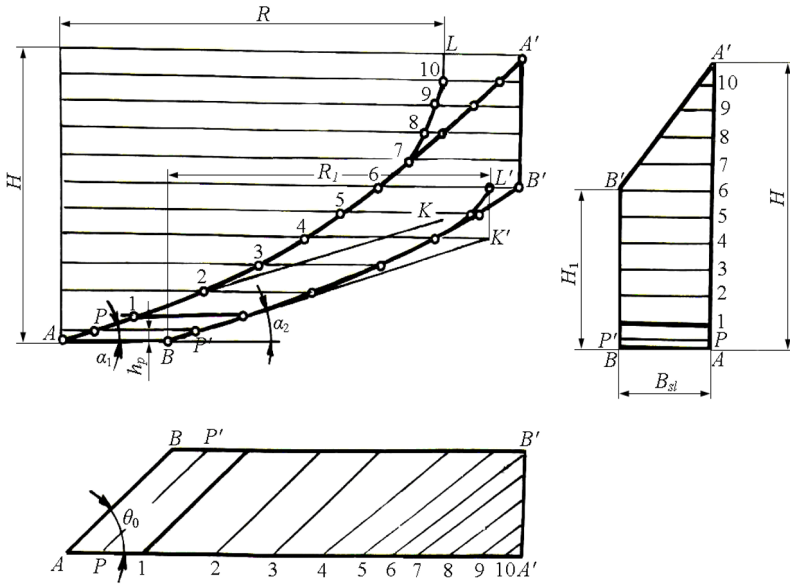


Fig. 2. Construction of working surface of slit by moving horizontal generatrix along two guide parabolas

The angle α_{sl} of the ascent of the large cheek (Fig. 3). During the operation of the slit, minimal lateral deformation of the soil towards the manure tape lying on the surface of the field should be ensured; it should not stick to the soil, be clogged with weeds, fill up the manure with soil, be well buried in the soil, ensure the required uniformity of the depth of travel and minimum traction resistance.

It was found that the least lateral deformation and the associated loosening of the family bed are produced by coulters in the form of an asymmetrical wedge with a protruding flat cheek. Therefore, in our case, the large cheek is somewhat pushed forward relative to the small one. This reduces the deformation of the soil that occurs during the operation of the ploughshare and the soil-lifting plate to the sides lying on the surface of the manure belt field.

Experimental studies by several authors [12-16] have shown that the angle of entry of the knife part has a significant impact on both the execution of the technological process and the traction resistance of earthmoving and tillage machines and implements.

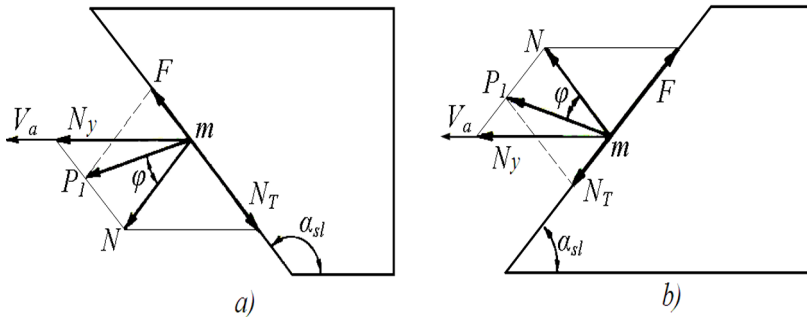


Fig. 3. Diagram of forces acting on soil particle in contact with large cheek of slit: *a, b* are the slit, respectively, with a blunt and sharp angle of entry into the soil; *N* is the normal pressure; *P₁* is the resultant of the forces acting on the soil particle; *N_y*, *N_T* are the components of the normal pressure forces directed in the direction of movement and along the blade

The required value of the angle of entry of the large cheek into the soil can be determined from the condition of ensuring the sliding of soil particles along the blade [18-20].

Fig. 2 shows the forces acting on a soil particle with a slit with an obtuse angle of entry into the soil, and Figure 2b shows a slit with an acute entry angle.

It can be seen from Figure 2a that for sliding cutting, it is necessary that the tangent force be greater than the friction force, i.e., $N_T > F$. But $N_T = N \operatorname{tg}(\alpha_{sl} - \pi/2)$, and $F = N \operatorname{tg} \varphi$, where φ is the angle of friction of the soil on steel. Therefore, the sliding condition will have the form:

$$N \operatorname{tg}(\alpha_{sl} - \pi/2) > N \operatorname{tg} \varphi. \quad (2)$$

Based on this, the optimal obtuse angle of entry of the cheek is equal to:

$$\alpha_{sl} > \pi/2 + \varphi.$$

$$N \operatorname{tg}(\pi/2 - \alpha_{sl}) > N \operatorname{tg} \varphi,$$

or

$$\alpha_{sl} < \pi/2 - \varphi.$$

Taking the angle of friction of the soil on steel equal to $\varphi = 23-27^\circ$ (60), we obtain the numerical values of the optimal angles of entry: *a*) the obtuse angle of entry of $\alpha_{sl} > 113^\circ$; *b*) the acute angle of entry of $\alpha_{sl} < 67^\circ$.

However, an obtuse angle of entry is undesirable due to the large size of the cheek, which reduces the strength and increases the friction of the cheek against the soil, as well as due to the deterioration of the depth. Therefore, the angle of entry of the blade of the large cheek of the slitter is assumed to be $\alpha_{sl} < 67^\circ$.

The final choice of the angle of entry of the knife part of the large cheek of the slitter will be made based on the results of experimental studies.

The distance h between the toe of the large cheek and the blade of the ploughshare (Fig. 2) in the vertical plane, taking into account previous studies, is assumed to be equal to 10 mm.

The removal of the l_{ii} of the large cheek (Fig. 2) relative to the toe of the ploughshare for design reasons can be assumed to be equal to 20 mm.

The angle i of the sharpening (Fig. 2) of the large cheek. Studies of the parameters of cutting knives have found that with an increase in the sharpening angle i to 15° , the cutting force decreases by about 20-22%. With a further increase in this angle, the cutting force increases and, finally, starting from 55° , remains almost constant. Considering these studies, the large cheek's sharpening angle can be equal to $i = 15^\circ$.

4 Conclusions

1. It has been established that when planting fertilizers, the following operations must be carried out: lifting the formation, forming a gap along the manure strip lying on the field's surface, pushing the latter into the gap, and leveling the gap with soil. The most acceptable for lifting the formation and the formation of a gap is the working bodies of the dump type.
2. The following optimal values of the parameters of the slitter are established: the removal of the large cheek is 710 mm, the width is 200 mm, the length and height of the window are 550 and 250 mm, respectively, and the angle between the forming and field edge in the horizontal plane is 42° , the height of the small and large cheeks of the slitter is 300 and 250 mm, respectively.

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