

## Technological process of uniform distribution of fertilizers over the width of the coulter

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**Abstract.** The applied methods of applying fertilizers for cotton in Uzbekistan do not fully ensure the supply of nutrients to the plant's root system. The study aims to substantiate the technological process of uniform distribution of fertilizers in the root development zone and the parameters of coulters. When the fertilizer is distributed in the root development zone in tiers and the right ratio, the coefficient of their use increases, and the yield of cotton increases. The research uses the laws and rules of theoretical mechanics, mathematical statistics, mathematical planning of experiments, and the methods given in existing regulatory documents. The technology of forming new ridges instead of existing ridges and new furrows instead of existing furrows in fields with harvested husk with simultaneous fertilization and an improved chisel cultivator-fertilizer with comb-forming agents for its implementation, as well as the results of theoretical studies to substantiate the main parameters of the tuk coulters chisel-cultivator are presented.

The study determined the parameters of universal fertilizer Coulter chisel-cultivator of fertilizer: the base cone of the diffuser in the form of an ellipse with minor axis width 10 mm, height tool provider relative to the upper base of the truncated cone of 60 mm, and a diameter of a half-cylinder of 20 mm.

## 1 Introduction

In the world, the leading place is occupied by the development of technologies and technical means for tillage [1-23], sowing [25-26], harvesting crops [10], and their processing [12], including the application of mineral fertilizers in the layer of plant root development [31].

Technologies and technical means for applying mineral fertilizers to the development layer of the root system of plants are some of the important issues in the production of agricultural crops. One of the important tasks in agriculture is the development of technical means for the formation of ridges with the simultaneous introduction of mineral fertilizers in the zone of development of the root system of plants [25, 27, 31]. At the same time, much attention is paid to the development of combined machines that perform the technological processes of applying mineral fertilizers to the root system of plants during the preparation of the soil for sowing [25, 27, 31, 36].

In the production of agricultural crops, special attention is paid to reducing labor and energy costs, saving resources based on advanced technologies, and developing high-performance agricultural machines.

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One of the main ways to increase crop production is not the expansion of acreage, but a steady increase in yield, in which the rational use of fertilizers is essential [33-35].

The advanced farms of the republic have long proved the possibility of obtaining high and stable cotton yields with the systematic and correct use of mineral and organic fertilizers against the background of high agricultural technology. Effective use of increasing doses of mineral fertilizers from year to year is achieved in compliance with scientifically-based terms and norms of fertilizer application for certain soil and climatic conditions of cotton-growing areas.

The study aims to substantiate the technological process of uniform distribution of fertilizers in the root development zone and the parameters of coulters.

## **2. Methods**

The research uses the laws and rules of theoretical mechanics, mathematical statistics, mathematical planning of experiments, as well as the methods given in existing regulatory documents. Preparation of the soil for sowing on the ridges can be carried out on cotton fields with a row spacing of 60 or 90 cm. The installation of rippers in front of the coulters helps to reduce the traction resistance [8, 31-37].

In the spring, strip processing is carried out on the ridges and sow without fertilizing. As a result, scattered fertilization for plowing is excluded in the fall, early spring harrowing with malovanie, and the labor-intensive plowing operation with the formation turnover is replaced by non-fall loosening with fertilization. Ridges are formed simultaneously [31-37].

An improved chisel cultivator CHKU-4M carries out the proposed method. To do this, it is equipped with the following working bodies: rippers for loosening the soil in the row spacing, rippers with a pipeline for loosening existing ridges with simultaneous fertilization along the sowing line, and ridges for forming new ridges instead of existing ridges.

When working with the CHKU-4M chisel cultivator in production conditions, it was found that its coulter has significant drawbacks. After the passage of the coulter, a deep furrow is formed, it unloads the soil in front of it and has a large traction resistance. In addition, additional partitions quickly fail and the uniformity of the distribution of fertilizers along the width of the capture is violated [8, 31-37].

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### 3 Results and Discussion

The technological process of the proposed cone diffuser of the coulter is shown in Fig. 1. On the uniform distribution of the fat by the width of opener influenced by the following parameters: diameter of the cylinder (half-cylinder), the angle of tool provider relative to the horizontal ( $\alpha_1$ ), the distance from the lower edge of tool provider to the cylinder (l1), the height of tool provider relative to the upper base of the truncated cone (h1) [31-37].

According to the results of preliminary studies and a priori data, the following levels and intervals of variation are accepted (Table.1) [34-36].

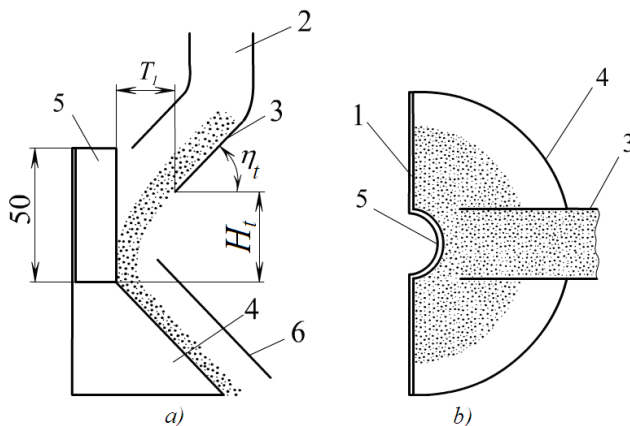
**Table 1.** Levels and intervals of variation of factors

The title of the factors	$T_1(x_1)$ , mm	$H_t(x_2)$ , mm	$\eta_m(x_3)$ , degree	$D(x_4)$ , mm
Basic level	30	40	30	30
Variation step	10	20	15	10
The upper level (+1)	40	60	45	40
The lower level (-1)	20	20	15	20

The experiments were carried out according to plan  $B_4$  (as the most accurate plan is close to  $D$  - optimal), on the stand. After processing the results of the experimental data, a regression equation was obtained that adequately describes the process of fertilizer distribution over the width of the coulter.

$$Y = 19.62 + 2.24X_2 - 4.12X_4 + 1.33X_1X_2 + 3.27X_1X_4 - 1.82X_2X_3 - 5.61X_2X_4 + 6.52X_3X_4 + 1.72X_1^2 + 1.72X_2^2 + 7.79X_3^2. \tag{1}$$

Analysis of equation (1) shows that the uniform distribution of fertilizer by the width of fertilizer Coulter greatest impact diameter of a half-cylinder ( $X_4$ ) and mounting height tool provider relative to the upper base of the truncated cone ( $H_1$ ). With an increase in the diameter of the semi-cylinder and with a decrease in the height of the installation of the pipeline, the uneven distribution of fertilizers decreases.



**Fig. 1.** Technological scheme of the cone diffuser operation: *a* is side view *b* is a top view;

1 is partition; 2 is take profit; 3 is feed part of tool provider; 4 is semi-cone; 5 is semi-cylinder; 6 is casing

It can be seen from equation (1) that the effects of factors  $X_1$  (distance from the lower edge of the pipeline to the cylinder) and  $X_3$  (the angle of inclination of the pipeline relative to the horizontal) were insignificant. The pair interactions and the values of the quadratic coefficients were significant.

To graphically interpret equation (1) and determine the degree of influence of factors  $X_1$  and  $X_2$ , we consider a two-dimensional cross-section of the response surface.

Consider the change in the unevenness of the distribution of fertilizers over the width of the capture, depending on the factors  $X_1$  and  $X_2$  at  $X_3 = 0, X_4 = 0$ .

In this case, equation (1) takes the following form

$$Y = 19,62 + 2,24X_2 + 1,33X_1X_2 + 1,72X_1^2 + 1,72X_2^2. \quad (2)$$

We determine the coordinates of the center of the surface by differentiating equation (2) and solving the system of equations

$$\frac{\partial y}{\partial x_1} = 1,33X_2 + 3,46X_1 = 0, \quad (3)$$

$$\frac{\partial y}{\partial x_2} = 2,25 + 1,33X_1 + 3,46X_2 = 0,$$

$$X_1 = 0,27; X_2 = -0,752.$$

Substituting the values of  $X_1$  and  $X_2$  in equation (2), we get the value of the optimization criterion in the center of the surface  $Y = 18,778$  %. Next, we perform a canonical transformation of equation (2), for which we solve the characteristic equation

$$f(B) = \begin{vmatrix} 1,72 - B & 0,66 \\ 0,66 & 1,72 - B \end{vmatrix} = 0 \quad (4)$$

and we get the eigenvalues (roots) of this characteristic equation, which turned out to be in  $B_{11} = B_{22} = 1,07$ , and the equation itself took the following canonical form

$$y - 18,778 = 1,07X_{11}^2 + 1,07X_{22}^2. \quad (5)$$

Determine the angle of rotation of the canonical axes  $X_1^1$  and  $X_2^1$  relative to the previous coordinates  $x_1$  and  $x_2$

$$\operatorname{tg} \alpha = \frac{b_{12}}{b_{11} - b_{22}} = \frac{1,25}{1,72 - 1,72} = \frac{1,25}{0} = \infty. \quad (6)$$

Substituting different values of unevenness in equation (5), we obtain the equations of the corresponding contour curves-circles, collectively representing a whole family of conjugate circles (lines of equal unevenness), which are shown in Fig.1.

Fig. 1 shows that with increasing height of the conductor relative to the upper base of the truncated cone, uneven seeding fertilizer by the width of fertilizer Coulter increases. The optimal values of the factors with the lowest unevenness (19%) are:  $P_7 = 20-32$  mm and  $E_1 = 30-36$  mm.

Consider a two-dimensional cross-section of the response surface depending on the angle relative to the horizontal tool provider  $\eta_l(x_3)$  and height of tool provider  $H_l(x_2)$ , which is shown in Fig.5.20. This cross-section is obtained for fixed values of the factors  $T_1 = 30$  mm;  $D = 30$  mm. Analysis of this cross-section of the response surface shows that the minimum value of unevenness can be achieved with the following values of the factors:

$$\eta_l = 28-32^\circ \text{ and } H_l = 24-32 \text{ mm.}$$

Consider a two-dimensional cross-section of the response surface, which characterizes the change in the uneven distribution of fertilizers depending on the distance from the lower edge of the pipeline to the cylinder  $T_1(x_1)$  and the angle of inclination of the pipeline relative to the horizontal  $\eta_m(x_3)$ , which is a family of conjugate ellipses. It shows that the minimum value of the uneven distribution of fertilizers  $y$  at the zero level of the factors  $H_m = (x_2)$  and  $D(x_4)$  is 20%, and it is achieved at  $T_1 = 26-34$  mm,  $\eta_l = 27-33^\circ$ .

As can be seen from previous analyses, a two-dimensional cross-section of the response surface at a certain level of factors shows a change in the uneven distribution of fertilizers over the width of the coulter grip in this cross-section.

To determine the optimal values of the factors at which the least unevenness of the distribution of fertilizers is achieved, the equation is studied at a minimum on a computer. The following parameters of the coulter diffuser for broadband fertilization  $L_t = 20$  mm,  $h_t = 60$  mm,  $\alpha_t = 25^\circ$ , and  $D = 20$  mm were obtained.

## 4 Conclusions

1. The technology of forming new ridges instead of existing ridges and new furrows instead of existing furrows in fields with harvested husk with simultaneous fertilization and an improved chisel-cultivator-fertilizer with comb-forming agents for its implementation is justified.
2. The study determined the parameters of universal fertilizer Coulter chisel-cultivator of fertilizer: the base cone of the diffuser in the form of an ellipse with minor axis width 10 mm, height tool provider relative to the upper base of the truncated cone of 60 mm, and a diameter of a half-cylinder of 20 mm.

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