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Cotton Cultivators Working Bodies Ensuring Stable Movement Through The Depth Of Processing

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Annotation. The article presents the results of the theoretical and experimental research conducted on ensuring the stable movement of the working bodies of the cotton cultivator on the depth of cultivation. According to our research, the working bodies of cotton cultivators provided the specified tillage depth in all options when the longitudinal pulls of the parallelogram mechanism with respect to the horizon were zero, that is, the working bodies sank to the specified depth, and the change in aggregate movement speed and mass of the working bodies section did not significantly affect the tillage depth**.** Therefore, in order for the working bodies of cotton cultivators to sink to the specified depth and to move stably at this depth, the longitudinal pulls of the parallelogram mechanisms must be horizontal or close to it during the work process.

Keywords: cotton cultivator working bodies, tillage depth, stable movement, parallelogram mechanism, longitudinal drags, section mass of working bodies, aggregate movement speed.

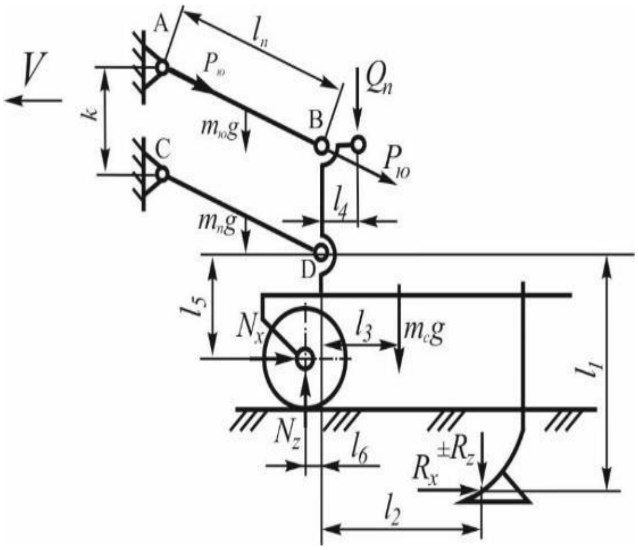
Introduction. The depth of processing and its stability (evenness) are the main performance indicators of all tillage machines. If the tillage depth is at the required level and its stability is ensured, i.e. it is uniform, uniform development and ripening of crops and a high yield are achieved, otherwise, i.e. if the specified tillage depth and its stability are not ensured - uneven development and ripening of plants is observed, productivity decreases [1-5].

For this reason, there are strict requirements and restrictions on the working depth and its deviations (unevenness) for each tillage machine. On the basis of these points, we have conducted studies aimed at ensuring that soil tillage machines used in the agriculture of our country sink to the specified processing depth and ensure stable movement at this depth.

This article presents the results of studies on ensuring the stable movement of working bodies of cotton cultivators on the depth of cultivation.

It is known [6] that the working bodies of cotton cultivators are sectioned to their frames and connected by means of parallelogram mechanisms equipped with support wheels and compression springs. Figure 1 shows the diagram of the forces acting on the section of the working bodies of the cotton cultivator during the work process. Using this scheme, we create the equation of the moment of the forces acting on the section of the working bodies relative to the point S- (hinge)

$$M_C = m_c g\left(l_3 + l_n \cos\varphi_n\right) \pm R_z\left(l_2 + l_n \cos\varphi_n\right) + \\ +Q_n\left(l_4 + l_n \cos\varphi_n\right) + 0,5\left(m_{ю} + m_n\right) g l_n \cos\varphi_n + P_{ю} k \cos\varphi_n - \\ -R_x\left(l_1 + l_n \sin\varphi_n\right) - N_x\left(l_5 + l_n \sin\varphi_n\right) - N_z\left(l_n \cos\varphi_n - l_6\right), \quad (1)$$



A, S – fixed hinges of the parallelogram mechanism;

V, D are movable joints of the parallelogram mechanism

Figure 1. Work for the section of the cotton cultivator work bodies the scheme of the forces acting in the process

where mc, mu, mp are the section of the working bodies and the mass of the upper and lower longitudinal pullers of the parallelogram mechanism, kg;

g – acceleration of free fall, m/s2;

Qn is the pressure force of the spring, N;

Rx, Rz are the horizontal and vertical components of the equal force of the resistance forces acting on the working bodies by the soil, N;

Nx, Nz–horizontal and vertical components of the reaction force reaching the base wheel of the section of working bodies by the soil, N;

Pyu is the force exerted by the upper pull of the parallelogram mechanism on the section of working bodies, N;

ln - the length of the parallelogram mechanism, m;

k - the vertical distance between the fixed hinges A and S of the parallelogram mechanism, m;

l_1,l_6 - the shoulder of the movable joint D of the parallel-log mechanism of forces Rx, Rz, mcg, Qn, Nx and Nz, respectively, m;

φn is the angle of deviation of the parallelogram mechanism's longitudinal pulls relative to the horizon, degrees.

Considering that myu+mp<<mc, we write the expression (1) in the following form

$$M_C = m_c g\left(l_3 + l_n\cos\varphi_n\right) \pm R_z\left(l_2 + l_n\cos\varphi_n\right) +$$
$$+Q_n\left(l_4 + l_n\cos\varphi_n\right) + P_ю k\cos\varphi_n - R_x\left(l_1 + l_n\sin\varphi_n\right) -$$
$$-N_x\left(l_5 + l_n\sin\varphi_n\right) - N_z\left(l_n\cos\varphi_n - l_6\right).$$

Forming the moment of the forces acting on the section of the working bodies relative to point D-(hinge) and solving the obtained expression with respect to Pyu, we get the following

$$P_ю = \left[R_x l_1 + N_x l_5 - N_z l_6 \mp R_z l_2 - m_c g l_3 - Q_n l_4\right] / \left(k\cos\varphi_n\right).$$

Putting this value of Pyu into the expression (2), we get the following result

$$M_C = (mg + Q_n \pm R_z - N_z)l_n\cos\varphi_n - (R_x + N_x)l_n\sin\varphi_n.$$

We get the same result by creating the equation of the moments of the forces acting on the section of the working bodies with respect to the fixed hinge A of the parallelogram mechanism, i.e.

$$M_A = (mg + Q_n \pm R_z - N_z)l_n\cos\varphi_n - (R_x + N_x)l_n\sin\varphi_n.$$

The analysis of expressions (4) and (5) shows that in the study of the stable movement of the working bodies of the cotton cultivator according to the depth of cultivation, all the forces acting on them are considered as being placed on the movable hinge D or V of the parallelogram mechanism, and the mathematical scheme depicted in Fig. 2 as a calculation scheme a pendulum scheme can be adopted.

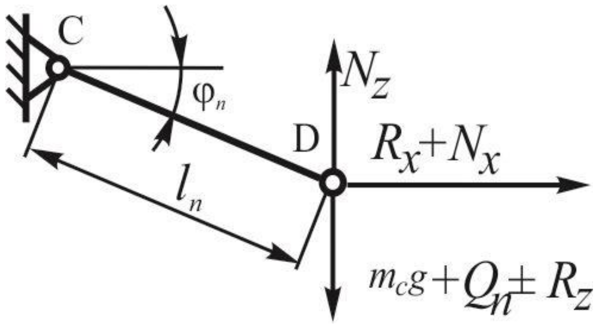


Figure 2. Cotton Cultivator Working Bodies Section accounting scheme

According to the scheme presented in Figure 2, the following condition must be met in order for the working bodies of the cotton cultivator to sink to the specified depth and to move stably at this depth

$$\left(mg + Q_n \pm R_z\right) l_n \cos\varphi_n > R_x l_n \sin\varphi_n$$

Or

$$mg + Q_n \pm R_z > R_x tg\varphi_n .$$

When these conditions are met, during the working process, the support wheel of the parallelogram mechanism (hereinafter referred to as the support wheel) is constantly pressed against the soil surface, and as a result, the working bodies sink to the specified depth and work without changing the working depth.

Otherwise, that is

$$\left(mg + Q_n \pm R_z\right) l_n \cos\varphi_n < R_x l_n \sin\varphi_n$$

Or

$$mg + Q_n \pm R_z < R_x tg\varphi_n$$

when the moments of forces tending to sink them into the soil and eject them from the soil are mutually balanced sink to depth, that is, they do not sink to the specified depth, and the support wheel is raised above the soil surface. In addition, in this case, any change in soil resistance forces, that is, Rx and Rz forces, causes a change in the depth of immersion of the working bodies into the soil, because the moments of the forces tending to sink them into the soil and pull them out of the soil balance each other at a different depth.

It should also be noted that the Rx and Rz forces change depending on the physical properties of the soil, the speed of the aggregate, the number of working bodies installed on the parallelogram mechanism, the depth and width of processing. Therefore, when the condition (7) is not fulfilled, the change of each of the above-mentioned factors leads to a change in the depth of immersion of the working bodies into the soil, that is, the depth of processing is uneven.) expression analysis shows that the stability of the working depth of cotton cultivators mainly depends on the angle of installation of the longitudinal pullers of the parallelogram mechanism relative to the horizon.

The smaller this angle is, the less likely it is to change the working depth of the working bodies under the influence of the moment of force Rx that tends to pull them out of the soil. and when the longitudinal traction of the parallelogram mechanism occupies a horizontal position during the working process, the Rx force does not affect the depth of travel of the working bodies, and in this case, the influence of changes in the properties of the soil, speed of work and other factors on the depth of the working bodies is minimal.

For the case where the expressions (6) and (7) will have the following form

$$\left(m_c g + Q_n \pm R_z\right) l_n > 0$$

Or $m_c g + Q_n \pm R_z > 0.$

On the basis of these expressions, it can be noted that, if there is, immersion of the working bodies to the specified depth and smooth movement in this depth can be ensured without a pressure spring and with the minimum possible mass of the section. This can be explained as follows: firstly, the working bodies are not affected by the force or moment that tends to pull them out of the ground, and secondly, the longitudinal pulls of the parallelogram mechanism in the process of sinking the working bodies into the ground,

As shown in Fig. 3, it works by occupying an upward position, and therefore the force Rx acting on the working bodies also creates a moment M = Rxl, which tends to sink them into the ground. As a result, the working bodies sink into the soil under the influence of the Rx force in addition to the mcg and Rz forces. After the working bodies are completely immersed in the soil, the longitudinal pulls of the parallelogram mechanism take a horizontal position, and the Rx force does not affect the working depth of the working bodies.

After the working bodies have sunk into the soil to a certain depth, it is not desirable for the parallelogram mechanism to work with the longitudinal pullers deflecting upwards (Fig. 4), because under the influence of the Rx force, the load on the support wheel will increase excessively, it will work leaving a deep mark in the soil and will have a great resistance to traction.

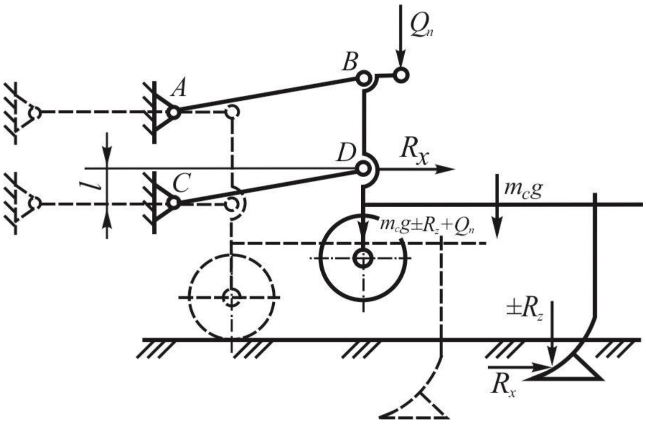


Figure 3. The initial (–) and final (- - -) cases of the cotton cultivator sinking the working bodies into the soil.

In order to verify the above-mentioned points, experiments were conducted to study the influence of the angle of deviation of the parallelogram mechanism longitudinal pullers relative to the horizon on the depth of processing between the rows of cotton. The experiments were carried out at unit speeds of 1.9 and 2.3 m/s, taking the mass of the working body section as 70.6 and 91.0 kg, and with and without the use of a compression spring. In this case, the mass of the section of working bodies was changed by placing an additional load. For all options, the processing depth is set to 14 cm.

Experiments were carried out in 5 seed-planted fields of the QXMITI experimental farm with an MTZ-80X tractor and an experimental cultivator hanging behind it.

During the experiments, the installation angle of the parallelogram mechanism longitudinal pullers of the working body section relative to the horizon was changed in the range of 30-0° with 15° intervals, and this was experimentally

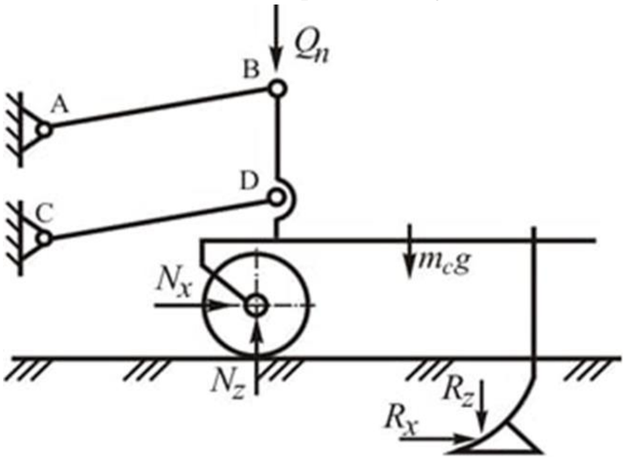


Figure 4. Cotton Cultivator Working Bodies Section

The parallelogram mechanism is installed with the longitudinal pulls tilted upwards.

the placement height of the cultivator frame relative to the field surface is achieved by raising or lowering its support wheels.

The data obtained in the experiments (see the table below) fully confirm the above comments, and based on them, the following can be noted:

- with a decrease in the installation angle of the parallelogram mechanism's longitudinal pulls relative to the horizon, the depth of processing has increased in all options;

- when the angle of installation of the parallelogram mechanism's longitudinal pulls relative to the horizon is equal to zero, in all options (including when the pressure spring is not used), the specified processing depth is provided, that is, the working bodies have sunk to the specified depth, and the overall speed of movement and the mass of the section of the working bodies the change did not have a significant effect on the processing depth;

Dependence of the depth of processing between cotton rows on the angle of deviation of the parallelogram mechanism longitudinal pullers relative to the horizon.

	Aggregate movement speed, m/s	
	1,9	**2,3**

Parallelogram mechanism longitudinal pulls relative to the horizon deviation angle, degrees	**$M_{ўр}$, см**	**±σ, см**	**$M_{ўр}$, см**	**±σ, см**
Option 1: the mass of the section is 70.6 kg, a compression spring is used				
30	7,6	0,82	6,9	0,84
15	10,7	0,78	9,6	0,81
0	14,4	0,68	14,2	0,73
Option 2: the mass of the section is 70.6 kg, the pressure spring is not used				
30	6,4	0,87	5,8	0,91
15	9,6	0,84	8,7	0,86
0	14,2	0,71	13,7	0,74
Option 3: the mass of the section is 91.0 kg, a compression spring is used				
30	8,6	0,76	7,9	0,78
15	11,6	0,74	10,8	0,72
0	14,6	0,64	14,2	0,67
Option 4: the mass of the section is 91.0 kg, the pressure spring is not used				
30	7,2	0,84	6,7	0,87
15	10,3	0,79	9,0	0,83
0	14,2	0,67	13,8	0,72

- when the parallelogram mechanism's longitudinal pullers are set at an angle of 15 and 30° relative to the horizon, in all options (including when a pressure spring is used), the actual working depth is less than the specified one, that is, the working bodies did not sink to the specified depth. In addition, here, the change in the speed of aggregate movement and the mass of the working body section led to a change in the processing depth.

CONCLUSION

So, according to our research, in order for the working bodies of cotton cultivators to sink to the specified depth and to move stably at this depth, the longitudinal pulls of the parallelogram mechanisms should work in a horizontal or close position during the work process.

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