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Justification of the basic parameters of the rotary soil subsoiler

D Alijanov[1], Sh Abdurokhmonov[1], N Umirov[1], Kh Ismaylov[2] and J Ogalikov[1]

[1]Tashkent Institute of irrigation and agriculture mechanization engineers" National research university, Republic of Uzbekistan.
2Termez Institute of Agrotechnology and Innovative Development, Termez, Republic of Uzbekistan.

E-mail: abduroxmonov.shavkatjon@bk.ru

Abstract. The article presents materials for substantiating the main parameters of a rotary soil cultivator of a new sowing device equipped with a device for loosening the soil of non-performed primary tillage. To justify the width and diameter of the rotary ripper, consisting of 5 packages of pointed paws, tests were carried out to determine the location of corn stalks along the axis of the row. The test results were processed using mathematical statistics methods. Using the obtained formulas, distribution density curves of random variables were constructed. The width was taken from the plotted graph and based on this the diameters of the rotary shredder packages were taken.

1. Introduction

In the context of deepening market relations and the transition to the path of self-financing, agricultural science and practice have faced a real need for rational (effective) use of land, increasing its fertility, protecting soils from erosion, reducing the cost of cultivating crops while observing the requirements of the ecology of the natural environment. Therefore, there was a need for widespread introduction into production of new optimal methods and techniques of surface tillage.

The further development of the crop growing industry of the agro-industrial complex is based on the introduction of highly effective knowledge-intensive intensive technologies for cultivating agricultural crops, ensuring an increase in the productivity of arable land and obtaining environmentally friendly products with minimal costs of material, labor and energy resources.

One of the most important areas for increasing the efficiency and quality of the complex of works on tillage and sowing seeds of agricultural and fodder crops is improving the technological process, i.e. perform loosening, soil preparation and sowing operations in one go to the field. There are sowing devices for loosening and sowing seeds of agricultural plants for lands deeply cultivated in the fall and those produced by zero tillage. For such devices, it is necessary to first prepare the soil for sowing seeds. This technological process must be performed with other special devices. As a result, for cultivated lands, special equipment enters twice: once to loosen the soil and a second time to sow. In addition, in desert areas for sowing seeds of desert forage crops, row spacing is wider and in such cases, bringing in special equipment requires twice as much labor and increases costs. For this reason, it is advisable to loosen the soil and sow crop seeds in one go for uncultivated lands in the fall or desert lands.

The goal of the research work is to create a new device with the ability to immediately prepare the soil of the required depth and width, as well as for sowing plant seeds for uncultivated lands in the fall or desert lands [1,2,3].

2. Materials and research methods

For the practical implementation of the assigned tasks, a scheme of a sowing device equipped with a rotary soil ripper has been developed.

To prepare the soil with loosening, a rotary soil ripper consisting of packages of pointed paws, a drive and a gearbox are installed in front of the sowing device. The diagram of the rotary soil ripper is shown in Figure 1.

The packages of the lancet paws of the rotary soil grinder are made with different diameters, the diameters of the first and fifth packages are made with smaller diameters D_1, the diameters of the second and fourth packages are made with average diameters D_2, the diameter of the third package is taken to be large D_3. But the diameter and width of the rotary tiller must be taken taking into account the location of the root system of the crop being sown [4,5,6,7,8].

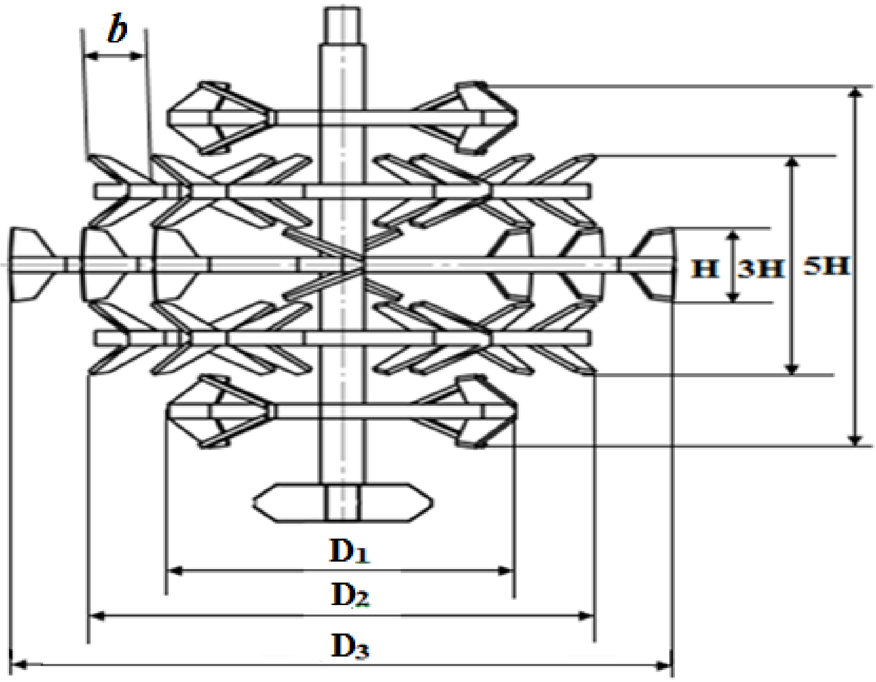

Figure 1. Diagram of a rotary soil ripper

The width of the rotary tiller depends on the location of the root system of row-sown plants relative to the axis of the bed, and the diameter depends on the depth of the root system.

The corn stalks in the rows are not exactly on the center line. There is always a scattering of places where stems are planted relative to the center line of the row. When considering the position of the stems along the axis of the row, the random nature of the distribution of the distance between adjacent stems is also noted. There are cases of paired stems. To assess this position, it is necessary to have static data on the location of the stems along the axis of the row. For this purpose, from October 15 to October 17, 2023, appropriate tests were carried out on the harvested fields of the Roziya opa farm in the Zangiata district of the Tashkent region using the example of a corn plant.

3.Results and Samples

The test results were processed by methods of mathematical statistics. Let us denote by the index X the random value of the deviation of the place where the stem is planted from the measurement line,

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and by the index Y we denote a random value characterizing the distance between adjacent stems along the axis of the row [9,10,11,12,13,14,15].

Expected value:

$$\overline{X} = \frac{1}{n}\sum_{i=1}^{n} X_i = 7,66\ cm \quad (1)$$

$$\overline{Y} = \frac{1}{n-1}\sum_{j=1}^{n-1} Y_j = 17,5\ cm \quad (2)$$

The corresponding variances and standard deviations are determined by the formulas:

$$\sigma_x^2 = \frac{\sum_{i=1}^{n}(X_i-\overline{X})^2}{n-1} = 5,99\ cm;\ \ \sigma_x = 2,45\ cm; \quad (3)$$

$$\sigma_y^2 = \frac{\sum_{j=1}^{n-1}(Y_i-\overline{Y})^2}{n-1} = 17,5\ cm; \qquad \sigma_y = 7,86\ cm. \quad (4)$$

Let us assume that the random variable X is characterized by a normal distribution law with density:

$$\varphi_{(x)} = \frac{1}{\sigma_x\sqrt{2\pi}} * e^{\frac{-(x-\overline{x})^2}{2\sigma_x^2}} = \frac{1}{2,45\sqrt{2\pi}} * e^{\frac{-(x-7,66)^2}{2*5,99}} \quad (5)$$

The random variable Y satisfies the Erlang distribution hypothesis:

$$\varphi_y = \frac{m\lambda}{(m-1)}Y^{m-1} * e^{-\lambda y} = \frac{3*1,45}{2}y^2 * e^{-1,45y} \quad (6)$$

here m=3 is a parameter characterizing the average number of measurements on the accepted interval of division of possible values of Y; λ=1.45 - distribution parameter.

Using the obtained formulas, it is not difficult to construct distribution density curves of random variables X and Y.

Using the function φ(x) you can select the width of the rotary soil cultivator. From the graph shown in Fig. 2 it can be seen that if the row axis coincides with $\overline{X}$= 7.66, then taking the width of the rotary soil ripper to be 20 cm, we obtain X_1 = 1.34 cm and X_2 = 13.34 cm. Then the probability of plant seeds falling into a given interval is:

$$P\left(x_1 < \overline{x} < x_2\right) = P(1,34 < \overline{x} < 13,34) = 0,982 \text{ or}$$

$$P(x) = \varphi\left(\frac{5}{2,4}\right) - \varphi\left(\frac{-5}{2,4}\right) = 2\varphi(2,08) = 0,932 \quad (7)$$

Using the tabular data of the normal distribution density function, we obtain $P\left(x_1 < \overline{x} < x_2\right) = 2 * 0,3146 = 0,6292$. If $\overline{x}$=0, $\sigma = 2,45$, $x_1 =- 5$, $x_2 =+ 5$. Taking into account the installation of the rotary soil ripper at a depth of h = 16 cm, we will take the diameter of the smaller package of the rotary soil ripper D_1 = 2(h + r) = 38 cm we accept (here r - is the radius of the rotary soil ripper shaft). Taking into account the installation of the pointed paw of the cultivator at a depth of 10 cm, we will accordingly take D_2 =58 cm and D_2 =78 sm.

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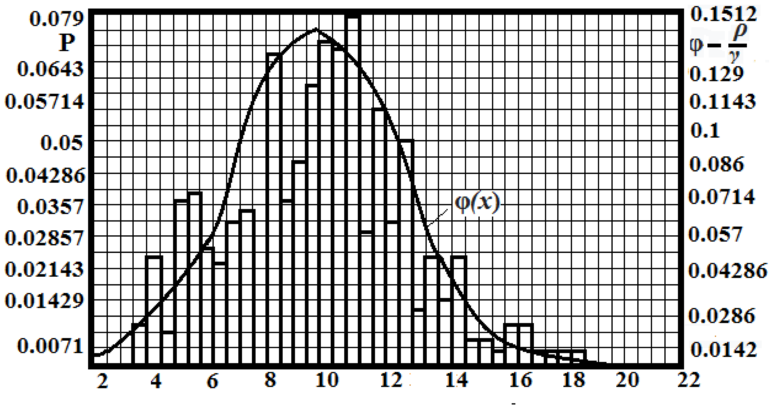

Figure 2. Histogram of the distribution of transverse deviations and theoretical φ(x).

Corn, like all cereals, has a fibrous root system.
The main root of the plant dies or is invisible among the other adventitious roots growing from the stem. Loosened soil with a rotary soil cultivator during corn growth may not sufficiently ensure the development of the root system. This deficiency is compensated by a hiller when forming a bed or a cultivator when processing plants between rows.

Conclusion

As a result of experimental and theoretical studies, the width of the rotacin soil cultivator is assumed to be 5H = 20 cm and the width of each package is H = 4 cm, and the diameters, respectively, are D_1 = 38 cm, D_2 = 58 cm and D_2 = 78 cm.

To determine the power consumption and rotation speed of a rotary soil ripper, it is necessary to study the input force on the ripper shaft; it is necessary to develop and create a special stand.

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