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Substantiation the Parameters of the Rotary Operating Element of Combination Machine Preparing Row-Spasings for Sowing

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Abstract

The structure and work process of machine used in preparation for sowing between row-spacings of newly established gardens in one way passing, as well as results of theoretical studies implemented on basis of parameters of its rotational operating element are specified in the article. Combination machine is equipped with flat cutting claws, a rotary operating element that forms soft soil layer, lump collectors, and operating elements that compact the top and sides of flower-beds, while passing between the rows of garden, they soften the soil to a specified depth, loosen the surface of soil layer, and also it forms a flower-bed and compacts them, bringing them ready for sowing. In implemented theoretical studies, diameter of the rotational operating element should be at least 36 cm in order to crush the lumps encountered on the way and immerse to specified depth, and vertical load applied to it at 1.7-2.2 m/s of assembly movement velocities and the compression forces of spring are 5.73-6.46, appropriately. It was determined that it should be in range of and 2.37-2.74 kN .

Keywords: Rotary Operating Element; Flat cutting claws; Commonwealth of Independent States; Crops sowing; Fundamental laws and rules

Introduction

In soil-climatic conditions of the Republic of Uzbekistan, vegetables, rice and other crops sowable at row-spacings are sown and cultivated between newly established garden row-spacings for 6-8 years [1,2]. Presently, agrotechnical activities are being carried out separately by agricultural machines and devices in preparing the garden rows for sowing in spring season. It causes an increase in labor, energy, and fuel consumption, soil macro-microstructure disruption and excessive compaction, and losing soil moisture. In addition, agricultural machines and tools created 50-60 years ago are imported from countries of the Commonwealth of Independent States (CIS), and they are being used in implementation the above activities. A large amount of material costs is being expended for using these machines and repairing them [3-6]. Based on the above, the design of a combined machine that prepares garden rows of plows for one-way sowing was developed at the Scientific-Research Institute of Agriculture Mechanization (see Figure 1).

The Structural Scheme of Combination Machine that Prepares the Garden Row-Spacings for One Way Sowing of the Crops

Combination machine is consists of frame 1 equipped with a suspension device, flat cutting claws 2 installed on it, a rotary operating element 3 that forms a soft soil layer in the form of spiral roller, flower -bed former 4, operating elements 5 that compact top and sides of the flower-bed. Operating elements of rotational and compacting the flower-beds are hingedly mounted to frame and equipped with compression springs.

Working process of developed machine for sowing at garden row-spacing is as follows: when the assembly moves along with the garden row-spacing, its flat cutting claws loosen the soil between the garden row-spacings; rotary operating element grinds the soil crushes by flat cutting claws and forms a soft soil layer. Then, flower-bed is formed by means of flower-bed former device, and then its top and sides are compacted to required level with a compactor, and lands are made ready for crops sowing. Results of studies on the basis of parameters of rotary operating element of the developed combination machine are specified in this article.

Materials and Methods

In the process of implementing theoretical research, the fundamental laws and rules of higher mathematics, theoretical mechanics and agricultural mechanics were applied.

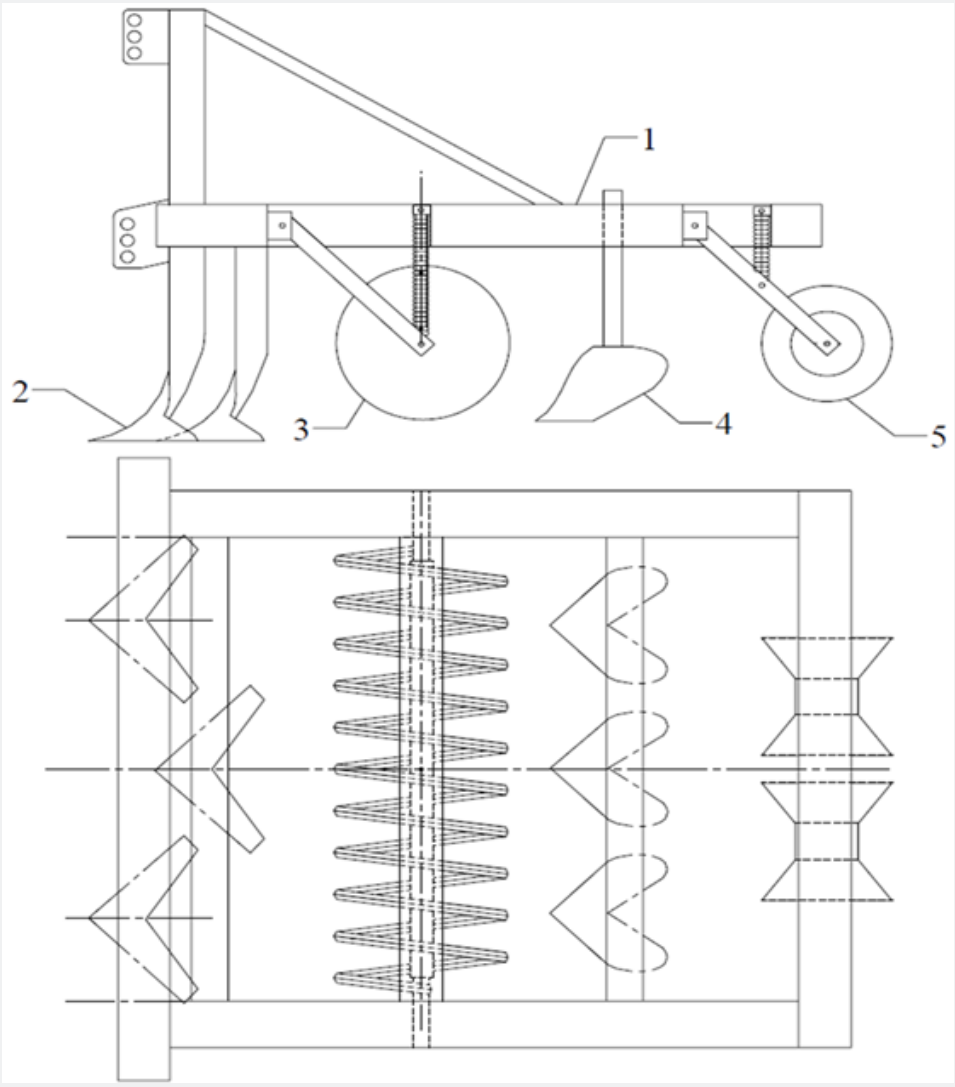

Figure 1.

Results and Discussion

Let's determine the diameter of rotational operating element D by using the following formula [7,8]:

$$D \geq \frac{\left[1+\cos\left(\varphi_1+\varphi_2\right)\right]d_k+2h_0}{1-\cos\left(\varphi_1+\varphi_2\right)}, \qquad (1)$$

where φ_1, φ_2 – are angles of external and internal friction of soil appropriately, °;

d_k - diameter of lump pieces encountered on the way of rotary operating element, m;

h_0 - depth of immersion (cultivation) of rotary operating element, m.

(1) when the term is fulfilled, rotary operating element compacts the lump pieces encountered on the way instead of dumping them. As a result, they are effectively crushed.

Let's determine vertical load to the rotary operating element Q by the following formula, which is derived from the working

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condition in soil to the specified immersed depth:

$$Q=\frac{1}{\sin\beta}\left(\frac{B_q}{S}+1\right)q_0\left(1+kV^2\right)\times$$

$$\times\left\{\delta R\left[\sqrt{2Rh_0-h_0^2}-\left(R-h_0\right)\arccos\frac{R-h_0}{R}\right]+\right.$$

$$+\left[R^2-\left(R-\frac{\Delta-\delta}{2}ctg\gamma\right)^2\right]\left(\frac{1}{\cos\gamma}+\frac{f}{\sin\gamma}\right)\times$$

$$\left.\times\left[\sqrt{\left(R-\frac{\Delta-\delta}{4}ctg\gamma\right)^2-\left(R-h_0\right)^2}-\left(R-h_0\right)\arccos\frac{R-h_0}{R-\frac{\Delta-\delta}{4}ctg\gamma}\right]\right\},\quad(2)$$

here β - angle of spiral displacement of rotary operating element relative to its rotation axis, °;

B_q - coverage width of rotary operating element, m;

S - spiral step, m;

q_0 - volumetric loosening coefficient of soil, N/m^3;

k proportionality coefficient, s^2 /m^2;

V - movement velocity of the combination machine (assembly), m/s;

δ - thickness of spiral blade of rotational operating element, m;

R - radius of rotational operating body, m;

Δ - thickness of spiral of rotational operating body, m;

γ – sharpening angle of rotational operating body, °;

f - coefficient of friction.

Compression Force of the Spring of the Rotary Operating Element

In order for rotational operating element to work at specified depth, vertical load applied to it is provided by its gravity and the vertical compressive force applied to it by springs. Based on this, assuming that gravity (mass) force of operating element is known, we formulate the compression force given by one of its springs as follows:

$$Q_p=\frac{Q-mg}{n},\quad(3)$$

where m - weight of rotational operating element, kg;

g - free falling acceleration, m/s^2;

n - number of springs installed on the rotational operating element, pieces.

Conclusions .

= 30°, = 40°, = 0.1 m, = 0.05 m, = 80°, = 1.8 m, = 0.1 m, = 1.5·106 N/m3, = 0.08 s2/m2, = 0.002 m, = 0.5, = 0.18 m, = 0.02 m, = 45°, = 0.5, = 100 kg, = 9.81 m/s2 and taking into account = 2 pcs and calculations made according to formulas (1)-(3) the diameter of combination machine developed at working velocities of 1.7-2.2 m/s to compress and crush the lumps found on the way of rotary operating element and sink to specified depth at least 36 cm, vertical load applied to it is the range of 5.73-6.46 kN, it showed that compression force of compression spring should be in range of 2.37-2.74 kN.

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