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# Determination of the vertical installation angles of the leveling soil pushers

## Tekislovchi tuproq surgichlarning vertikal o‘rnatilish burchaklarini aniqlash

## Определение углов вертикальной установки выравнивающих почвообрабатывающих рабочих органов

**Golibjon Ulugbek ugli JALOLDINOV**[1,*]

[1] *Scientific-Research Institute of Agricultural Mechanization, Gulbakhor, Tashkent Region, Uzbekistan*

***** Corresponding author: jaloldinov.golibjon95@gmail.com

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**CONTACT**
ReFocusJournal@gmail.com



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**Golibjon Ulugbek ugli JALOLDINOV**[1,*]
[1] *Scientific-Research Institute of Agricultural Mechanization, Gulbakhor, Tashkent Region, Uzbekistan*

**Abstract.** This study experimentally investigated the effect of the installation angle of soil-pushing elements, measured relative to the direction of travel, on the operational performance of a disc ripper-leveler designed for inter-row tillage in vineyards. During the experiments, the angle was adjusted between 25° and 40° in 5° increments. The performance of the implement was assessed using several key parameters, including the root mean square deviation of field-surface irregularities, the degree of soil fragmentation, and the specific draft resistance. The experimental findings demonstrated that the position of the soil pushers has a considerable influence on both the quality and energy efficiency of the tillage process. The most favorable results were obtained when the soil-pushing elements were positioned at an angle of approximately 30–35° to the direction of movement. Within this range, the leveling quality of the field surface improved, while the draft resistance of the implement decreased, resulting in more efficient operation. The experiments also indicated that the leveling soil spreader should be positioned at an angle of not less than 40° relative to the vertical. Such a configuration contributes to more effective redistribution of the soil and better correction of surface irregularities during operation. The results provide a practical basis for optimizing the structural and operational parameters of disc ripper-levelers used in vineyard inter-row cultivation. Appropriate selection of the installation angles can contribute to improved surface leveling, reduced energy requirements, and increased overall efficiency of the tillage process.

**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

#### O‘ZBEKCHA

**JALOLDINOV Golibjon Ulugbek ugli**[1,*]
[1] *Qishloq xo‘jaligini mexanizatsiyalash ilmiy-tadqiqot instituti, Gulbahor, Toshkent viloyati, O‘zbekiston*

**Annotatsiya.** Ushbu tadqiqotda tokzorlar qator oralariga ishlov berishga mo‘ljallangan diskli yumshatkich-tekislagichning ish ko‘rsatkichlariga harakat yo‘nalishiga nisbatan o‘lchanadigan tuproq surgich ishchi organlarining o‘rnatilish burchagi ta’siri eksperimental ravishda o‘rganildi. Tajribalar davomida o‘rnatilish burchagi 25° dan 40° gacha 5° qadam bilan o‘zgartirildi. Agregatning ish samaradorligi dala yuzasidagi notekisliklarning o‘rtacha kvadratik chetlanishi, tuproqning uvoqlanish darajasi va solishtirma tortish qarshiligi kabi asosiy ko‘rsatkichlar orqali baholandi. Eksperimental tadqiqot natijalari tuproq surgich ishchi organlarining holati tuproqqa ishlov berish sifati va energiya samaradorligiga sezilarli ta’sir ko‘rsatishini ko‘rsatdi. Eng maqbul natijalar tuproq surgich ishchi organlari harakat yo‘nalishiga nisbatan taxminan 30–35° burchak ostida o‘rnatilganda olindi. Ushbu oraliqda dala yuzasini tekislash sifati yaxshilandi, agregatning tortish qarshiligi esa kamaydi, natijada ish jarayonining samaradorligi oshdi. Tajribalar shuni ko‘rsatdiki, tekislagich tuproq taqsimlagichi vertikalga nisbatan kamida 40° burchak ostida o‘rnatilishi lozim. Bunday joylashuv tuproqni yanada samarali qayta taqsimlashga hamda ish

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jarayonida dala yuzasidagi notekisliklarni yaxshiroq bartaraf etishga imkon beradi. Olingan natijalar tokzorlarning qator oralariga ishlov berishda qo‘llaniladigan diskli yumshatkich-tekislagichlarning konstruktiv va ekspluatatsion parametrlarini optimallashtirish uchun amaliy asos bo‘lib xizmat qiladi. Ishchi organlarning o‘rnatilish burchaklarini to‘g‘ri tanlash dala yuzasini tekislash sifatini yaxshilash, energiya sarfini kamaytirish va tuproqqa ishlov berish jarayonining umumiy samaradorligini oshirish imkonini beradi.

**Kalit so‘zlar:** diskli yumshatkich; tekislagich; tuproq surgich; o‘rnatilish burchagi; tokzor qator oralig‘i; tortish qarshiligi; tuproqning uvoqlanishi; dala yuzasini tekislash; eksperimental tadqiqot; ish samaradorligi ko‘rsatkichlari; vertikal o‘rnatilish burchagi

## РУССКИЙ

**ЖАЛОЛДИНОВ Голибжон Улугбек угли**[1,*]

[1] *Научно-исследовательский институт механизации сельского хозяйства, Гулбахор, Ташкентская область, Узбекистан*

**Аннотация.** В данном исследовании экспериментально изучено влияние угла установки почвосдвигающих рабочих органов, измеряемого относительно направления движения, на эксплуатационные показатели дискового рыхлителя-выравнивателя, предназначенного для обработки почвы в междурядьях виноградников. В ходе экспериментов угол установки изменяли от 25° до 40° с шагом 5°. Эффективность работы агрегата оценивали по нескольким основным показателям, включая среднеквадратическое отклонение неровностей поверхности поля, степень крошения почвы и удельное тяговое сопротивление. Результаты экспериментальных исследований показали, что положение почвосдвигающих рабочих органов оказывает существенное влияние как на качество обработки почвы, так и на её энергетическую эффективность. Наиболее благоприятные результаты были получены при установке почвосдвигающих рабочих органов под углом примерно 30–35° к направлению движения. В этом диапазоне повышалось качество выравнивания поверхности поля, а тяговое сопротивление агрегата снижалось, что обеспечивало более эффективную работу. Эксперименты также показали, что выравнивающий почвораспределитель должен быть установлен под углом не менее 40° относительно вертикали. Такая конфигурация способствует более эффективному перераспределению почвы и лучшему устранению неровностей поверхности в процессе работы. Полученные результаты создают практическую основу для оптимизации конструктивных и эксплуатационных параметров дисковых рыхлителей-выравнивателей, применяемых для обработки междурядий виноградников. Правильный выбор углов установки рабочих органов позволяет повысить качество выравнивания поверхности, снизить энергетические затраты и увеличить общую эффективность процесса обработки почвы.

**Ключевые слова:** дисковый рыхлитель; выравниватель; почвосдвигатель; угол установки; междурядье виноградника; тяговое сопротивление; крошение почвы; выравнивание поверхности поля; экспериментальное исследование; показатели эффективности; угол вертикальной установки

## 1. INTRODUCTION

Introduction. The modernization of agricultural production increasingly requires the adoption of resource- and energy-efficient technologies aimed at improving labor productivity, maintaining soil fertility, and developing advanced agricultural machinery. In Uzbekistan, these priorities have been reflected in a number of state programs and strategic documents. In particular, the Decree of the President of the Republic of Uzbekistan No. UP-6091 of October 23, 2020, entitled “On Approval of the Strategy for the Development of Agriculture of the Republic of Uzbekistan for 2020–2030,” emphasizes the modernization of agricultural production and the broader application of efficient, resource-saving machinery and technologies [1]. These objectives were further developed in the Decree of the President of the Republic of Uzbekistan No. UP-60 of January 28, 2022, “On the Development Strategy of New Uzbekistan for 2022–2026.” The document identifies important measures aimed at introducing innovative technologies into the agro-industrial sector, expanding integrated mechanization of agricultural operations, improving energy- and resource-efficient machinery, and developing competitive technical equipment.

Within the framework of these strategic objectives, improving machinery used for inter-row cultivation of vineyards is of particular scientific and practical interest. The effectiveness of a disc ripper-leveler depends considerably on the rational selection of its main design and operating parameters. Among these parameters, the angle at which the leveling element is positioned relative to the direction of travel has a direct influence on traction resistance, the degree of soil loosening and crumbling, and the quality of surface leveling. Consequently, establishing an appropriate installation angle through theoretical and experimental investigations is essential for improving machine performance, reducing unnecessary energy expenditure, and ensuring high-quality soil cultivation in vineyard inter-rows.

## 2. RESULTS AND DISCUSSION

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**

Tekislagich tuproq surgichining harakat yo‘nalishiga nisbatan o‘rnatilish burchagi qurilma ish ko‘rsatkichlariga ta’sirini o‘rganish bo‘yicha eksperimental tadqiqotlar natijalari / **Table 1.** Results of experimental studies of the influence of the installation angle of the leveler soil slide relative to the direction of movement

| Angle of installation of the leveler soil slide relative to the direction of movement, ° V=7 km/h | 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 |
|---|---|---|---|
| 25,0 | 1,85 | 86,7 | 3,97 |
| 30,0 | 1,53 | 83,9 | 3,70 |
| 35,0 | 1,65 | 85,2 | 3,89 |
| 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

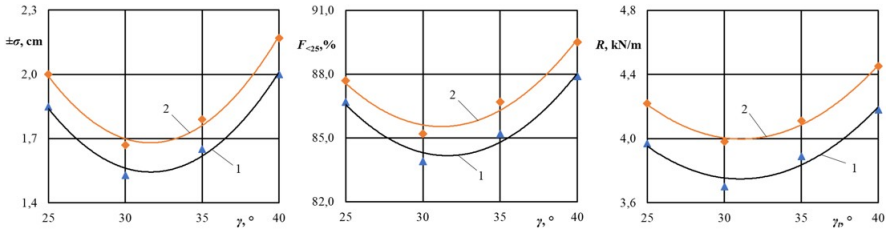


**Fig. 1.** Dala yuzasi notekisliklari balandligining o‘rtacha kvadratik og‘ishi ±σ (a), tuproqning maydalanish darajasi (b) va qurilmaning solishtirma tortish qarshiligi (c) o‘zgarishi: 1 — 7 km/soat tezlikda; 2 — 9 km/soat tezlikda / **Fig. 1.** Changes in the mean square deviation of the height of the field surface irregularities ±σ (a), the degree of soil crumbling (b) and the specific traction resistance of the device (c): (1) at a speed of 7 km/h; (2) at a speed of 9 km/h

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[2-4].

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°[5], 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.[6-7]

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°.

**Fig. 2.** Tuproq surgichlarni harakat yo‘nalishiga nisbatan 25 (a), 30 (b), 35 (c) va 40° (d) burchak ostida o‘rnatish / **Fig. 2.** Installation of soil pushers at angles of 25 (a), 30 (b), 35 (c) and 40° (d) relative to the direction of movement

**Fig. 3.** Tuproq surgichlarning vertikalga nisbatan 30, 35, 40 va 45° burchak ostida o‘rnatilishi / **Fig. 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.

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 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[8].

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.

**Fig. 4.** Tekislagich bilan jihozlangan dala qurilmasining ishchi ko‘rinishi / **Fig. 4.** Working view of a field installation equipped with a leveler

**Fig. 5.** Tekislagichlar bilan jihozlangan qurilmada ishlov berilgan dala yuzasining ko‘ndalang profilini olish / **Fig. 5.** Obtaining the transverse profile of the cultivated field surface on a device equipped with levelers

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. 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[9]. 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°.

## 3. CONCLUSION

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.

## DECLARATIONS

### Author contributions CRediT

Conceptualization; Methodology; Investigation; Data curation; Writing – original draft; Writing – review & editing. All authors have read and agreed to the published version of the manuscript.

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### Ethics approval

Not applicable. This study did not involve humans, animals or other regulated materials.

### Informed consent

All authors have read and approved the final version of the manuscript and have given their consent to its submission and publication. The study involved no human participants and no personal data.

### Data availability statement

All data supporting the findings of this study are presented in the article and are available from the corresponding author upon reasonable request.

### Conflict of interest

The authors declare no conflict of interest.

### Generative AI disclosure

Generative AI was used only partially. The authors used Claude (Anthropic, Opus 5) for language editing, formatting of the reference list and preparation of the English and Russian metadata. No text, data, figures or conclusions were generated by AI. The authors reviewed and verified all output and take full responsibility for the content of the publication.

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