

# Automated attachment device for controlling position of a gricultural implements i n a n aggregate

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**Abstract.** Improving the controllability of mounted agricultural implements as part of the unit during soil cultivation and planting crops is an important condition for obtaining high yields. The article presents the results of a field experiment developed by a controlled attachment (UNU-3) designed to improve the accuracy of various technological operations. Recommendations on its use are given. The process of functioning of the device is described. It was determined that this device will allow to increase the level of positioning of the landing tool in the unit, by minimizing the lateral displacement of the agricultural implement. The device will allow the agricultural implement and tractor to be on the established path with an accuracy of 2.5 cm.

## 1 Introduction

The quality of work of mounted agricultural machines does not always correspond to agrotechnical requirements. In the process of operation of the machine-tractor unit (MTU), an mounted agricultural implement, due to the unevenness of the soil density, the presence of slopes, tends to deviate from the tillage and planting lines. In the transport position, the tractor's lower hinged rods are fixed, and in the working position with the mounted agricultural implement their lateral deviation relative to the direction of movement is possible. At the same time, the tractor operator, while carrying out technological operations in the field to increase productivity, seeks to increase the working speed, which, with constant tractor maneuvering, leads to the withdrawal of agricultural implements from the tillage line. Scientists have found that increasing the controllability of the mounted implements in the composition of the unit during soil cultivation and planting crops is an important condition for obtaining high yields [1,2]. To solve this problem, various devices are used, which, together with navigation equipment, are able to send an agricultural implement to the processing line [3,4]. A sufficiently high accuracy of tractor positioning is achieved through the use of a navigation system mounted on the tractor [5,6]. When the unit moves along a given trajectory, its direction to the working line is constant, but the agricultural implement constantly changes its position due to the peculiarity of the tractor attachment. We propose the use of the developed controlled attachment (UNU-3) as part of the MTU with navigation

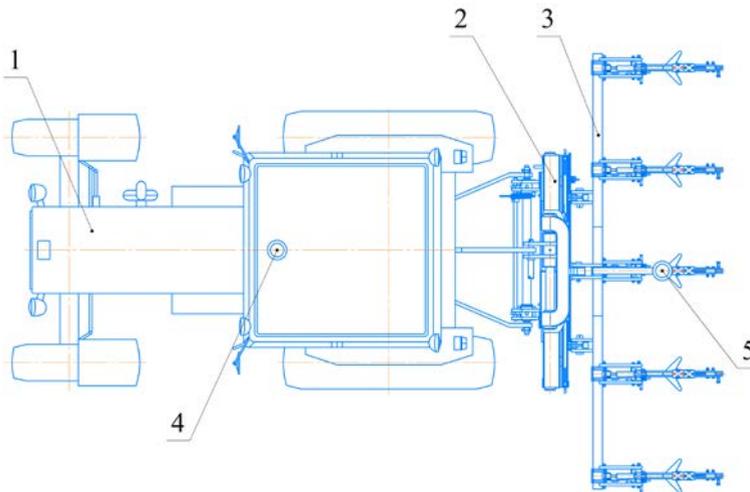
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equipment installed both on the tractor and agricultural implements, the use of which will allow to achieve a significant increase in the accuracy of various technological operations.

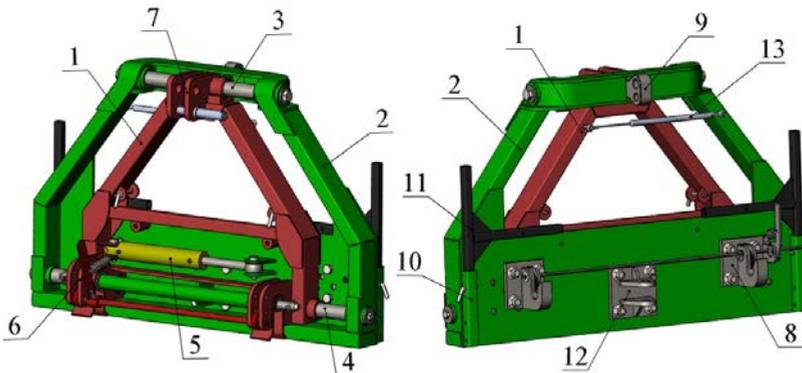
## 2 Materials and methods

As a result of the analysis of existing methods for controlling the position of agricultural implements in the unit, a controlled mounted device for its use in the MTU with installed navigation equipment has been developed. The proposed scheme for connecting various agricultural machines and equipment with a tractor into a single unit (for example, the KON-2.8 cultivator) is shown in Figure 1.



**Fig. 1.** Connection diagram of a tractor with UNU-3 and a cultivator in a single machine-tractor unit: 1 - a tractor, 2 - UNU-3, 3 - a cultivator, 4, 5 - navigation equipment

The controlled attachment is the actuator of the autopilot system, installed on a three-point mounted tractor system. 3D model of UNU-3, developed in CAD SolidWorks is presented in Figure 2.



**Fig. 2.** UNU-3 guided attachment for agricultural implements: 1 - inner frame, 2 - outer frame, 3,4 - tubes for attaching frames, 5 - hydraulic cylinder, 6 - lower links, 7 - upper fork, 8 - hooks, 9 - earring top link, 10 - rack bracket, 11 - rack, 12 - bracket, 13 - linear potentiometer

The device consists of an inner 1 and an outer frame, interconnected in the upper and lower parts by round pipes 3.4. The offset of the outer frame 1 relative to the outer 2 is carried

out using a hydraulic cylinder. The lower links 6 of the device are connected to the tractor, have semi-automatic locks that simplify the process of connecting the tractor to the device. The upper link of the device 7 is connected to the tractor using a finger. The lower link 8 of the device is connected to an agricultural implement with semi-automatic locks. The upper link earring 9 has height adjustments, which simplifies the process of connecting the device to the implement. The brackets of the rack 10 with the racks 11 are intended for storing the device. For aggregation with trailed implements, a bracket is provided on the device 12. An installed linear potentiometer 13 allows you to track the position of the outer frame 2 of the device relative to the inner frame 1. Technical characteristics of UNU-3 are presented in table 1.

**Table 1.** Technical characteristics of UNU-3.

Name of indicator	Indicators
Cross displacement of frames in the horizontal plane, mm	250±5
Weight kg	240±5
Overall dimensions, mm	562x1433x883
It is aggregated with tractors, a class	2 and 3
Speed km/h - working - transport	by tractor speed
The distance from the suspension axis of the hitch to the axis of rotation of the upper tractor link, mm: - class 2 tractor - class 3 tractor	610-635 685-700
The distance between the hooks, mm - class 2 tractor - class 3 tractor	1005 1130
Service life, years	8

To assess the accuracy of agricultural technological operations, to estimate the deviation of the ridge top from the center line using the developed controlled attachment, a field experiment was conducted (Ryazan region, Podvyazye village). The plan of the field experiment included the cultivation of planting of potatoes with various compositions and operating modes of the MTU. Experiment 1 - cultivation of row-spacings with the help of a tractor and an agricultural implement KON-2.8 (without using UNU-3). Experiment 2 - cultivation of row-spacings using a tractor and a cultivator KON-2.8 using UNU-3 and navigation equipment mounted on a tractor. Experiment 3 - cultivation of row-spacings using a tractor and cultivator KON-2.8 using UNU-3 and navigation equipment installed on a tractor and cultivator. The speed of the MTU is constant - 2.3 m / s. Trimble TrueTracker was used as navigation equipment, the declared positioning accuracy of which is 2.5 cm. To read the coordinates of the position of the agricultural implement relative to the line of movement, a navigation antenna (GLONASS\GPS) was installed on the KON-2.8 cultivator. The passage of the MTU was carried out on a pre-prepared section of the field with a length of 30 meters. At the command of the tractor operator began to move at a speed previously set for the experiment. The navigation equipment automatically controlled the tractor. Measurements were taken of the deviation of the center of the agricultural implements from the center line of the row in 3-fold repetition with a step of 1 meter. To do this, a tape with applied divisions is stretched along the longitudinal axis of the treated area (Fig. 3). The results of the technological operation of cultivating potato plantings using MTU with UNU-

3 and navigation equipment mounted on a tractor and agricultural implements: a - appearance of the will, b - MTU with UNU-3.



**Fig. 3.** The results of the technological operation of cultivating potato plantings using MTU with UNU-3 and navigation equipment mounted on a tractor and agricultural implements: a - appearance of the will, b - MTU with UNU-3.

The navigation display mounted on the tractor in real time recorded the deviation of the landing machine from the actual line specified by the navigation equipment. Statistical processing of the obtained experimental data was carried out, the range of variations, standard deviation, variance and total untreated area were determined. The raw area of the field was found by the graphical method, by plotting on a scale of 1: 1.

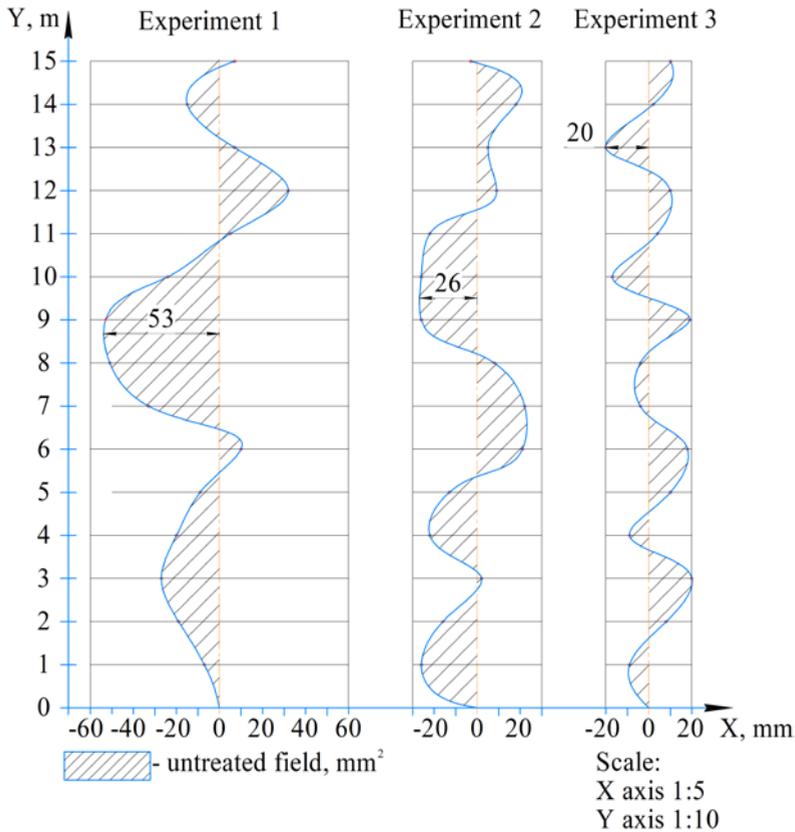
### 3 Results and discussions

The results of the analysis of the obtained experimental data are presented in table 2.

**Table 2.** The results of field studies of MTU with UNU-3 and navigation equipment

Measurement Repeatability	The average deviation, mm	Standard deviation, mm	Dispersion according to the general population, mm <sup>2</sup>	Raw area, m <sup>2</sup>
Experiment 1. Without using navigation				
1	24,67	11,49	179,56	1,71
2	23,83	12,16	204,67	1,73
3	24,90	14,17	260,36	1,7
Experiment 2. When using UNU-3 and navigation equipment mounted on a tractor				
1	11,13	5,00	32,78	0,45
2	10,23	5,38	37,65	0,46
3	10,70	5,05	34,28	0,45
Experiment 3. When using UNU-3 and navigation equipment mounted on a tractor and agricultural implements				
1	4,07	3,07	11,53	0,27
2	4,70	3,11	8,28	0,24
3	4,53	3,09	8,58	0,29

A graph of the deviation of the center of the KON-2.8 cultivator from the center line was plotted for various operating modes described in the methodology of the field experiment (Fig. 4).



**Fig. 4.** Fragment of the graph of deviation of the cultivator KON-2.8 in the unit from the center line

According to the results of field experiments, it was found that during the movement of the MTU in the tractor and the cultivator without navigation equipment, the maximum deviation of the ridge top from the center line was 62 mm, while the movement of the MTU in the composition with the tractor with navigation equipment and the cultivator the maximum deviation of the ridge top from the center line was 22 mm, when the unit is moving as part of a tractor with navigation equipment, UNU-3 and a cultivator with navigation, the maximum deviation of the ridge top from the center line 20 mm, which is not significantly less than when using navigation only on the tractor, but the untreated area of the MTU section consisting of the tractor, UNU-3 and cultivator with navigation equipment on the tractor and cultivator was 0.27 m<sup>2</sup> in relation to 0.45 m<sup>2</sup> a tractor unit with navigation equipment and a cultivator. The average untreated area of the unit as part of the tractor and cultivator was 1.71 m<sup>2</sup>.

It was found that the average deviation of the ridge top from the processing line using navigation on the tractor and UNU-3 was 0.004 m, which is 2.5 times less than when using navigation only on the tractor.

## 4 Conclusions

As a result of the research, a device was developed for the automated positioning of the position of agricultural implements and an algorithm for its operation. The use of the UNU-3 guided attachment will eliminate the angular rotation of the implement and direct it to the soil tillage line. The device will allow the agricultural tool to be on the established trajectory with an accuracy of 2.5 cm, reduce damage and rolling crops, compensate for irregularities when working on terrain with difficult terrain, increase the accuracy of planting crops, reduce the load on the operator, improve the quality of the crop. The most effective use of UNU-3 will be in the cultivation of crops that require increased positioning accuracy for planting and processing.

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