

# Influence of the parameters of support wheels on the amount of the device of the trailer from the tracking course

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**Abstract.** The effect of the parameters of the left support wheel of the trailed cabbage machine, the hardness of the soil and its difference under the support wheels on the magnitude of the deviation of the unit from the direction of motion were studied experimentally. It is established that the rational values of the structural parameters of the supporting-running system of the trailed agricultural machine allow minimizing the values of the longitudinal vibrations of the working bodies during the execution of the technological process. Rotating parts of the trailing machine received movement from the power take-off shaft through a specially designed drive shaft. The system for measuring and recording the deviations of the machine from a given course is represented by a bridge electrical system based on a rheostat with a sliding brush connected via an analog port to an electronic data processing system, and then to a laptop computer. As a result of the research, it was found that with a decrease in the hardness of the soil under the right wheel, the stability of the stroke is sharply reduced, while the angle of deviation of the drawbar increases to unacceptable values. This is due to the fact that under these conditions, the resistance of the soil to the support wheels of the trailing machine is mainly applied on the right side, in addition, with decreasing hardness of the soil, the rolling resistance of the wheel increases. The results of the conducted studies confirm and supplement the results of theoretical studies. Investigating the stability of the movement of the trailer with support wheels of different sizes with the same hardness of the soil, it was found that the value of the angle of deflection of the machine's tail significantly decreases compared to the results of previous experiments and does not exceed the limits set by the agricultural requirements.

## 1. Introduction

Agriculture at all times is the foundation of the economy of any country, and ensuring the food security of its population is an important part of the economic policy of their governments [1]. There is Food Security Doctrine of the Russian Federation, adopted in 2010 and adjusted in 2014 [2].

In the second half of the last century, in our country and abroad, there was a trend of specialization in vegetable growing, enlarging the areas under the main vegetable crops. Conservation agriculture is one of the so-called emerging agrosociences [3] and encompasses techniques that minimize or eliminate tillage and, thus, maintain a vegetative cover that protects soil from its degradation. As a result of this concentration of production at the time, it was felt necessary to create more productive agricultural machinery. Certainly, conservation agriculture concept goes beyond conservation tillage and is defined by three linked core principles that must be jointly applied to create synergies [4]: minimum



soil disturbance; permanent organic soil cover; and crop rotations. The results showed that new tillage did not affect grain yields and reduced 80% of energy consumption [5]. Qualitative indicators of the operation of trailed agricultural machines are in direct dependence on the stability of their movement in the aisle, the greatest influence on which is provided by natural conditions. These trials, which began in 1982 and still continue today, resulted in higher yields in new tillage fields than in those with traditional tillage [6].

Therefore, increasing the stability of the agricultural machine in the aisle is an urgent task in creating promising agricultural machines.

Earlier, on the example of a cabbage harvesting machine for determining the optimum parameters of a support-trailer part, a dependence was obtained:

$$Q = \frac{Pc}{r \sqrt{1 - \left( \frac{P}{0.5\pi brV} \right)^2}}, \quad (1)$$

where  $Q$  is the rolling resistance of the support wheel, N;  $P$  is normal load on the wheel, N;  $c$  is the rolling friction coefficient of the support wheel;  $r$  - the radius of the support wheel, m;  $b$  is width of the support wheel, m;  $V$  is hardness of soil, N / m<sup>2</sup>.

For the existing machine sample, according to the Equation (1), it was established that the following dimensions of the support wheels should ensure the smallest deviations of the unit from the direction of travel:

- diameter of the left support wheel 620 mm;
- width of the left support wheel 145 mm;
- diameter of the right support wheel 762 mm;
- width of the right support wheel 235 mm.

In some studies, it was remarkable the collaboration with the technical departments of the industry [7]. All too often experimental protocols are not rigorous enough to unveil real differences in tillage systems [8–10].

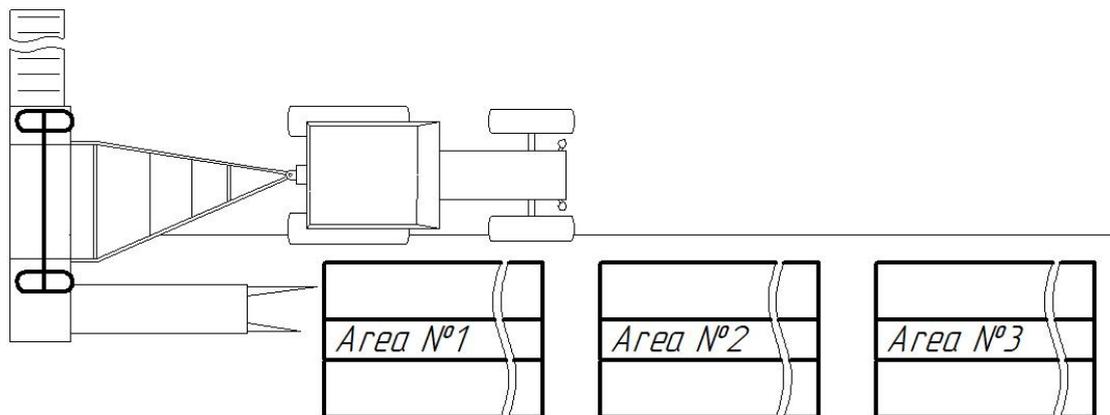
The purpose of the research is to experimentally test the theoretically rational values of the constructive parameters of the support-running system of a trailed agricultural machine, which allow minimizing the values of the longitudinal vibrations of the working bodies during the execution of the technological process.

## 2. Experimental

In order to carry out an experimental test of the theoretical positions put forward, a laboratory field installation was built that can be aggregated with a tractor of class 1.4 (in this case MTZ-82) by means of a trailing drawbar. The rotating parts receive movement from the power take-off shaft through a specially designed drive shaft. The measurement system as well as the registration of the deviations of the machine from the given course is represented by a bridge electrical system based on a rheostat with a sliding brush connected via an analog port to an electronic data processing system (in this case - 3B NET log U11300ip), and then to a laptop computer.

Studies of the stability of the trailer were carried out on the plot of the areas with a differentiated hardness of the soil under the support wheels. The numbering of the areas is shown in Figure 1.

In this system, the resistance of the rheostat varies smoothly depending on the angle of the rotation of the drawbar of the trailing machine relative to the tractor's ear with the help of a sliding contact kinematically connected by a flexible connection with an arc rigidly attached to the drawbar of the machine centered at the trailer's point. During the movement of the installation, the resistance created by the rheostat changes the potential difference at the output of the bridge measuring circuit, that is, the value of the measured voltage is proportional to the angle of rotation of the drawbar relative to the trailer point.



**Figure 1.** The number of plots in the plot in the study of the effect of soil hardness on the stability of the machine.

### 3. Results and Considerations

As it was already revealed theoretically, the condition for the best functioning of the trailer is to ensure the following of its working body strictly in the direction of movement of the unit. Compliance with this condition under the proposed support-trailer system was checked in the field by studying the machine's follow-up to a given straight-line course at previously prepared areas of the soil cover (Figure 1).

The investigations were carried out at predetermined parameters of the support-trailer system, ie: the length of the trailing drawbar is 2.35 m, the diameter of the right wheel is 762 mm and the width of the right wheel is 235 mm.

Variable parameters were the diameter and width of the left wheel, as well as the density of the soil in the sections.

Figure 2 shows a fragment of an oscillogram of the deviation angle of the unit from a given heading, recorded in real time. The oscillogram records the values of the deflection angle  $\varphi$  from the direction of travel of the trailer in the horizontal plane.

The received oscillograms allowed to analyze the process of trailer movement in the field plane in real time mode. It can be seen from them that on a plowed section of  $L_1$ -length soil the machine deviates from the set course (section  $T_1$ ), and when entering a site with hard soil, the length  $L_2$  approaches it (section  $T_2$ ). Initially,  $L_1 \gg L_2$  is selected. The soil in each plowed area had different relative humidity  $W$  and, accordingly, hardness  $V$ . It is noticeable that with decreasing soil hardness the amount of deviation of the trailer from a given course increases somewhat.

For the sample inside the section  $T_1$ , it is possible to isolate the steady-state movement -  $T'$ , on which the unit moves steadily after a transition from one site to another.

As the statistical analysis shows, the values of the angle of deviation of the trailing drawbar  $\varphi$  from a given course are predominantly subject to the normal distribution law, as evidenced by the results of estimating the discrepancies between the empirical and theoretical frequencies of the Pearson's variational series.

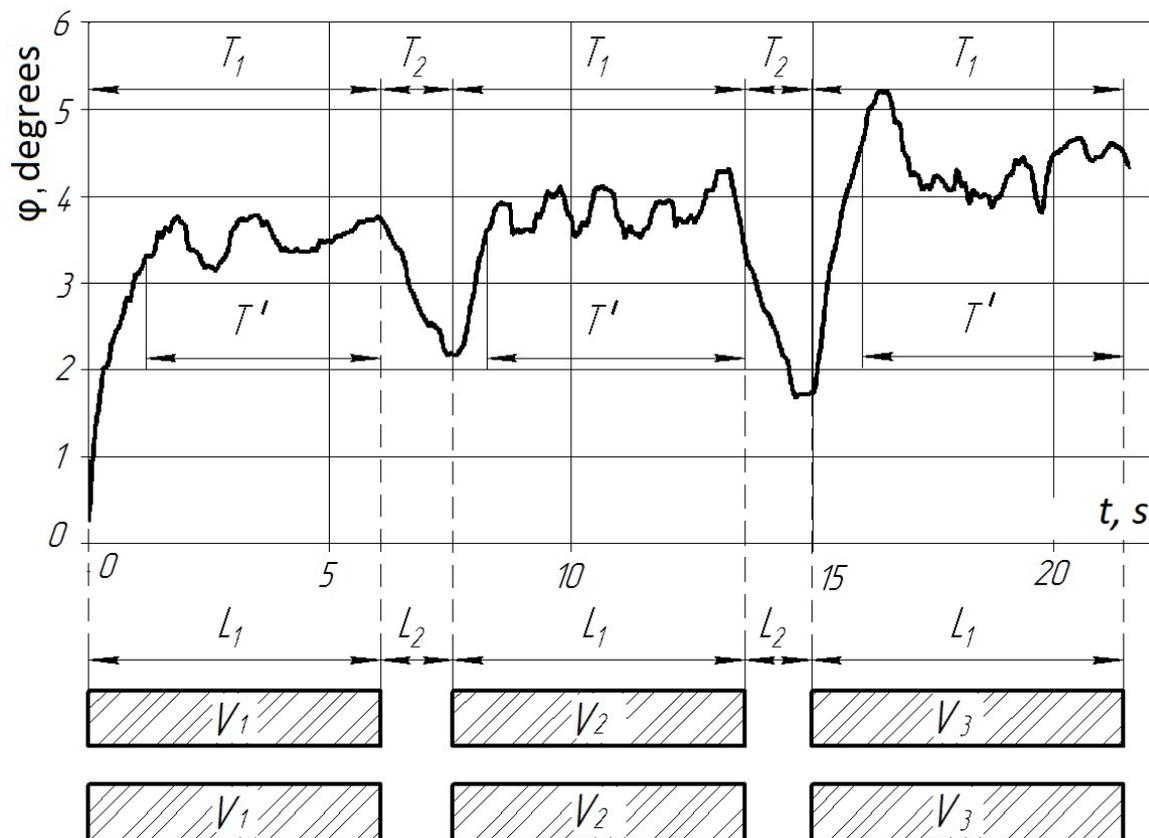
The nature of the variation in the angle of inclination of the trailer with the support wheels of the same (a) and different (b) sizes from the set course, depending on the position of the wheel (1-over the plowed plot, 2-over the unplowed plot) was considered with a straight trajectory of the machine.

The experimentally obtained values of the deviations of the trailing drawbar of the machine from the direction of motion are given in Table 1.

**Table 1.** The value of the angle  $\varphi$  deviation of the trailing drawbar from the direction of motion of the unit, deg.

Position of machine	The value of the deflection angle $\varphi$ , deg.			Average value of angle, deg.
	At $V = 168 \text{ N/cm}^2$	At $V = 113 \text{ N/cm}^2$	At $V = 90 \text{ N/cm}^2$	
1-a	5.86	7.99	10.45	8.04
1-a	5.12	6.17	9.93	7.07
1-b	4.01	4.31	4.78	4.36
1-b	3.56	3.89	4.44	3.96
2-a	3.14	4.04	4.33	3.84
2-a	3.16	3.76	4.15	3.69
2-b	1.83	1.64	1.63	1.70
2-b	1.99	2.26	1.88	2.04

From Table 1 it can be clearly seen that with the reduction of the hardness of the soil in this position (under the right wheel) the stability of the stroke sharply decreases, while the angle of deviation of the drawbar increases to values exceeding in 2...3 times permissible for agricultural requirements. This is due to the fact that under these conditions, the resistance of the soil to the support wheels of the trailing machine is mainly applied on the right side, in addition, with decreasing hardness of the soil, the rolling resistance of the wheel increases.



**Figure 2.** Component of the fragment of the oscillogram of the deviation angle  $\varphi$  of the trailer from a given course in different parts of the soil in real time  $t$ :  $L_1$ ,  $L_2$  – length of plowed and unplowed plots, respectively;  $T_1$ ,  $T_2$  – time of passage of the plowed and not plowed sections accordingly;  $T'$  is the time of steady movement of the aggregate along the plowed section;  $V_1$ ,  $V_2$ ,  $V_3$  – the hardness of the soil.

Thus, the results of the carried out studies of the oscillations of the trailer machine in the horizontal plane are correlated and, complementing each other, confirm the results of theoretical studies.

Investigating the stability of the movement of the trailer with support wheels of different sizes in position 2, we note that if the soil hardness is close to the value under both wheels, the value of the drawbar angle significantly decreases compared to the results of the previous experiments and does not exceed the values set by the agricultural requirements.

#### 4. Conclusion

Having studied the physical and mechanical properties of the soil as a medium with which the trailer machine interacts, the nature and degree of influence of the main factors of the process and the design of the support system on the stability of its movement in the aisle are theoretically and experimentally determined. It has been experimentally established that with the implementation of the radius and width of the left supporting wheel of a smaller size, and also the displacement of the trailer point to the right from the center by one hole, the amount of deviation of the trailed drawbar from the predetermined heading decreases to 1...3 degrees, which corresponds to 20...60 mm deviation of the cutting apparatus from a row of cabbage. This value does not exceed the established agricultural requirements.

It has been experimentally established that the theoretical values of the parameters of the support-trailer system (the diameter of the left support wheel is 0.62 m, the width of the left support wheel is 0.145 m, the diameter of the right support wheel is 0.762 m, the width of the right support wheel is 0.235 m, the length of the trailing drawbar is at least 1.44 m) are indeed optimal and rational for the performance of the work process by a trailer.

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