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Determination of Acceptable Values of the Device Parameters that Measure the Working Depth of Soil Working Machines

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Abstract:

In the article, it is noted that a device for mechanized measurement of the working depth of soil tillage machines has been developed, and the results of multi-factor experiments conducted to determine the optimal values of the main parameters affecting its measurement accuracy (the diameter of the parallelogram mechanism, the width of the hub and the vertical load applied to it) are presented. Multivariate experiments were conducted according to plan V4. In this case, the absolute value of the difference between the average values of the processing depth determined by the existing method and device was taken as an evaluation criterion.The data obtained in the experiments were processed by the "planexp" program and a regression equation was obtained that adequately represents the evaluation criterion. Cochran's criterion was used to evaluate the uniformity of variance, Student's criterion was used to evaluate the value of regression coefficients, and Fisher's criterion was used to evaluate the adequacy of the regression model. According to the obtained regression equation, the device for mechanized measurement of the working depth of soil tillage machines - in order to measure their working depth with high accuracy, the diameter of the base wheel is 37.19-38-34 cm, the width of the axle is 12.94-13.43 cm, and the vertical it was determined that the loading should be in the range of 192.34-201.0 N.

1. Introduction

It is known that one of the main performance indicators of soil tillage machines is the tillage depth and its stability (evenness). Currently, laborious and less accurate methods are used to determine the working depth of soil tillage machines and its stability (obtaining transverse and longitudinal profiles, dipping a ruler into the treated layer, measuring the height of the wall of the earth with an earth meter, etc.) [1-3] and where a lot of time and effort is spent on separate reprocessing processes for the results obtained. Based on these points, we developed a device that mechanized the depth of tillage machines and determines its statistical characteristics (arithmetic mean value, mean square deviation and coefficient of variation) [4-7] and optimal parameters of its parameters. that is, experimental studies were conducted to determine the values of soil tillage machines that provide high accuracy measurement of tillage depth.

2. EXPERIMENTAL PROCEDURES

We developed a device that mechanized the depth of tillage machines and determines its statistical characteristics (arithmetic mean value, mean square deviation and coefficient of variation) and optimal parameters of its parameters. that is, experimental studies were conducted to determine the values of soil tillage machines that provide high accuracy measurement of tillage depth.

Figure 1 An experimental copy of the device was designed and prepared for conducting experiments. (Figure 1) shows the general view of the device, and (Figure 2) shows its combined views with data transmission, reception and recording devices.

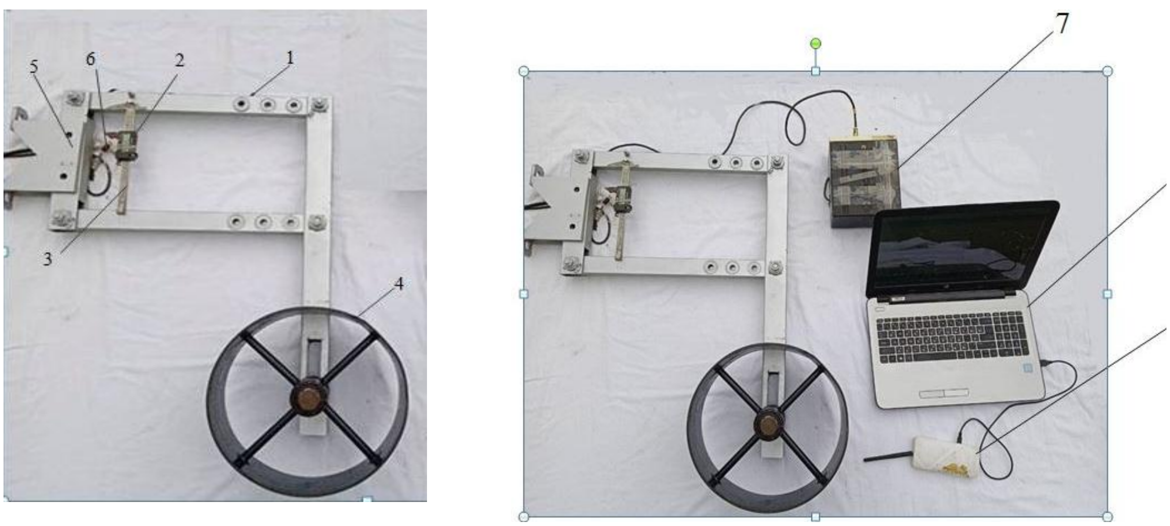

Figure 1. General view of the device that determines the depth of cultivation of soil tillage machines

The device consists of an electronic module that includes a parallelogram mechanism 1, an electronic block 2 and its rod 3 and a support wheel 4, and is fixed to the frame of soil tillage machines by means of a lock 5. The rod of the electronic block is hinged with the pulls of the parallelogram mechanism, and the electronic block 2 itself is fixedly connected to the lock 5 through the holder 6, which has the ability to change its length. The device works in the following order: when the working bodies of the machine sink to a certain depth, the support wheel 4 of the device rises to a height equal to the depth of immersion (processing) of the working bodies into the soil compared to its initial position, and this rise is recorded by the electronic unit 2 and transmitted to the data transmission device 7 transmits. Transmitted data is received by the receiving device 8 and displayed on the monitor of the recording device 9 in the form of graphics or numbers, and their statistical characteristics are determined.

In order to determine the optimal values of device parameters that ensure high-accuracy measurement of processing depth, multifactorial experiments were conducted using the method of mathematical planning of experiments [8,9].

3. Results and discussion

In the course of research, the device that measures the working depth of soil tillage machines in a mechanized way, the diameter of the stick wheel (X_1), the width of the beam (X_2) and the vertical load applied to it (X_3) and the movement speed of the unit (X_4) were selected as factors affecting its measurement accuracy. Table 1 lists the factors, their designations, change intervals and levels.

Multifactorial experiments were conducted according to the V_4 plan [9], and correspondingly, the support wheels with different diameters and widths were prepared, the vertical loading applied to it was changed by placing additional loads, and the working speed was changed by means of the tractor gearbox.

Table 1. Intervals and levels of change of factors

№	Factors and their unit of measurement	Factor`s				
		coded designation change interval		levels		
				lower (-1)	main (0)	high (+1)
1.	Diameter of parallelogram mechanism base wheel, cm	X_1	5	30	35	40
2.	Width of parallelogram mechanism support wheel axis, cm	X_2	2.5	10	12.5	15
3.	The vertical pressure force applied to the support wheel of the device, N	X_3	50	150	200	250
4.	Working speed, km/h	X_4	1	5	6	7

Multi-factor experiments were carried out in the experimental fields of QXMITI using a TTZ-812 tractor and a drive unit consisting of a PN-3-30 plow equipped with the developed device (Figure 3). In this case, the absolute value of the difference between the average values of the driving depth determined using the existing method and device was taken as an evaluation criterion.

The data obtained from multifactorial experiments were processed according to the program "PLANEXP" developed in the experiment-testing department of QXMITI. In this case, Cohran's test was used to evaluate the uniformity of variance, Student's test was used to evaluate the value of regression coefficients, and Fisher's test was used to evaluate the adequacy of regression models [9].

Figure 3. The process of conducting experiments

Research results and their discussion.

The experimental results were processed according to the specified program, and the following regression equation was obtained, which adequately represents the evaluation criterion**:**

$$Y = 0{,}554 - 0{,}455 - 0{,}317x_2 + 0{,}212x_3 + 0{,}300x_4 + 0{,}420x_1^2 - 0{,}050x_1x_2 - 0{,}050x_1x_3 +$$
$$+ 0{,}088x_1x_4 + 0{,}585x_2^2 - 0{,}341x_2x_3 + 0{,}078x_2x_4 + 0{,}680x_2^3 + 0{,}079x_3x_4 + 0{,}005x_4^2$$

The analysis of this regression equation and the graphical links built on it (Figure 4) shows that the measurement accuracy changed according to the law of the bubble parabola with the increase of the diameter of the support wheel of the device, the width of the node and the vertical load applied to it, i.e. the factors X_1, X_2 and X_3. , that is, with an increase in the X_4 factor, the measurement accuracy decreased.

1.2.3-when the speed of movement is 5.0; 6.0 and 7.0 km/h,

Figure 4. Variation of the absolute value of the difference between the average values of the processing depth determined by the existing method and the device depending on the device parameters.

When determining the values of device parameters that ensure high-accuracy measurement of processing depth, the regression equation was solved on the PC "Pentium IV" using the Excel program "search for a solution" (poisk reshenia) under the condition that Y has a minimum value for speeds of 5.0-7.0 km/h [10]. The obtained results are presented in (Table 2).

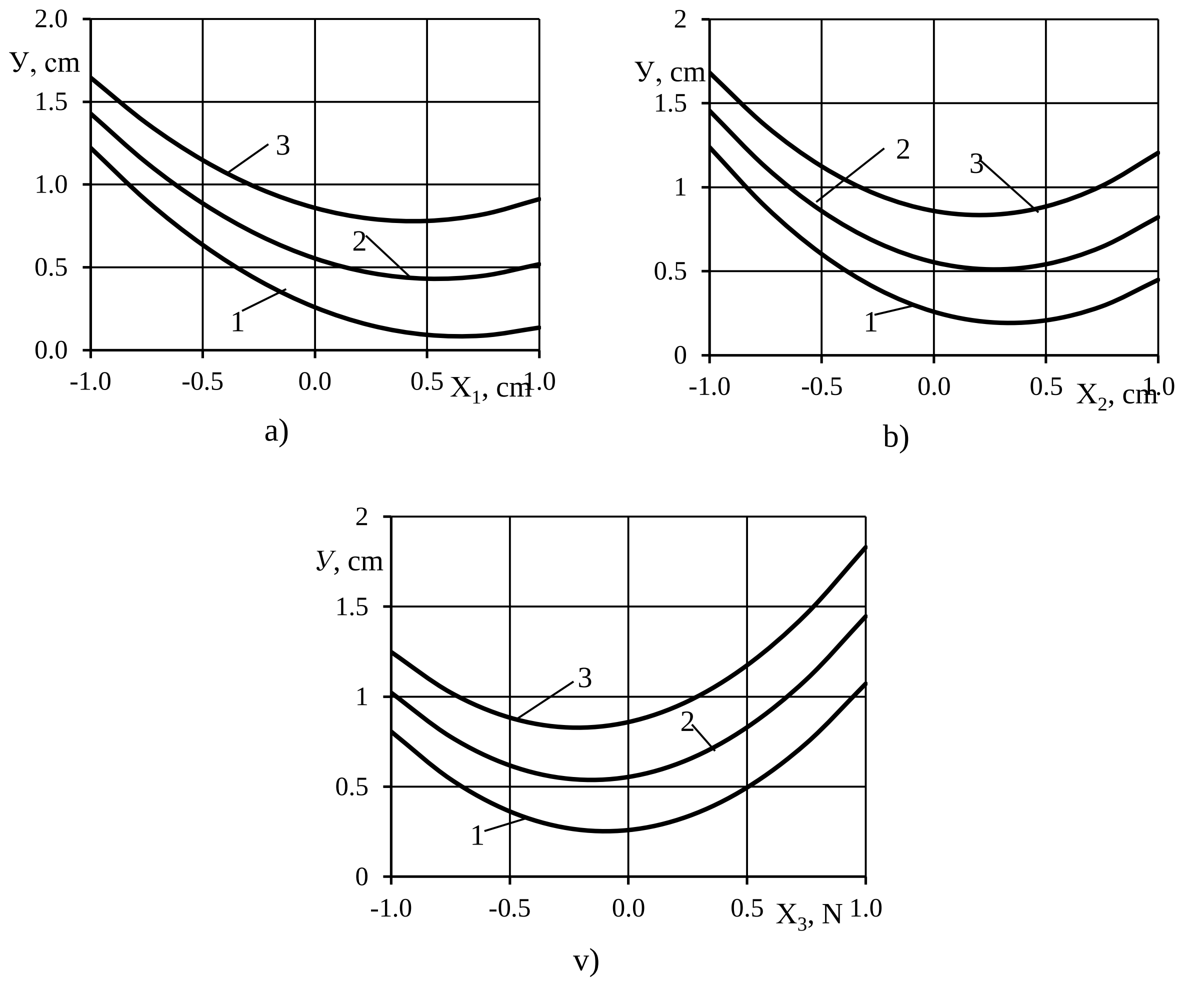

Table 2. **Acceptable values of the parameters of the device that mechanized the depth of cultivation of soil tillage machines**

x_4		x_1		x_2		x_3	
coded	real	coded	real	coded	real	coded	real
1	7	0,4384	37,19	0,1784	12,94	-0,1531	192,34
0	6	0,5541	37,77	0,2752	13,18	-0,0665	196,67
-1	5	0,6698	38,34	0,3721	13,43	0,0201	201,00

So, in order to measure the depth of cultivation in a mechanized way at speeds of 5,0-7,0, the diameter of the support wheel is 37.19-38-34 cm, and the width of the wheel is 12.94-13-43 cm and the vertical pressure applied to it should be in the range of 192.34-201.00 N. At these values of the factors, the absolute value of the difference between the average values of the processing depth determined by the existing method and device was 0.05-0.73 cm. These values are smaller than the permissible error (± 1 cm) for measuring the processing depth in existing normative documents.

4. Conclusions

According to the results of the conducted multi-factor experiments, the device for mechanized measurement of the working depth of soil tillage machines, in order to measure the working depth with high accuracy, the diameter of its base wheel is 37.19-38-34 cm, the width of the wheel is 12.94-13.43 cm and it vertical loading should be in the range of 192.34-201.00 N.

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