Mathematical processing of experimental data of the agricultural working body

Sergey V Belousov* and Anna I Belousova
Kuban State Agrarian University named after I.T.Trubilin, Krasnodar, Russian Federation

*sergey_belousov_87@mail.ru

Abstract. The work is devoted to experimental researches, namely, obtaining a comparative assessment of the quality parameters of the technological process of layer-by-layer soil treatment, in comparison with the serial and proposed working bodies. The article has an analytical character, which is expressed in the fact that the analysis of experimental and energy parameters of an arable unit with various working bodies is given. The quality of the technological process of layer-by-layer tillage with additional working bodies was determined. The conclusions outline the main results achieved so far.

The main task of agriculture in the Russian Federation is to increase the volume of crop and livestock production at all stages of production. The most energy-intensive process in agriculture is tillage [1]. The choice of soil treatment is determined by climatic conditions, biological characteristics of cultivated crops and their purpose. The efficiency of tillage depends largely on the technological properties of the soil. The most time-consuming is the soil processing with a turnover of formation. The main method of processing the arable horizon with the formation turnover is turning-moving in the vertical direction of soil layers that differ in agronomic properties [2].

The purpose of experimental studies was to obtain a comparative assessment of the quality parameters of the technological process of soil treatment, as well as experimental and energy parameters of the arable unit with various working bodies [3,4,9]. As a result of experimental studies, we determined the physical and mechanical properties of the agricultural background, the traction resistance of the proposed working bodies in comparison with the serial plough, as well as performance and energy parameters with additional working bodies of the crusher [6,8,10].

Studies of the dependence of the soil crumbling from the speed and width of additional working bodies were conducted by the results of the statistical analysis of the results of the experiment for the assessment of crushing by standard and modernized working bodies of the plough, the crushing of the studied fraction is from 0-50 mm, 50-100 mm and 50-100 mm. Data processing was performed using the developed program in the MathCAD [5,6,7].

Table 1. Parameters of operation when processing by a serial plough.

| Tractor transmission | 3   | 4   | 5   |
|----------------------|-----|-----|-----|
| Actual forward speed, km / h | 5,34 | 6,16 | 7,15 |
| Soil crushing, %, fraction sizes, mm | 85,9 | 91,80 | 92,90 |
According to the data obtained as a result of field researches, there were determined the regularity of changes in crushing in the soil horizon in figure 1 depending on the speed of movement of the arable unit on a given tractor transmission and the regression equation 4.8 and its graphic image in figure 1, curve 1.

\[ y = \frac{1000}{47,930 \cdot 10^{-3} \cdot x^2 + 572,50 \cdot 10^{-6} + \frac{54,229}{x}} \]  

(1)

**Table 2.** Parameters of operation when processing by the crusher 1.

| Tractor transmission | 3   | 4   | 5   |
|----------------------|-----|-----|-----|
| Actual forward speed, km / h | 5.52 | 6.39 | 7.61 |
| Soil crushing, %, fraction sizes, mm | 87.50 | 94.00 | 95.20 |

According to the data obtained as a result of field researches, there were determined the regularity of changes in crushing of the soil horizon in figure 1 depending on the speed of movement of the arable unit on a given tractor transmission, the regression equation and its graphic image in figure 1, the curve 2.

\[ y = \frac{+2,7099 \cdot 10^3}{e^x} - \frac{69,952}{X} + 1,7422 \cdot x \]  

(2)

**Table 3.** Parameters of operation when processing by the crusher 2.

| Tractor transmission | 3   | 4   | 5   |
|----------------------|-----|-----|-----|
| Actual forward speed, km / h | 5.65 | 6.57 | 7.76 |
| Soil crushing, %, fraction sizes, mm | 89.4  | 96.30 | 97.90 |

According to the data obtained as a result of field researches there were obtained the regularity of changes in crushing in the soil horizon depending on the speed of movement of the arable unit on a given tractor transmission, the regression equation, the formula Zee, the graphic image in figure 1, the curve 3.

\[ y = \frac{1000}{-269.1 \cdot e^x + 699,68 \cdot 10^{-6} \cdot e^x + \frac{67,423}{x}} \]  

(3)

Figure 1. Dependence of change of soil crushing on velocity and length of additional flat-cutting working bodies with serial working bodies.
As can be seen from figure 1, the comparative characteristic of soil crushing with a fractional composition of 0-50 mm shows that soil crushing is better when using additional working bodies more effectively at parameters close to the speed of movement \( V = 7.76 \text{ km/h} \). The soil crushing of this fraction is 97.90%.

Studies of the soil crushing from the speed and width of the additional flat-cutting working bodies were conducted due to results of the statistical analysis of the results of the crushing experiment by standard and additional flat-cutting working bodies of the plough, the crushing of the studied fraction is 50-100 mm.

Table 4. Parameters of operation when processing by the serial plough.

| Tractor transmission | 3   | 4   | 5   |
|----------------------|-----|-----|-----|
| Actual forward speed, \( \text{km/h} \) | 5.34 | 6.16 | 7.15 |
| Soil crushing, \( \% \), fraction sizes, \( \text{mm} \) | 9.20 | 5.10 | 4.80 |

According to the data obtained as a result of field researches, the regularity of changes in crushing in the soil horizon was determined depending on the speed of movement of the arable unit on a given tractor transmission. The regression equation, the formula 4 and its graphical representation in figure 2, the curve 1.

\[
y = \frac{2.7099 \times 10^3}{e^x} - \frac{69.952}{x} + 1.7422 \cdot x
\] (4)

Table 5. Parameters of operation under the crusher 1 processing.

| Tractor transmission | 3   | 4   | 5   |
|----------------------|-----|-----|-----|
| Actual forward speed, \( \text{km/h} \) | 5.52 | 6.39 | 7.61 |
| Soil crushing, \( \% \), fraction sizes, \( \text{mm} \) | 9.00 | 3.20 | 3.30 |

According to the data obtained as a result of field researches, the regularity of changes in crushing in the soil horizon was determined depending on the speed of movement of the arable unit on a given tractor transmission. The regression equation, the formula 5 and its graphic image in figure 2, the curve 2 were obtained.

\[
y = + \frac{3.0439 \times 10^3}{e^x} + 2.2361 \times 10^{-3} \cdot e^x - \frac{20.709}{x}
\] (5)

Table 6. Parameters of operation under the crusher 1 processing.

| Tractor transmission | 3   | 4   | 5   |
|----------------------|-----|-----|-----|
| Actual forward speed, \( \text{km/h} \) | 5.65 | 6.57 | 7.76 |
| Soil crushing, \( \% \), fraction sizes, \( \text{mm} \) | 8.50 | 2.50 | 1.60 |

According to the data obtained as a result of field researches, the regularity of changes in crushing in the soil horizon was determined depending on the speed of movement of the arable unit on a given tractor transmission. The regression equation, the formula 6 and its graphical representation in figure 2, the curve 3 were obtained.

\[
y = + \frac{3.2929 \times 10^3}{e^x} + 1.1415 \times 10^{-3} \cdot e^x - \frac{19.252 \times 10}{x}
\] (6)
As can be seen from figure 4.8, the comparative characteristic of soil crushing with a fractional composition of 50-100 mm shows that the soil crushing is better when using additional working bodies more effectively at speeds close to the speed of movement $V=7.76$ km/h. Soil crushing of this fraction is 1.60%.

We also conducted the studies of the dependence of soil crushing on the speed of movement and the gripping width of additional flat-cutting working bodies. We set the results of statistical analysis of the results of the experience of crushing with standard and modernized working bodies of the plough, the crushing of the studied fraction is from 100 - 150 mm. (See Appendix B).

Table 7. Parameters of operation when processing with a serial plough.

| Tractor transmission | 3   | 4   | 5   |
|----------------------|-----|-----|-----|
| Actual forward speed, km / h | 5,34 | 6,16 | 7,15 |
| Soil crushing, %, fraction sizes, mm | 3,90 | 3,10 | 2,30 |

According to the data obtained as a result of field researches, the regularity of changes in crushing in the soil horizon was determined depending on the speed of movement of the arable unit on a given tractor transmission, the regression equation, the formula 7 and its graphical representation in figure 3, the curve 1 were obtained.

$$y = \frac{340.33}{e^{1.0088 \cdot 10^{-3} \cdot x} + 464.08 \cdot 10^{-3} \cdot x}$$

Table 8. Initial parameters of operation under the crusher 1 processing.

| Tractor transmission | 3   | 4   | 5   |
|----------------------|-----|-----|-----|
| Actual forward speed, km / h | 5,52 | 6,39 | 7,61 |
| Soil crushing, %, fraction sizes, mm | 3,50 | 2,80 | 1,50 |

According to the data obtained as a result of field researches, the regularity of changes in crushing in the soil horizon was determined in figure 4.9 depending on the speed of movement of the arable
unit on a given tractor transmission, the regression equation, the formula 8 and its graphic image in figure 3, the curve 2 were obtained.

\[ y = -546.34 \cdot 10^{-6} \cdot e^{x} + \frac{20.369}{x} - 9.7129 \cdot 10^{-3} \cdot x \]  

(8)

Table 9. Initial parameters of operation under the crusher 2 processing

| Tractor transmission | 3  | 4  | 5  |
|----------------------|----|----|----|
| Actual forward speed, km / h | 5,65 | 6,57 | 7,76 |
| Soil crushing, %, fraction sizes, mm | 2,10 | 1,20 | 0,50 |

According to the data obtained as a result of field researches, the regularity of changes in crushing in the soil horizon was determined in figure 3 depending on the speed of movement of the arable unit on a given tractor transmission, the regression equation, the formula 9 and its graphic image figure 3, the curve 3 were obtained.

\[ y = e^{(5,1950 \cdot \ln(x) - 1,4609 \cdot x)} \]  

(9)

1- under processing by the serial working bodies; 2 – under the crusher 1 processing; 3 – under the crusher 2 processing

Figure 3. Dependence of soil crushing on velocity of motion and gripping of serial flat-cutting working bodies

As can be seen from figure 3, the comparative characteristic of soil crushing with a fractional composition of 100-150 mm shows that its crushing is better when using additional flat-cutting working bodies more effectively at parameters close to the speed of movement \( V = 7.76 \) km/h. The soil crushing of this fraction is 0.50%

As can be seen from the presented material, the use of additional working bodies in the cultivation of agricultural crops has a promising direction [1]. These working bodies have a positive impact on the quality of the technological process of the main layer-by-layer tillage. Moreover, by studying the obtained dependencies, we can conclude that the width of the crusher and the speed of movement are
equally important for the quality of tillage, and, consequently, they must be taken into account when planning this technological operation in advance [2,3].

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