Constructive Parameters of Earthquake Unit Before Sowing

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ABSTRACT
This article presents the results of theoretical studies to determine the force acting on the working body of the pre-sowing leveller, as well as the resistance force appearing from the soil dragging prism when moving in front of the working body of the leveller and the installation angle, height of the working body of the pre-sowing leveller.

Keywords: Leveller; slope angle; installation angle; the height of the working body; soil drag prism; reaction force; deformation of the soil; absolute speed; traction resistance

Introduction:
Land levelling before planting is one of the agro-technical measures that have a significant impact on increasing productivity in irrigated agriculture. By studying the parameters and working speed of the levelling machines and selecting their optimal parameters, it is possible to increase the working efficiency of these machines and ultimately reduce the time, energy consumption and other costs for levelling before planting. To this end, several studies have been conducted to reduce energy consumption and increase the productivity of the land levelling machine before planting.

Research methods
Tilling the soil before sowing cotton solves several necessary tasks: levelling the field surface, creating favourable conditions for seed germination, ensuring the cleanliness of the field and preventing the appearance of weeds, preserving soil moisture loss, and preventing soil erosion.
The type of tillage machines for processing and their number depends on the soil compaction, the presence of clods, the number of crop residues, the system of pre-processing for winter crops and the precursor crop. The timely and correct sequence of all pre-sowing cultivation techniques is the main requirement, and the quality of cultivation directly depends on the tillage implements involved in the work. [1-7]
Theoretical research was conducted in the following areas:
- study of the forces acting on the working parts of the levelling machine before planting;
- to study the reaction forces acting on the surface of the working part of the leveller from soil deformation;

– study of the resistance force caused by the displacement of the soil pile in front of the working part;
– determine the installation angle and height of the working body of the levelling machine before planting [8-12].

To study the forces acting on the working parts of the levelling machine before planting, a diagram of the forces acting on the working parts of the machine was first formed (Fig. 1).

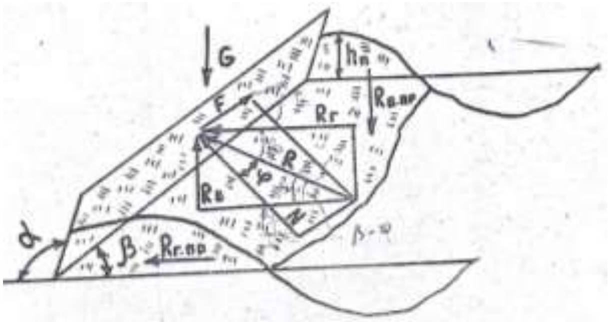

Figure 1. Schematic of the forces acting on the working part of the levelling machine before planting

The following forces act on the working parts of the leveller during the technological process: R-is the reaction force acting on the surface of the working part of the leveller from soil deformation; N-normal compressive strength; F-is the friction force; G-gravity of the working part; R_{gtek}, $R_{v.single}$-resistance of the soil pile to sliding in the horizontal and vertical planes;
α-is the angle of inclination of the working part;
Reaction forces act on the surface of the working part of the leveller from soil deformation. The reaction force R on the workpiece is affected when the workpiece moves forward with a straightener at an angle to the horizon. From reaction 1, the reaction force can be written as follows.

$$R = \frac{N}{\cos\varphi} \quad (1)$$

The normal compressive strength received by the workpiece depends on the dynamic and static parameters of the process, the mass of soil moving in front of the workpiece per unit time, and the working speed of the leveller [8-16].

The normal compressive force acting on the working part of the straightener consists of two parts:

$$N = N_d + N_{st} \quad (2)$$

In this: N_d -is the force depending on the dynamic parameters of the process; N_{st}-horizontal and vertical directions of the soil crushed the generated power.

Assume that the direction of the absolute velocity of the leveller coincides with the absolute trajectory of the ground motion. It is possible to obtain the absolute velocity constituents by dividing the velocity V_p -in the direction of motion and the velocity V_N in the direction of the working part. It can be seen from the figure that the direction of the absolute motion of the velocity V_N, the normal component of velocity, deviates from the angle of friction ph. From this

$$V_N = V_p sin\beta \quad (3)$$

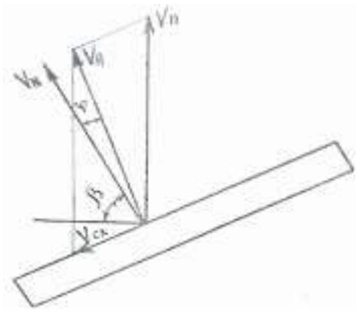

Figure 2. Scheme of separation of soil into components of the absolute velocity of displacement in front of the working part.

Taking into account the width V of the leveller, the working speed V, the bulk density of the soil, and the height h_p pushed in front of the working part, N_d can be written as follows:

$$V_d = K'VV^2\gamma h_p sin\beta \quad (4)$$

K'-levelling factor taking into account the location of the working part. It is known that before planting, the working parts of the levelling machine can be installed in 2 or 3 rows.

A special coefficient "K'" was introduced to take into account the actual amount of reaction forces acting on the rectifier. If the workpiece is a row and is perpendicular to the direction of motion of the straightener, the total length of the workpiece is assumed to be 1, and the workpiece is calculated as the second and third rows are at an angle to the direction of movement. It was assumed that K'=1.75 for a 2-row straightener and K'=2.5 for a 3-row straightener.

When the aggregate moves in soft soil, the soil is crushed to a certain distance due to the gravitational force of the aggregate. As a result, the working part is subjected to static compressive forces [11-19].

The crushing strength N_s -of the soil is determined as follows;

$$N_c = g_{afraid} G' \quad (5)$$

in this g_{afraid}-bruising labour component affects the average pressure, MPA;

The area of the working part of the G-leveller is M^2.

Since the leveller works on soft soils, the static pressure force can be expressed as follows, taking into account the depth of subsidence, the rate of subsidence, and the density:

$$N_{st} = \frac{gB\gamma K' h_p h_g}{2(1+\Delta\gamma)} \quad (6)$$

Substituting (4) and (6) into 2, we obtain the normal compressive force acting on the working part of the straightener;

$$N = K' B h_p \gamma \left[v^2 \sin\beta + \frac{h_p g}{2(1-\Delta\gamma)} \right] \quad (7)$$

based on the above considerations, the normal force acting on the levelling workpiece is determined, and the following expression was obtained to determine the reaction forces acting on the surface of the levelling workpiece from soil deformation;

$$R_r = M \frac{K' B h_p \gamma \left[v^2 \sin\beta + \frac{h_p g}{2(1+\Delta\gamma)} \right]}{\cos\varphi} \quad (8)$$

in this: R_r -the coefficient taking into account the effect of the angle of inclination of the working part of the M-planer on the reaction force; v-is the speed of the straightener, m \ sec. g-acceleration of free fall m \ sec^2;

In the study of the resistance force generated by the displacement of the soil pile in front of the working part, it is assumed that the soil has been ideally dispersed during previous operations.

Taking the projections of the stress components on the OX and OY axes and adding them together, the ground shear resistance in the horizontal plane is determined by the following expression;

$$R = \frac{K' B h_p^2 \gamma g}{2} A_{pr} (\sin\alpha + tg\alpha) \quad (9)$$

Adding 8 and 9, we obtain an equation representing the total gravitational resistance of the rectifier.

$$R = K' B h_p \gamma \{ \frac{M \left[v^2 \sin\beta + \frac{h_p g}{2(1+\Delta\gamma)} \right]}{\cos\varphi} + \frac{h_p}{2} A_{pr} (\sin\alpha + tg\varphi \cos\alpha) \} \quad (10)$$

this expression allows you to analytically determine the gravitational resistance of the leveller, depending on the coverage width of the leveller, the speed of movement, the thickness of the sliding soil, and the physical and mechanical properties of the soil [13-20]

To obtain the required flatness in one pass on the levelling machines before planting, the working parts of the knife-type levelling machines mounted on the existing frame are mounted in three rows. The working parts of the first and second rows are mounted at an angle to the direction of movement of the machine, and the third row is mounted perpendicular to the direction of movement. The workpieces, set at an angle to the direction of movement, move the soil in two directions, filling the microns, and the last row completely flattens the microns. Therefore, researching the installation angle of working parts moving at an angle to the direction of movement of the machine and determining the optimal option will improve the quality of the levelling process before planting and reduce energy consumption.

The angle between the projection of the workpiece on the horizontal plane and the forward direction of movement of the unit is called the installation angle of the workpiece. The quality of the alignment depends in many ways on the value of this angle.

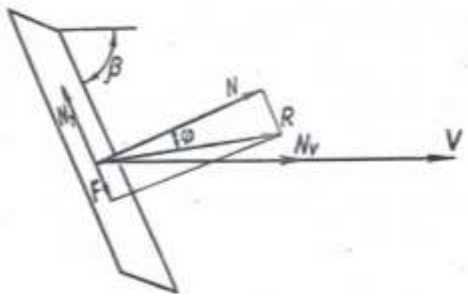

Figure 3. Schematic for determining the installation angle of the levelling workpiece.

Several researchers studied the working part of a levelling machine and set its installation angle at 30-50⁰. The presence of such a large range of installation angles of the working part of the ground levelling machine before planting made it necessary to study the optimal option of the installation angle of the working part of the ground levelling machine before planting this angle.

Research results:

In front of the workpiece mounted at an angle to the direction of movement, the soil moves in transverse and longitudinal directions. Assume that the soil moves perpendicular to the direction of motion and at an angle b.

We divide the normal force N acting on the soil by the working part into two, N_v and N_t, respectively, which are formed by the movement of the leveller in the direction of movement V and in front of the working part (Fig. 3). In addition to the normal force N, the friction force F on the soil is affected. The forces N and F give the resulting force R, which deviates from the normal force at an angle ph. Therefore, it is possible to set the following two modes of operation of the levelling unit before planting:

1. The soil slides in front of the working part. In case of β it can be clearly observed;

$$B \prec \frac{\pi}{2}$$

2. The soil slides along with the working part and falls asleep in front of the working part. The maximum alignment of the soil in front of the working part can be observed at b = 90⁰. In this case, there is no transverse movement of the soil in front of the working part. [1-4]

The soil may slide in front of the working part if the force of the normal compressive force is greater than the frictional force:

$$N_T > F_{max} \text{ but}$$

$$N_T = Ntg\ (\frac{\pi}{2} - \beta) \cdot F_{max} = \ Ntg\varphi\ \frac{\pi}{2} - \beta > \varphi \quad (11)$$

From this, the condition of sliding the soil in front of the working part will have the following appearance.

$$Ntg(\frac{\pi}{2} - \beta\ ) > Ntg\varphi \ \text{ or } \ (\frac{\pi}{2} - \beta\ ) > \varphi \qquad (12)$$

If β, the forces $\frac{\pi}{2} - \prec \varphi\ \frac{\pi}{2}$ —and F are mutually balanced, no displacement of the soil in front of the working part is observed, and the direction of movement of the soil coincides with the direction of movement of the working part, and the only driving force is N_v. In this case, the soil moves with the working part in the direction of its movement, the working part pushes the formed soil pile in front of it. The condition of the landslide in front of the working part at an angle to the direction of movement can be expressed as follows;

$$(\frac{\pi}{2} - \beta\ ) > \varphi \qquad (13)$$

in this β is the installation angle of the working part of the leveller, grad;

φ-angle of friction of the soil in steel. [13,14,18]

Therefore, b =ph can be taken as the lower limit of the installation angle of the straightening workpiece. Depending on the type and physical-mechanical properties of the soil, the lower limit of the installation angle can be taken β=22-30⁰ We find the upper limit of the working part installation angle using the soil displacement rate. Depending on the installation angle of the workpiece, the speed at which the soil exits the workpiece area will vary. As a result of friction, the movement of the soil is delayed, resulting in a decrease in the rate of subsidence of the soil along the working part. Assume that the direction of absolute velocity V_A corresponds to the absolute trajectory of ground motion and dividing the velocity V_A by the velocity V_t in the direction of motion and the velocity in front of the workpiece V_{sx} we obtain the component of absolute velocity [1-4].

In this case, the velocity $V_A$deviates from the normal of the working surface by the angle of friction. As can be seen from Figure 3, V_{sx} and V_t are interconnected as follows;

$$\frac{V_{sx}}{\sin[90-(\beta+\varphi)]}=\frac{V_t}{\sin[90-(\varphi)]} \quad (14)$$

After the mathematical changes, we get the following.

$$V_{sx}=V_t\frac{\cos(\beta+\varphi)}{\cos\varphi} \quad (15)$$

Table 1 shows the calculated values of the soil exit velocity from the working part depending on the installation angle.

Table 1. Installation angle of V_{sx} and ground leveller. Values depend on the speed of movement

Installation angle of the working part, grad	*The speed of the workpiece is m \ s*		
	1.66	2.55	3.3
60	0.24 \ 0	0.37 \ 0	0.49 \ 0
55	0.40 \ 0.16	0.60 \ 0.25	0.80 \ 0.33
50	0.55 \ 0.33	0.83 \ 0.5	1.10 \ 0.66
45	0.69 \ 0.49	1.05 \ 0.74	1.39 \ 0.99
40	0.84 \ 0.65	1.25 \ 0.97	1.67 \ 1.30
35	0.97 \ 0.81	1.46 \ 1.26	1.93 \ 1.61
30	1.10 \ 0.40	1.66 \ 1.44	2.19 \ 1.90

As can be seen from the table, as the installation angle decreases, the soil projection velocity V_{sx} increases regardless of the speed of the ground leveller [1-4].

An excessive increase in the soil outlet angle causes the soil to pass through the top of the working part and as a result, the quality of field levelling is impaired. Therefore, the value of the installation angle should be chosen so that it allows the soil to move normally at the high speeds of the leveller. As can be seen from the table, the soil ejection velocity is 0 when the installation angle is b = 60^0 and ph= 30^0. Based on the above, it can be said that the levelling angle of the levelling machine before planting should be in the range of 50 ... 55 when operating at high speeds. One of the factors influencing the quality and productivity of the levelling machine before planting is the height of the working part. During the operation of the unit, the working part cuts the soil and moves a certain amount of soil collected in front of it. For this soil volume to shift at the required level, the height of the working part must be chosen so that during the work the soil is pushed in front of the working part without passing through the top of the working part [1-4].

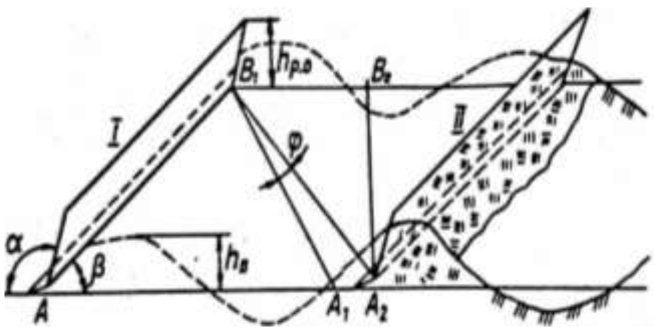

Figure 4. Schematic for determining the height of the working part of the leveller.

The height of the working part of the leveller can be found by equalizing the volume of soil moving in front of it as a result of the movement of the working part, and the size of the soil prism that can be placed in front of it. Assume that the working part of the leveller is located at an angle b to the direction of movement and the depth of the moving soil is sunk to h_t.

When the working part moves from the position I to position II, the ground triangle moves from position $AV_1 A_1$ to position $A_2 V_1 V_2$. Thus, in front of the working part will be a constant pile of soil, the size of which is determined by the following expression.

$$W^{'}=\frac{h_t lAA_2\sin\beta}{2} \quad (16)$$

The volume of soil that can be placed in the form of a prism in front of the working part:

$$W = \frac{H^2}{tg\mu} lK \quad (17)$$

Where is the cross-sectional area of the soil

prism, M² ;
μ - the angle of inclination of the soil prism, grad;
l- length of one section of the working part, m=1m.
Cross section of the ground prism in front of the working part
We imagine it in the form of a triangle as shown in Figure 5.

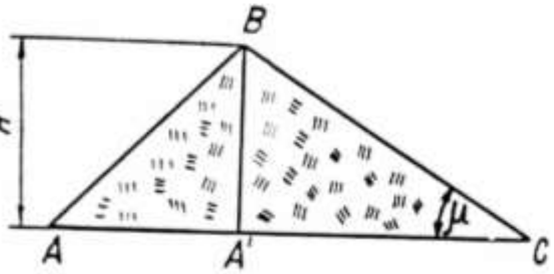

Figure 5. Cross section of the soil pile in front of the workpiece.

The slope of the levelling work is part of the soil cross-sectional area A VS, the inclination angle of 90^0, which is equal to the area of a triangle ABC. From this

$$\theta = \frac{S\Delta_{AVS}}{S\Delta_{A'VS}} \quad (18)$$

$$h = \sqrt{\frac{h_i b \sin\beta tg\mu}{2\theta}} \quad (19)$$

Given the angle of inclination of the workpiece, its height can be found in the following expression.

$$h_{iq} = \frac{1}{\sin\alpha}\sqrt{\frac{h_i b \sin\beta tg\mu}{2\theta}} \quad (20)$$

Conclusion:
It can be seen from this expression that the height of the working part depends mainly on the dimensions of the mobile soil layer and its physical-mechanical properties (μ).
The angle of inclination of the working part a = 120^0, its installation angle
When b = 50-55^0, μ = 30-32^0, the height of the working part of the levelling machine before planting is 0.164-0.172 m.

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