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Article

Determining The Movement Direction and Installation Angles of Soil Plowers for The Disk Softener-Gradilator Related to The Vertical

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Abstract: In this article, the influence of the installation angle relative to the direction of motion of the soil pushers of the disc ripper leveler for cultivating vineyard inter-rows on the device's performance indicators was experimentally studied. In the studies, the installation angle was varied from 25° to 40° with an interval of 5°, and the mean square deviation of the height of the field surface irregularities, the degree of soil crumbling, and the specific tractive resistance of the device were evaluated. According to the experimental results, it was established that when the installation angle of soil pushers relative to the direction of movement is within 30–35°, Experimental studies have shown that the installation angle of the leveling soil spreader relative to the vertical must be at least 40°, the quality of field surface leveling improves, traction resistance decreases, and the efficiency of the workflow increases. The results obtained are of practical importance for substantiating the design parameters of disc ripper levelers and increasing their operational efficiency.

Keywords: disc ripper, leveler, soil slider, installation angle, vineyard row spacing, traction resistance, soil crumbling, field surface leveling, experimental research, performance indicators, vertical installation angle.

1. Introduction

Today, special attention is paid to the widespread introduction of resource-saving technologies in our country's agriculture, increasing labor productivity, preserving soil fertility, and creating energy-saving agricultural machinery. In this regard, based on the Decree of the President of the Republic of Uzbekistan No. UP-6091 dated October 23, 2020, "On Approval of the Strategy for the Development of Agriculture of the Republic of Uzbekistan for 2020-2030," the agricultural sector modernization, development, and widespread practical implementation of resource-saving and high-efficiency machinery[1].

Furthermore, Decree of the President of the Republic of Uzbekistan No. UP-60 dated January 28, 2022, "On the Development Strategy of New Uzbekistan for 2022-2026," defines specific tasks for the introduction of innovative technologies in the agro-industrial complex, integrated mechanization of agriculture, improvement of energy- and resource-saving machinery, and the creation of competitive technical means [2].

In implementing these tasks, the scientific substantiation of the design parameters of disc ripper levelers used in the cultivation of vineyard inter-rows is of great importance. In particular, the installation angle of the soil leveler relative to the direction of movement directly affects the traction resistance of the device, the quality of soil crumbling, and the leveling level of the field surface [3]. Therefore, determining these parameters based on experimental studies is of great scientific and practical importance in increasing the operational efficiency of the device and reducing energy consumption [4].

2. Materials and Methods

The object of the research was a disc softener-leveler intended for cultivating vineyard inter-rows, equipped with leveling soil pushers. The field experiments were carried out in accordance with the generally accepted methods for testing agricultural machinery [5]. The experiments were planned, and the number of replications was substantiated, on the basis of the methods of experiment planning in agricultural process research [6]. The statistical processing of the experimental data was performed using the generally accepted methods of field experiment analysis [7]. The mean square deviation of the height of the field surface irregularities was determined by profiling the field surface before and after the passage of the device [8].

In the first series of experiments, the installation angle of the leveler soil pushers relative to the direction of movement was varied from 25° to 40° at intervals of 5°; in this case, the installation angle of the soil pushers relative to the vertical was 40°, the grip width was 30.0 cm, the height was 6.0 cm, the vertical load per meter of the grip width was 4.0 kN/m, and the unit speed was 7 and 9 km/h. In the second series of experiments, the installation angle of the soil pushers relative to the vertical was varied from 30° to 45° at intervals of 5° at a constant installation angle of 30° relative to the direction of movement, the remaining parameters being unchanged.

The performance of the device was evaluated by the mean square deviation of the height of the field surface irregularities ($\pm\sigma$), the degree of soil crumbling ($F<25$), i.e., the amount of soil fractions smaller than 25 mm, and the specific tractive resistance (R). The forces acting on the working bodies of the device were analyzed on the basis of the principles of applied mechanics [9]. The kinematics of the movement of soil particles along the working surfaces of the soil pushers was considered in accordance with the provisions of theoretical mechanics [10].

3. Results and Discussion

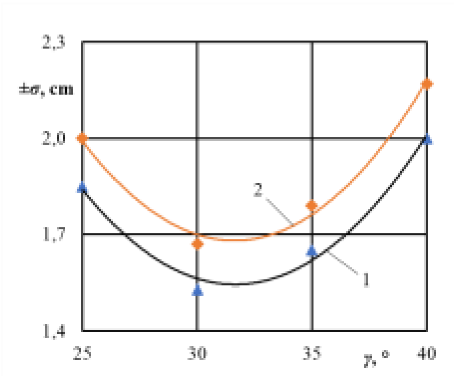
In the experiments, the leveler was used for soil plowing the installation angle relative to the direction of travel was changed from 25° to 40° at an interval of 5°. In this case, the installation angle of the leveler's soil spreader relative to the vertical is 40°, the grip width is 30.0 cm, the height is 6.0 cm, the vertical load per meter of the leveler's grip width is 4.0 kN/m, and the unit speed is 7 and 9 km/h.

Table 1. Results of experimental studies to study the influence of the installation angle of the leveler soil slide relative to the direction of movement on its performance indicators

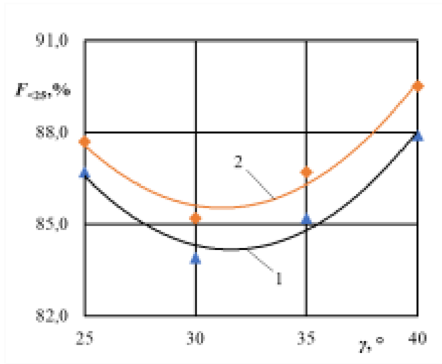
Angle of installation of the leveler soil slide relative to the direction of movement, °	Mean square deviation of the height of irregularities on the field surface, cm	Degree of soil crumbling, i.e., the amount of soil fractions smaller than 25 mm, %	Specific tractive resistance of the device, kN/m
V=7 km/h			
25,0	1,85	86,7	3,97
30,0	1,53	83,9	3,70
35,0	1,65	85,2	3,89

Angle of installation of the leveler soil slide relative to the direction of movement, °	Mean square deviation of the height of irregularities on the field surface, cm	Degree of soil crumbling, i.e., the amount of soil fractions smaller than 25 mm, %	Specific tractive resistance of the device, kN/m
40,0	2,00	87,9	4,18
V=9 km/h			
25,0	2,00	87,7	4,22
30,0	1,67	85,2	3,98
35,0	1,79	86,7	4,11
40,0	2,17	89,5	4,45

The results of the experiments are presented in Table 1 and Figure 1. It can be seen from them that depending on the installation angle of the leveler soil pusher relative to the direction of movement, the mean square deviation of the heights of irregularities on the field surface and the traction resistance of the device change according to the law of a concave parabola, where the mean square deviation of the heights of irregularities on the field surface increases from 25° to 30° with an increase in the installation angle of the leveler soil pusher relative to the direction of movement at both movement speeds[11].



a



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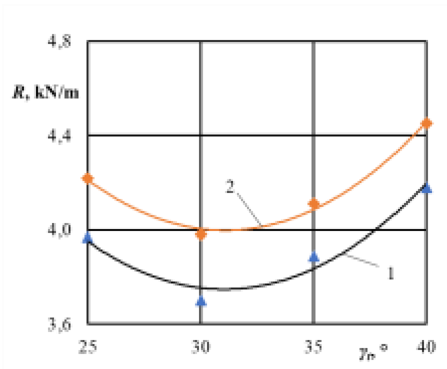

v

(1) at a speed of 7 km/h; (2) at a speed of 9 km/h

Figure 1. Changes in the mean square deviation of the height of the field surface irregularities ±σ (a), the degree of soil crumbling F<25 (b), and the specific draft resistance R (v) of the leveler depending on the installation angle (γ) of the leveler soil slide relative to the direction of movement

This is due to the fact that when the installation angle of the leveler soil spreader relative to the direction of movement is within the range of 27-30° [12], determined by theoretical research, the soil does not adhere to their working surfaces, and the volume of soil accumulated in front of them is small. As a result, they ensure high-quality smoothing of field surface irregularities and a reduction in tractive resistance. For the same reasons, soil crumbling is high-quality at the aforementioned values of the alignment angles of the leveler soil slide relative to the direction of movement. When this angle is within 30–40°, it was observed that soil particles adhere to the working surfaces of the leveling soil trawl. As a result, the quality of the leveler's operation deteriorated, and its traction resistance increased.

Increasing the speed from 7 km/h to 9 km/h led to an improvement in soil crumbling quality, an increase in the mean square deviation of the height of the field surface irregularities, and an increase in tractive resistance [13].

Based on the results of the conducted research, we assume the installation angle of the leveler soil spreader relative to the direction of movement to be within 30-35°.

Figure 2. Installation of soil pushers at angles of 25 (a), 30 (b), 35 (c), and 40° (d) relative to the direction of movement

Research was conducted to study the influence of the soil leveler's installation angle β relative to the vertical on the mean square deviation of the field surface irregularity heights (±σ), the degree of soil crumbling (F<25), i.e., the amount of soil fractions smaller than 25 mm, and the draft resistance R of the device.

Figure 3. Installation angle of soil pushers relative to the vertical at angles of 30, 35, 40, and 45°

During the experimental studies, based on the results of theoretical studies, the installation angle of the soil leveler relative to the vertical was changed from 30° to 45° every 5°. In this case, the installation angle of the leveler's soil sucker relative to the direction of travel is 30°, the coverage width is 30 cm, the height is 6.0 cm, the vertical load per meter of the leveler's coverage width is 4.0 kN/m, and the unit's travel speed is 7 and 9 km/h.

Their analysis shows that with an increase in the installation angle of the soil leveler relative to the vertical, the standard deviation of the height of the field surface irregularities decreases, i.e., the leveling quality of the field surface improves. As this angle increases from 30° to 45°, the standard deviation of the height of the field surface irregularities decreased from ±2.35 cm to ±1.72 cm at a speed of 7 km/h, and at a speed of 9 km/h, this indicator decreased from ±2.50 cm to ±1.84 cm.

This is explained by the fact that with an increase in the installation angle of the soil leveler relative to the vertical, the probability of clod formation under its influence increases, and as a result, the degree of leveling of irregularities improves [14].

Figure 4. Working view of a field installation equipped with a leveler

This is also explained by the fact that an increase in angle β leads to an increase in the interaction time of soil particles with the leveling soil spreader and their further grinding [15]. It should also be noted that an increase in angle β leads to an increase in the subsoiler's depth of penetration into the soil, which also improves soil crushing [16].

Figure 5. Obtaining the transverse profile of the cultivated field surface on a device equipped with levelers

Increasing the installation angle of the soil leveler relative to the vertical from 30° to 45° led to an increase in the amount of soil fractions smaller than 25 mm. At a unit speed of 7 km/h, this indicator ranges from 78.5% to 84.0%. Increasing the installation angle of the soil leveler relative to the horizon led to an increase in the tractive resistance of the device at both travel speeds. Increasing this angle from 30° to 45° led to an increase in traction resistance from 3.59 kN to 4.18 kN at a speed of 7 km/h, while at a speed of 9 km/h, this indicator increased from 3.80 kN to 4.39 kN. This also occurs for the reasons mentioned above.

Experimental studies have shown that the installation angle of the leveling soil spreader relative to the vertical must be at least 40°.

4. Conclusion

According to the experimental results, it is advisable to set the installation angle of the soil slide relative to the direction of movement within 30–35°. Experimental studies have shown that the installation angle of the leveling soil spreader relative to the vertical must be at least 40°.

At these values, the quality of field surface leveling improves and the required level of soil crumbling is ensured. The results obtained serve as the basis for substantiating the design parameters of the disc ripper leveler, improving its operating process, and developing scientific and practical recommendations for reducing energy and resource consumption when cultivating vineyard inter-rows.

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