Ensuring the stability of the processing depth of suspended soil mounted machines

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Abstract. The article presents the results of research conducted to ensure the stability of the depth of processing of suspended soil processing machines with a base wheel on the example of a mounted plow and a chisel-cultivator. It is noted that for the operation of the suspended soil processing machines with a base wheel to sink to the specified depth, and for a stable (uniform) walk at this depth, their base wheels must be continuously pressed against the field surface. This should be provided for the calculation of changing the steep distances from the base plane to the increase in the steep distances from the base planes of the mounted plow and chisel-cultivator to the bottom hanging points in the experimental studies conducted on the vacant areas of the experimental farm of the institute. This has led to an increase in the processing depth and a decrease in its average square deviation. According to the results obtained from the where, the base wheels of the mounted plow and chisel-cultivator should be pressed against the field surface. Hence, the steep distance from the base plane to the bottom hanging points should be between 78-83 and 63-68 cm respectively to work at the specified depth and to move.

1. Introduction

It is known that if the processing depth is at the required level, and its stability, that is, it is ensured to be uniform, uniform development and ripening of crops is achieved, as well as a high harvest from them, otherwise an uneven development and ripening of plants are observed, productivity decreases by 12-15 per cent. These found their proof in many researches conducted in our Republic and other countries [1-9]. Therefore, strict requirements and restrictions have been imposed on the depth of processing and its deviation from the established (uneven) for each soil processing machine [10-12].

In previous researches, it has been shown that the processing depth of existing soil processing machines varies within a wide range, and this variation is even 3-4 times greater than that allowed in a field itself. But in these studies, the issues of immersion of soil tillage machines to the specified depth and ensuring a stable gait at that depth have not been adequately studied. In most researches, it has been proposed that the depth of processing of soil processing machines and their stability at the required level should be provided by increasing their mass, putting additional loads on them, equipping them with various stabilizing devices. But this naturally increases the material and energy expenses of machines, their constructions become more complicated, and the set goal is not fully achieved.
In this article, the results of research on the stability of the depth of processing of suspended soil processing machines with a base wheel (wheels) are presented on the example of a mounted plow and a chisel-cultivator. 

In order for the suspended soil processing machines with a base wheel (wheels) to work at a fixed depth and to walk steadily (evenly) at the same depth, their base wheels must be continuously pressed against the field surface [13, 14], that is $N>0$ (where $N$ – the force of steep pressure imposed on the soil by the base wheel).

It should be noted that if $N>0$ is not done the base wheel of the machine rises above the field surface, and the machine runs without immersion in the specified depth.

Our studies [15-18] have shown that $N>0$ is crucial for mounted plow and chisel-cultivators. Hence, the performance of them sinking to the specified depth and their stable gait at the same depth are basically perpendicular distances from their base plane to the lower hanging points are provided on account of the displacement of $H_p$ and $H_{ch}$ (Figure 1 and 2). By the increase in these distances, the depth of machining of the base wheels touches the field surface increases, and its stability is also improved. An experimental study was conducted to examine these highlights.

![Mounted plow](image1.png)

**Figure 1.** Mounted plow

![Mounted chisel-cultivator](image2.png)

**Figure 2.** Mounted chisel-cultivator

### Method

To conduct experimental studies, a universal mounted device was developed and prepared for the mounted plow and the chisel-cultivator to change the steep distances from their base plane to the lower hanging points, and this ensures that the distances between their lower and upper hanging points remain unchanged (Figure 3).
Figure 3. Universal mounted construction

The replacement of the distances of the plow and the chisel-cultivator from the base planes to their lower hanging points, and remaining unchanged the distances between their lower and upper hanging points was provided by special holes opened in the lower and upper crowns of the device. The device was installed on a plow and a chisel-cultivator and their tests were carried out. In the tests, the depth of processing of the steep distances from the base plane of the plow and chisel-cultivator to the bottom hanging points and its effect on the average square deviation were studied.

In the research, the steep distance from the base plane of the mounted plow to the bottom hanging points was changed from 68 cm to 83 cm with an interval of 5 cm. The vertical distance from the lower hanging points of the plow to the upper hanging point of the plow was 90 cm [10] for all variants, while the depth of the tillage was 35 cm, the velocity of movement was 6 and 8 km/h. In the tests of the chisel-cultivator, the steep distance from its base plane to the bottom hanging points was changed from 53 cm to 68 cm with an interval of 5 cm. Where aggregate movement velocity was 6 and 8 km/h, processing depth was 20 cm, vertical distance between the bottom and top hanging points of the linear cultivator was 70 cm by using methodological manual SAUS (State all-union standard) 10677-2001 “The device rear mounted of agricultural tractors 0,6-8 classes. Types, basic parameters and dimensions”.

The tests were conducted in the fields of the experimental farm of the Institute during the period of repeated sowing of crops. Before the tests were carried out, moisture, hardness and density of the soil in layers 0-10, 10-20; 20-30 and 30-40 cm were determined by using the existing methods SAUS (State all-union standard) 20915-2011. "Agricultural technics. Methods determination conditions experiment". They made 15,7; 17,3; 18,1 and 18,9 per cent, 1,57; 3,19; 3,45 and 3,62 MPa and 1,23; 1,32; 1,37 and 1,41 g/sm3
respectively.
The tillaging depth of the plow was determined along the height of the open ridge wall left by its last furrow by means of a furrow gauge according to Tst 63.02.2001 “Experiment agricultural technics. Machines and devices for depth tillaging the soil. Programs and methods of experiments”. Measurements were taken with an accuracy of ± 0.5 cm. On each variant, 50 units of measurement were performed in four repetitions (twice to this side, twice to that side).
The working depth of the linear chisel-cultivator was determined by immersing a line with a cross-sectional area of 1 cm² (1×1 cm) to the bottom of the threated layer according to Tst 63.04.2001. “Experiment agricultural technics. Machines and devices for depth tillaging the surface of soil. Programs and methods of experiments”. Measurements were taken with an accuracy of ± 0.5 cm where was measured in four repetitions (twice to the side and twice to this side) 50 units. Half of the measurements was measured it in the depth of the unevenness formed by work bodies, the other half was measured on the surface of the field.

3. Results and Discussions

3.1. Results of mounted plow tests

The results obtained in the tests are presented in Figure 4 in the graphic form. It can be seen from them that the increase in the steep distance of the mounted plow from the base plane to the bottom hanging points led to an increase in the depth of the tillaging, while its average squared displacement was reduced.

According to the data presented in Figure 4, the steep distance from the base plane of the mounted plow to the bottom hanging points is 68 and 73 cm, when it is not possible to achieve its performance by immersing it in the specified processing depth (35 cm), during the working process its base wheel is raised from the field surface. For this reason, the depth of the tillaging was 4.6 and 1.2 cm, less than 6 km/h, and 5.7 and 1.9 cm, respectively, at 8 km/h velocity of movement.

Figure 4. Graphs of variation depending on the depth of processing and its average square deviation from the base plane of the plow to the steep distance from the bottom hanging points

The steep distance from the base plane of the mounted plow to the bottom hanging points is 78 and 83 cm when the specified processing depth is provided, that is, the mounted plow worked at a specified
processing depth, and its base wheel continuously pressed against the field surface. As a result, the depth of the processing was suitable and smooth to the determined.

3.2. Results of mounted chisel-kultivator tests
As can be seen from the results obtained in the tests (Figure 5), the vertical distance from the base plane of the mounted chisel-cultivator to the bottom hanging points at both movement speeds increased from 53 cm to 63 cm, and the processing depth at 6 and 8 km/h movement velocity increased to 3,6 and 4,0 cm respectively, while the average squared deviation was reduced to ±0,01 and ±0,02 cm. This can be explained by the fact when the vertical distance from the base plane of the mounted chisel-cultivator to the bottom hanging points is 53 cm and 58 cm, the bodies of its work did not sink to the specified (20 cm) depth and the base wheels did not touch the field surface, when this distance was 63 and 68 cm, the bodies sank to the soul and the base wheels touched the field surface. This means that the results of the conducted tests provide for the calculation of the performance of suspended soil treatment machines having a base wheel (wheels) immersed in the specified depth and stable movement at the same depth, by changing the steep distance from their base plane to the bottom hanging points. This distance should be 78-83 cm for the mounted plow, 63-68 cm for the mounted chisel-cultivator.

![Graphs of variation depending on the depth of processing and its average square deviation from the base plane of the chisel-cultivator to the steep distance from the bottom hanging points](image)

**Figure 5.** Graphs of variation depending on the depth of processing and its average square deviation from the base plane of the chisel-cultivator to the steep distance from the bottom hanging points

4. Conclusions
The operation of the suspended soil processing machines with a base wheel (wheels), in which the base wheels are immersed on the surface of the field and, as a result, immersed in the specified depth, as well as stable movement at this depth, is provided by the calculation of changing the steep distance from the base plane to the bottom hanging points. This distance should be 78-83 cm for the mounted plow, 63-68 cm for the mounted chisel-cultivator.

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