Laboratory study of the technological process of the screw device for formation of longitudinal pawls between cotton rows and simulation of the obtained results

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Abstract: The article analyzes the process of working with a screw device for the mechanization of longitudinal burns in laboratory conditions, which are still formed manually between cotton rows in cotton farms on irrigated areas. In it, the results obtained in laboratory experiments were obtained by processing them through mathematical modeling. Through the developed multi-factor mathematical model, the results of the experiment obtained in a special laboratory device were mathematically processed and the determination of the most optimal values was achieved. From the article, it is possible to analyze the method of mathematical processing and determine the optimal value for the results of experiments obtained in the laboratory apparatus. At the same time, the article provides a method of summing the interconnectedness of different sizes in different ranges by means of variability in a combined small range. The resulting value allows the detection and application of cord devices in any interrelated parameters, and taking into account the proximity of the received optimal values to the real value, it is recommended that the presented methods be used to solve similar issues.

1. Introduction

The following President's Resolution and Decree show the importance of mechanization: the decree number PF 4947, dated February 7, 2017, "Attempting strategies to develop the Republic of Uzbekistan" and the resolution number PQ 3459 2018 4th of January "Supplementary measures to increase agricultural equipment" [1, 2, 3].

Nowadays, the majority of cotton grown is suitable for irrigated farming. Nevertheless, cotton growing in irrigated agriculture demands more work. It is considered preferable for its productivity. Because of the crops’ area of relief and uneven fields, the cotton irrigating process will be better done with the help of pawls dividing the small fields. In this process, along and across pawls should be made before irrigating and using them till the end of the crop period. Taking into consideration and making it in quantities is considered the actual problem. Nowadays, the process is being done by hand work by some farmers. Handmade capsizers that create surface pawls are also being used. This technique device does not give an opportunity to be used widely because it creates a cross pawl between cotton raw and done-in-two, the height of hurting cotton's young growth. Because of this problem, Tashkent Institute of Mechanization and Agricultural Engineers’ Bukhara branch scientists are doing research work according to plan. The novelty of this recommended construction, which is created along the pawl between cotton rows, is defended by the useful patent model number FAP 00671 by the intellectual ownership of the Republic of Uzbekistan.
2. Statement of the problem
In order to examine, the results of theoretical study research to create this device, to work parameters, its measures and productivity. It planned to motivate energetic indication of works in laboratory and its parameters.

The model was made according to experimental research to do experiment in laboratory to create along pawls between cotton rows.

According to this laboratory model the following research work:
- investigate fixing corner, speed movement of soil raiser coil conveyor according to its number rotation
- determining productivity of rising corner of coil conveyor screw according to its axis.
- determining impact of coil conveyor step and its diameter to its energetic and agro technique indications.
- identifying working parameters and worth of rational working regimes by using more planning style of experiment.

3. Materials and methods
Special laboratory construction was projected and made to make an experimental research in laboratory. (Figure 1)

Laboratory construction consists of the following parts: Soil channel 1, free movement cart 2, (electric motor) 3, coil conveyor working organ 4, special appliance to fix in working movement cart 5, and position of turning threading combination according to working movement 6, redactor to send circular movement in work perpendicular plain 7, providing organ rotation number during the movement of the cart 9, toothed star 10, carrier 11 and carried belt passer 13, between pulley.

Laboratory construction works in following order. Electro motor which is moved cart frees in soil channel acts ahead 2.

Experimental construction is fixed by special device to the cart. Coil conveyor works by cone reducer fixed by belt passer cart. According to laboratory construction movement direction coil conveyor’s descent corner is changed by threading combination. Taken results by laboratory experiment are assessed by size of soil which is carried from construction.

In order to change descent corner by special threading combination (6) can have an opportunity to make corner to construction from 0 to 75 according to movement direction of laboratory.

![Figure 1. Laboratory construction to investigate technologic process of creating along pawl device between cotton rows](image)

Main working element of laboratory construction is coil conveyor (4) which carry soil to the corner, to this rotary and cart movement together is given to cone reducer (7), validator goes out from that is sent to coil conveyor carrier pulley (12) through rotary movement belt (13) from 3 diametric pulley. The aim of it is to change pulley’s step, rotary movement.
Laboratory model of creating along pawl between cotton rows’ construction is prepared according to working organ size 1/3 and fixed to soil channel cart through special device creating along pawl in soil channel laboratory construction, gives an opportunity to practice several speed movement in work regimes (Figure 2).

4. Requirement of soil and experimenting
Making laboratory experiments with hard soil, its wetness and granules are the same condition as fields. Soil’s layer wetness 0…15 sm. keep the same with hardness of it 10.3…12.1 % and 0.16…0.33 MP.

In laboratory construction is aimed to determine descent corner according to movement direction of coil conveyor working organ, number of coil conveyor step and rotatory number, speed movement and coil conveyor diameter, effect of raising coil conveyor to energetic and agro technique indications, this is assessed by productivity of work.

![Figure 2. Side view of laboratory construction which creat along pawl between cotton rows.](image)

All indications are planned to do according to UZ RH 63.07: 2001 and TST 63.03:2001 “Experiment of agro cultural technique. Methods of economic effectiveness of experimental technique” Programs and methods of experiments RD 10.5.1-91 [3, 4]

Experiments make an opportunity fixing α=25°; 35°; 45°; 55° and 65° descendat corner according to horizon and speed movement of coil conveyor rotatory movement number ν=30; 42 na 55 rot/min.

Version of coil conveyor diameter $d_{sh}=80; 90$ and $100$ mm, raising corner $γ=70°; 80°; 90°$ and its step $q_{sh}=25; 35$ and $45$ mm are prepared on the base of theoretical research results.

5 repeated measuring process will be done on the base of these parameters the results are taken from 3 point of soil channel and determined average mathematical value in experiments.

Laboratory construction gives an opportunity moving in $V=0.5; 0.75; 1.2$ m/s working organ of soil channel direction. These speeds coincide with II and III step of aggregate.

Special reducer elector motor fixed in laboratory construction and it provides rotator number (750, 1000 and 1500 rpm) and model 4A Y128 works to move cart which is in soil channel.

Coil conveyor diameter, steps and raising corner parameters are determined by making 3 version experimental models coincide with laboratory device which is created pawl between cotton rows coincide with its value. So taken results from laboratory coincides with field and lands.

5. Discussion of research results
Mathematical modeling has always been highly valued as a method of solving scientific and technical problems.

The complex development of agriculture in all countries is determined by the demand for an annual increase in the level of mechanization. For a longitudinal pawl forming device between cotton rows, the
slope angle relative to the direction of movement and the effect of the screw on the volume of soil transported in the change in the number of revolutions were mathematically modeled to avoid material-to-material and time-saving experiments [3, 4].

Experimental parameters in modeling, the results of changes in the volume of soil transported in the change of the angle of inclination relative to the direction of its movement and the number of rotations of the screw in the model of the pawl formation device tested in the soil channel in the laboratory of TIIAME Bukhara branch.

The experiments were obtained at five repetitive values on multivariate. We are one of them here $\alpha=25...65^\circ$ and we present the results of the correlation and regression analysis for the experimental data obtained.

**Table 1.** Experimental parameters for modeling, i.e., the values of soil volume obtained when the slope angle of the pawl-forming device between cotton rows at a rotational speed of $n$ are set at 25, 35, 45, 55, 65 degrees, respectively

| Speed rotation corner slope | The volume of soil transported (kg) |
|----------------------------|-----------------------------------|
| n=30 rpm                   | $\alpha=25$ 0.31 $\alpha=35$ 0.281 $\alpha=45$ 0.252 $\alpha=55$ 0.223 $\alpha=65$ 0.195 |
| n=42 rpm                   | $\alpha=25$ 0.434 $\alpha=35$ 0.393 $\alpha=45$ 0.353 $\alpha=55$ 0.313 $\alpha=65$ 0.272 |
| n=55 rpm                   | $\alpha=25$ 0.568 $\alpha=35$ 0.515 $\alpha=45$ 0.462 $\alpha=55$ 0.409 $\alpha=65$ 0.357 |

Here we consider the relationship between the slope angle of the pawl-forming device between cotton rows and the volume of soil obtained at that angle as a function.

The correlation-regression analysis method was used to model the correlation between the two indicators. In doing so, we first determine the degree of correlation between these two indicators.

In the study of correlations, two categories of issues are cross-cutting. One is to assess how closely (i.e., strong or weak) the relationship is between the events being studied. This is the function of a method called correlation analysis [4, 6, 7].

Correlation analysis is based on the determination of correlation coefficients and the assessment of their importance and reliability.

The correlation coefficients are twofold. The values obtained as a result of their calculation can be considered as the norm of correlation between $X$ and $Y$ events or, conversely, between $Y$ and $X$ events. Correlation coefficient ($r$) -1 from 1 lies on the border, if $r=0$ - no connection, $0<r<1$, lies on the border $-1<r<0$ - there is a feedback loop $r=1$ there is a functional connection, that is $|r(x, y)| \leq 1$.

The bond density level is usually interpreted as follows. If $r<\pm 0.3$ almost no connection $\pm 0.3 < r < \pm 0.5$ weak connection. $\pm 0.5 < r < \pm 0.8$ middle connection. $\pm 0.8 < r < \pm 1$ strong connection.

The correlation coefficient is determined using the following formula [2]:
The values showing the correlations between the values of Table 1, which show the angle of inclination of the pawl-forming device between the cotton rows, and the amount of soil obtained, are given in Table 2.

Table 2. Statistical regression module results

| Name of coefficient          | Speed rotation |
|------------------------------|----------------|
|                              | 30             | 42             | 55             |
| Correlation coefficient      | -0.99          | -0.99          | -0.99          |
| Mathematical expectation     | 0.29           | 0.41           | 0.54           |
| Dispersion                   | 0.00281        | 0.00545        | 0.00939        |
| Default error                | 0.0530         | 0.0738         | 0.09693        |

Table 2 shows that the correlation of the indicators in the experimental results is strong, and the negative value of the correlation coefficient shows that the correlation between the indicators is inverse (Table 1).

The second task in checking the correlation is to determine how much the second event changes depending on the change in one event, that is, to determine the regression equation. [5, 8]. Regression equations play an important role in solving practical problems. It allows the evaluation of the effectiveness of the events affecting the outcome event with practically sufficient accuracy.

Based on Table 1, when analyzing the relationship between the slope angle of the floor formation device between the rows of cotton and the soil volume obtained at that angle, we see that this relationship is parabolic. That's the connection

$$Y^2 = a + bx + cx^2$$

(2)

In determining the coefficients of the equation for the given second-order parabola, the system of normal equations according to the method of least squares has the following form:

$$\begin{cases}
Na + a\Sigma x + b\Sigma x^2 = \Sigma y \\
a\Sigma x + b\Sigma x^2 + c\Sigma x^3 = \Sigma xy \\
a\Sigma x^2 + b\Sigma x^3 + c\Sigma x^4 = \Sigma xy^2
\end{cases}$$

(3)

There N- number of experimentation.

The number of revolutions in this system of equations n=30 rot/min we find from Table 1 (2) that the coefficients in the model are as follows.

$$y = 0.447261 - 0.003543 \cdot x + 0.000002 \cdot x^2$$

(4)

Table 3. When calculating theoretical data using Equation (4), we see the following differences:

| Slope angle, grad | Soil volume, kg | Theoretical volume, kg | difference |
|-------------------|-----------------|------------------------|------------|
| 25                | 0.360           | 0.360029               | 0.00003    |
| 35                | 0.326           | 0.325886               | 0.0001     |
| 45                | 0.292           | 0.292171               | 0.0002     |
| 55                | 0.259           | 0.258886               | 0.0001     |
| 65                | 0.226           | 0.226029               | 0.00003    |

Now, when the number of revolutions is 42, we find from Table 1, based on experimental data (2), that the coefficients on the basis of the smallest squares of the model are equal to:
\[ y = 0.620854 - 0.004734 \cdot x + 0.00002 \cdot x^2 \]  

(5)

**Table 4.** When calculating theoretical data using Equation (5), we see the following differences:

| Slope angle, grad | Soil volume, kg | Theoretical volume, kg | difference |
|------------------|----------------|------------------------|------------|
| 25               | 0.503          | 0.502943               | 0.001      |
| 35               | 0.456          | 0.456029               | 0.0001     |
| 45               | 0.409          | 0.404957               | 0.0003     |
| 55               | 0.363          | 0.362629               | 0.0004     |
| 65               | 0.316          | 0.316143               | 0.0002     |

Also, when the number of revolutions is 55, we find from Table 1 that on the basis of experimental data (2) the coefficients on the basis of the smallest squares of the model are equal to:

\[ y = 0.815761 - 0.006323 \cdot x + 0.00002 \cdot x^2 \]  

(6)

**Table 5.** When calculating theoretical data using Equation (6), we see the following differences:

| Slope angle, grad | Soil volume, kg | Theoretical volume, kg | difference |
|------------------|----------------|------------------------|------------|
| 25               | 0.659          | 0.659029               | 0.00003    |
| 35               | 0.597          | 0.597086               | 0.0001     |
| 45               | 0.536          | 0.535571               | 0.0003     |
| 55               | 0.474          | 0.474486               | 0.0004     |
| 65               | 0.414          | 0.413829               | 0.0002     |

The lines formed on the basis of the above three models are shown in Figure 1 in comparison with the experimental points. The models shown in the figure are close to the experimental points.

![Diagram of the relationship between the slope angle of the floor formation device between the cotton rows and the soil volume obtained at that angle.](image)

**Figure 3:** Diagram of the relationship between the slope angle of the floor formation device between the cotton rows and the soil volume obtained at that angle.  
1) number of rotation n=30 rpm, 2) number of rotation n=42 rpm, 3) number of rotation n=55 rpm.

We also check that the experimental values are adequate to these derived models. As an example, we use Fisher's test for model (6) [9, 10].
Table 6. To do this, we refer to Table 5 for extended regression values

| №  | X(i) | Y(i) | y-theoretical | y_i − ŷ_i | (y_i − ŷ_i)^2 |
|----|------|------|---------------|------------|---------------|
| 1  | 25   | 0.659| 0.659029      | 0.00003    | 0.000000000   |
| 2  | 35   | 0.597| 0.597086      | 0.0001     | 0.000000001   |
| 3  | 45   | 0.536| 0.535571      | 0.0003     | 0.000000009   |
| 4  | 55   | 0.474| 0.474486      | 0.0004     | 0.00000016    |
| 5  | 65   | 0.414| 0.413829      | 0.0002     | 0.00000009    |
| number | 228 | 2.68 | 2.680001      | 0.00113    | 0.00000035    |

Before and using this y_i dispersion S_y^2 and the sum of the squares of the remains Ŝ_y^2 we calculate:

\[ S_y^2 = \frac{1}{n-1} \left[ \sum_{i=1}^{n} y_i^2 - \frac{1}{n} (\sum_{i=1}^{n} y_i)^2 \right] \]  \hspace{1cm} (7)

(6) if substituting the values of the variables in the formula

\[ s_y^2 = \frac{1}{n-2} \left[ \sum_{i=1}^{n} (y_i - \bar{y}_i)^2 \right] = \frac{1}{5-2} \cdot 0.00000035 = \frac{0.00000035}{3} = 0.00000012 \]  \hspace{1cm} (8)

now we calculate the statistic F of Fisher criterion:

\[ F = \frac{S_y^2}{S_y^2} = \frac{0.009395}{0.00000012} = 80317.75 \]

A pair of degrees of freedom of the Fisher criterion

(\nu_1 = k - 1; \nu_2 = n - k) = (1; 3) we find from the table the critical point of 5%

FT = 0.95 (1; 3) = 5.32

According to the results of the experiment, \( F = 80317.75 > 5.32 \), which means that the regression equation we have determined does not contradict the results of the experiment, that is, it can be taken as the equation we are looking for with an error of 5%.

In all calculations, we used the capabilities of the Pascal programming language and the PascalABC programming environment, and the capabilities of the MathCAD design system when drawing graphs.

[11].

6. Conclusion

Using this style will help you do hard and difficult experiments and get fast and suitable results. Through the use of this style, one can easily get the best and fastest results during experiments. The results are worked out mathematically, and it gives an opportunity to prepare working examples without mistakes. So it will reduce working expenditure. It will also enable us to compare results which are taken from construction in the field and laboratory, and through that, research work will be assessed. The obtained regression equations can be used in experiments to determine the relationship between the slope angle of the floor formation device and the amount of soil obtained at this angle between the rows of cotton in the absence of experiments and in scientific research in this area.

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