INSIGHTS-JOURNAL OF
LIFE AND SOCIAL SCIENCES

INSIGHTS-JLSS
Insights-Journal of Life and Social Sciences

COMPARATIVE ANALYSIS OF CULTIVATOR AND DISC HARROW ON FIELD EFFICIENCY, SOIL STRUCTURE, GROWTH AND YIELD OF SUNFLOWER CROP

Original Article

Shafique Ahmed Lakhan[1], Barkat Ali Nindwani[1]*, Noreena Memon[1], Ain Ul Abad Syed[2], Nadir Ali Rajput[3], Asif Ali Noonari[4]

[1]Department of Farm Power and Machinery, Faculty of Agricultural Engineering & Technology, Sindh Agriculture University, Tandojam 70060, Pakistan.

[2]Department of Farm Structures and Postharvest Engineering, Faculty of Agricultural Engineering & Technology, Sindh Agriculture University, Tandojam 70060, Pakistan.

[3]Department of Energy and Environment, Faculty of Agricultural Engineering & Technology, Sindh Agriculture University Tandojam 70060, Pakistan.

[4]Department of Irrigation and Drainage, Faculty of Agricultural Engineering & Technology, Sindh Agriculture University, Tandojam 70060, Pakistan.

Corresponding Author: Barkat Ali Nindwani, Department of Farm Structures and Postharvest Engineering, Faculty of Agricultural Engineering & Technology, Sindh Agriculture University, Tandojam 70060, Pakistan, barkatali_04@yahoo.com

Conflict of Interest: None | Grant Support & Financial Support: None

Acknowledgment: The authors gratefully acknowledge the support of Sindh Agriculture University, Tandojam, for providing field and technical assistance during the study.

ABSTRACT

Background: Efficient soil management is critical for enhancing crop productivity, yet many farmers continue using conventional self-owned tillage tools without understanding their long-term impact on soil structure and crop performance. Sunflower (*Helianthus annuus* L.) is an economically vital oilseed crop whose optimal growth is highly dependent on soil conditions. Thus, investigating the role of tillage implements in modifying soil structure and influencing sunflower growth and yield parameters is essential to improve sustainable farming practices.

Objective: The present study aimed to comparatively assess the effects of cultivator and disk harrow-based tillage systems on field efficiency, soil structure, growth, and yield performance of sunflower crop under silt loam soil conditions.

Methods: A field experiment was conducted during the Rabi season of 2019–2020 at Latif Experimental Farm, Sindh Agriculture University, Tandojam. Treatments included cultivator two passes (C2), punj hari one pass plus cultivator two passes (P1C2), disk harrow two passes (DH2), and punj hari one pass plus disk harrow two passes (P1DH2). The trial followed a randomized complete block design with three replications. Key soil properties (moisture content, dry bulk density, porosity, mean weight diameter) and growth parameters (seedling emergence, plant height, head diameter, stalk diameter, 1000 seed weight, seed yield) were recorded and statistically analyzed using LSD test at a 5% significance level.

Results: Field efficiency was highest under P1DH2 (74.5%) and lowest under C2 (68.1%). P1C2 treatment exhibited maximum soil moisture content (9.61%), highest porosity (50.94%), and lowest dry bulk density (1.30 g/cm³). Seedling emergence (95.8%), plant height (147 cm), head diameter (47 cm), stalk diameter (5.83 cm), 1000 seed weight (60.20 g), seed moisture content (11.23%), and seed yield (3.55 t/ha) were significantly superior under P1C2. Conversely, DH2 produced the least favorable outcomes across all parameters measured.

Conclusion: The combination of punj hari and two passes of cultivator (P1C2) markedly improved soil structure and enhanced sunflower growth and yield, offering a promising tillage approach for maximizing productivity in silt loam soils.

Keywords: Crop Growth and Yield; Field Efficiency; Soil Structure; Sunflower; Tillage Implements; Tillage Practices; Yield Improvement.

© 2025 et al. -Health And Research Insights-Open access under CC BY License (Creative Commons). Freely distributable with appropriate citation

INTRODUCTION

Sunflower (*Helianthus annuus* L.) stands as one of the world's most significant oilseed crops, ranking fourth globally by cultivated area. Its seeds, botanically classified as achenes, are notable for their high oil content, ranging between 40% and 50%, and a substantial protein composition of approximately 20%–27% (1). The oil derived from sunflower seeds is highly valued for its superior quality and elevated oleic acid content, both of which are recognized for their beneficial role in regulating blood cholesterol levels, making sunflower oil a preferred dietary component for individuals with cardiovascular conditions (2). Globally, sunflower production is estimated at 48 million tons, with Pakistan contributing 85,900 tons, achieving an average seed yield of 1040 kg ha^{-1} (3). Despite its importance, Pakistan faces a substantial gap in meeting its edible oil demand; only 28% of the required 2.966 million tons are produced locally, forcing the country to rely heavily on imports, second only to petroleum (3,4). A critical factor underpinning this low domestic productivity is suboptimal soil management, primarily arising from inappropriate tillage practices that impair seedbed conditions (4). Tillage practices are pivotal in altering soil physical properties, including dry bulk density, porosity, moisture retention, and root penetration capacity, all of which directly influence plant growth and crop yields (5). However, when unsuitable implements are employed, these practices may fail to achieve the desired soil structure, leading to compromised crop development. Studies have consistently demonstrated that the type of tillage implement used exerts a significant impact on soil physical attributes. For instance, chisel plow combined with tine cultivator passes and moldboard plow followed by tine cultivator have been associated with reduced soil compaction and increased moisture retention compared to single-pass operations with disk harrow or tine cultivator alone (6). Similarly, disk plow combined with cultivator operations in clay soil has resulted in better moisture conservation compared to the sole use of tine cultivators (7).

Further evidence suggests that primary tillage with a cultivator, followed by seedbed preparation with a disk harrow, optimizes seedling emergence and improves yield outcomes (8). Modern tillage trends have increasingly favored the use of rotary tillers for seedbed preparation, residue incorporation, and soil amendment mixing, reflecting a broader shift towards practices that enhance soil health (7,8). Combinations such as moldboard plow plus rotary tiller, or chisel plow plus rotary tiller, have been shown to significantly lower dry bulk density and penetration resistance, particularly in the upper 5–10 cm soil layer (9). In the province of Sindh, Pakistan, disk harrows and tine cultivators dominate as the principal tillage implements, readily available and widely used across diverse soil types. Most farmers, however, possess limited knowledge of tillage-soil-plant interactions and tend to persist with self-owned implements in an effort to minimize operational costs. While cost-effective in the short term, such practices often disregard the adverse long-term impacts on soil structure and crop productivity. Excessive and indiscriminate passes with disk harrows and tine cultivators have been implicated in soil organic matter depletion, nutrient loss, and escalating production costs, culminating in a notable decline in overall agricultural productivity (10). Despite their prevalence, the persistent and inappropriate use of disk harrow and tine cultivator has deteriorated soil quality across many farming systems in Sindh, negatively influencing crop yields. This concerning trend underlines a critical knowledge gap regarding the comparative effects of these implements on soil structure and crop performance. Addressing this gap is essential not only to enhance crop yield and soil health but also to optimize field operations and reduce production costs sustainably. Given the crucial role of soil structure in crop success and the widespread reliance on traditional tillage methods, there is an urgent need to investigate the comparative field efficiency of commonly used tillage implements and their subsequent impact on soil physical properties, plant growth, and yield. Therefore, the present study was designed to conduct a comparative evaluation of cultivator and disk harrow tillage implements, focusing on their effects on field efficiency, soil structure, and the growth and yield of sunflower, with the objective of identifying more sustainable and productive tillage practices suited to the agronomic conditions of Sindh, Pakistan.

METHODS

The field experiment was conducted to assess the impact of cultivator and disk harrow on field efficiency, soil structure, growth, and yield of the sunflower crop at Latif Experimental Farm of Sindh Agriculture University, Tandojam (25° 26′ 36.56″N latitude, 68° 32′ 20.42″E longitude, 26 m altitude) during the Rabi season of 2019–2020. Ethical approval for conducting the experiment was granted by the Institutional Research Ethics Committee of Sindh Agriculture University, Tandojam. Although the study did not involve human or animal participants, ethical oversight was sought as part of institutional requirements. The experiment was designed as a Randomized Complete Block Design (RCBD) with three replications to ensure the reliability and validity of the findings. The total experimental area (32 m × 60 m) was divided into nine plots, each measuring 10 m × 15 m. The treatments included cultivator two passes (C2), punj hari one pass followed by cultivator two passes (P1C2), disk harrow two passes (DH2), and punj hari one pass followed by disk harrow two passes (P1DH2). These treatments were selected to represent commonly practiced tillage combinations among local farmers and to capture the differences in soil structure modification and crop performance. Field efficiency parameters were assessed following the

operational methodology (11). Operating speed was calculated using the formula: Operating Speed (km h^{-1}) = (Distance (km)) / (Time (h)). The theoretical field capacity was determined as:
Theoretical field capacity (ha h^{-1}) = (Speed (km h^{-1}) × Width of Machine (m)) / 10.
Effective field capacity was measured by:
Effective field capacity (ha h^{-1}) = (Total area covered (ha)) / (Time required (h)).
Finally, field efficiency was calculated by:
Field efficiency (%) = (Effective field capacity) / (Theoretical field capacity) × 100.
Physical properties of the soil were evaluated both before tillage and after the harvest of the sunflower crop. Soil samples were collected at three depths: 0–15 cm, 16–30 cm, and 31–45 cm. Soil texture was determined using the Bouyoucos Hydrometer method (12), and the field capacity of the soil was evaluated by the Veihmeyer and Hendrickson method (13).
Soil moisture content (%) was measured gravimetrically as described by Blake and Hartge (14) using the following formula:
Moisture content (%) = (Weight of water) / (Weight of dry soil) × 100.
Dry bulk density (g/cm^3) was determined using:
Dry bulk density (g/cm^3) = (Dry weight of soil) / (Total volume of soil).
Soil porosity (%) was assessed using the relationship:
$n = 1 - \rho d/\rho s \times 100$, where ρd represents dry bulk density and ρs indicates particle density.
Soil aggregation was measured through mean weight diameter (MWD) following the method of Van Bavel (15) using the formula: $MWD = \sum(xi \times wi)$, where xi is the mean diameter of each size fraction and wi is the proportion of total sample weight in that fraction.
Crop management practices were standardized across treatments to minimize confounding factors. Sunflower cultivar HO-1 was sown manually in the third week of January at a seeding rate of 10 kg ha^{-1}. Row spacing was maintained at 75 cm with an intra-row plant spacing of 25 cm to ensure optimal growth conditions. Irrigation was applied based on soil moisture monitoring, ensuring water was provided when the soil moisture content dropped to 60% of field capacity, as recommended by the Ministry of Food, Agriculture, and Livestock guidelines (16). Soil moisture depletion (SMD) was calculated using the formula: $SMD = \theta f - \theta o$, where θf is the moisture content at field capacity (%) and θo is the moisture content at 60% SMD. Moisture content on a dry weight basis was computed as:
$\theta = ((Ww - Wd)) / (Wd) \times 100$, where Ww is the wet weight and Wd is the oven dry weight of the soil.
Fertilizers were applied according to standard agronomic practices. Nitrogen (N) was applied at the rate of 35–45 kg ha^{-1}, phosphorus (P_2O_5) at 30–35 kg ha^{-1}, and potassium (K_2O) at 15 kg ha^{-1}. Phosphorus, potassium, and half of the nitrogen were applied at sowing, while the remaining nitrogen was top-dressed when plants reached approximately 30 cm in height (17). Manual weeding was carried out uniformly across all plots to prevent competition effects. Growth and yield parameters were systematically recorded. Emergence was counted as one-week post-sowing, while plant height at maturity, head diameter, stalk diameter, and number of plants per plot were measured at five randomly selected locations within each plot. Mature sunflower heads were harvested manually, sun-dried, and threshed. A 1000-seed weight was determined by using an electronic balance to assess seed mass uniformity. Seed yield per plot was calculated using the following formula:
Seed yield (t ha^{-1}) = (Seed weight (kg/plot) × 10000 m^2) / (Plot size (m^2)) × 100.
Seed moisture content was determined using the relation:
Seed moisture content (g/kg) = ((Fresh weight – Dry weight)) / (Fresh weight) × 1000.
The data collected were statistically analyzed using Statistic 8.1 software (Analytical Software, 2005). Analysis of variance (ANOVA) was performed to identify significant differences among treatments, and mean comparisons were conducted using the Least Significant Difference (LSD) test at a 5% probability level, where appropriate.

RESULTS

The present study evaluated the comparative effects of cultivator and disk harrow tillage practices on field efficiency, soil structure, and the growth and yield of sunflower crop. Tillage treatments significantly influenced soil physical properties, growth attributes, and final crop yield, as indicated by the statistical analysis showing significant differences at $P < 0.05$ among treatments. The soil texture of the experimental field was characterized as silt loam at the 0–15 cm depth and loam from 16–45 cm depth. Soil electrical conductivity (ECe) ranged between 0.22 and 0.27 dS m^{-1}, pH values varied between 7.5 and 7.6, and sodium adsorption ratio (SAR) ranged from 5.41 to 6.05. Field efficiency varied markedly among the treatments. P1DH2 demonstrated the highest field efficiency at 74.5%, followed by P1C2 at 73.2%, DH2 at 69.3%, and C2 at 68.1%. These findings indicated that combining punj hari with disk harrow significantly improved operational performance over cultivator-alone treatments. Soil moisture content before the start of the experiment averaged

© 2025 et al. -Health And Research Insights-Open access under CC BY License (Creative Commons). Freely distributable with appropriate citation.

5.04%, 6.42%, and 8.21% at 0–15, 16–30, and 31–45 cm depths, respectively. Post-experiment observations revealed that the soil moisture content increased significantly across all treatments. P1C2 maintained the highest post-experiment soil moisture content with values of 8.30%, 9.61%, and 9.11% across the three respective depths, whereas DH2 exhibited the lowest moisture retention.

Dry bulk density decreased slightly across all treatments after tillage interventions. The lowest dry bulk density was recorded under P1C2 with post-experiment values of 1.30, 1.31, and 1.39 g cm^{-3}, respectively, across the measured depths. Conversely, the highest dry bulk density values were consistently observed under DH2 treatment, reflecting suboptimal soil loosening compared to other tillage systems. Soil porosity improved under all treatments after the experiment, with P1C2 achieving the highest porosity values of 50.94%, 50.57%, and 47.55% across increasing soil depths. DH2 consistently showed the lowest post-experiment soil porosity, correlating with its higher bulk density and lower moisture retention capacity. Mean weight diameter (MWD), indicative of soil aggregation quality, was significantly improved under all tillage treatments. The highest MWD was recorded under P1C2 at 1.57 mm, followed by P1DH2 at 1.55 mm. DH2 recorded the lowest MWD at 1.41 mm, demonstrating inferior soil aggregation compared to the combined tillage treatments. Seedling emergency percentages varied significantly among treatments. Maximum emergence rates were recorded under P1C2 and P1DH2, both at 95.80%, whereas DH2 exhibited the lowest emergence at 70.80%, demonstrating that optimal soil structure favored seedling establishment.

Plant height at maturity varied with tillage practices, with P1C2 producing the tallest plants at 147 cm, followed by P1DH2 at 143 cm. The shortest plants were recorded under DH2 at 118 cm. These differences reflected the impact of soil conditions created by various tillage treatments on sunflower vegetative growth. Head diameter measurements showed a similar trend, with the largest average head diameter of 47 cm observed under P1C2 and the smallest diameter of 33 cm under DH2. Stalk diameter also differed significantly across treatments, with P1C2 achieving the maximum average stalk diameter of 5.83 cm, and C2 recording the lowest at 4.73 cm. Seed moisture content at harvest varied significantly, with P1DH2 resulting in the highest average seed moisture at 11.23%, followed by P1C2 at 10.44%. DH2 had the lowest seed moisture content at 8.47%. This outcome further highlights the role of soil moisture conservation through better tillage practices. The 1000-seed weight showed notable variation among treatments, with P1C2 achieving the highest 1000-seed weight of 60.20 g, followed by P1DH2 at 55.10 g. DH2 produced the smallest seeds with an average 1000-seed weight of 43.20 g, suggesting that better soil conditions facilitated superior seed development. Seed yield per hectare also demonstrated significant differences among treatments. The highest average yield was recorded under P1C2 at 3.55 t ha^{-1}, followed by P1DH2 at 3.257 t ha^{-1}, C2 at 2.894 t ha^{-1}, and DH2 at 2.65 t ha^{-1}. Thus, tillage systems combining punj hari with cultivator or disk harrow proved more effective in enhancing sunflower productivity.

To further elucidate the relationships between soil physical properties and crop outcomes, Pearson correlation analyses were conducted between soil moisture content, dry bulk density, soil porosity, mean weight diameter, and the final seed yield and seedling emergence rates. The analysis revealed that soil porosity exhibited a strong positive correlation with seed yield ($r = 0.997$, $P = 0.003$) and a similarly strong correlation with seedling emergence ($r = 0.915$, $P = 0.085$). Dry bulk density demonstrated a significant strong negative correlation with seed yield ($r = –0.997$, $P = 0.003$), suggesting that higher compaction adversely affected crop performance. Soil moisture content also showed a strong positive association with seed yield ($r = 0.948$, $P = 0.052$) and with seedling emergence ($r = 0.989$, $P = 0.011$), highlighting the importance of moisture retention for early plant establishment and productivity. Additionally, mean weight diameter, representing soil aggregation quality, was positively correlated with seed yield ($r = 0.974$, $P = 0.026$) and seedling emergence ($r = 0.891$, $P = 0.109$). These findings collectively underscore the critical role of optimal soil physical conditions in enhancing sunflower crop establishment and yield outcomes.

Table 1: Physical and Chemical Properties of Experimental Soil at Different Depths

Depth (cm)	**Texture**	**ECe (dS m^{-1})**	**pH**	**SAR**
0–15	Silt loam	0.23	7.60	5.41
16–30	Loam	0.27	7.60	5.53
31–45	Loam	0.22	7.50	6.05

© 2025 et al. -Health And Research Insights-Open access under CC BY License (Creative Commons). Freely distributable with appropriate citation.

Table 2: Effect of Tillage Treatments on Field Efficiency, Seedling Emergence, Plant Height, and Seed Yield of Sunflower

Treatment	Field Efficiency (%)	Seedling Emergence (%)	Plant Height (cm)	Seed Yield (t/ha)
C2	68.1	87.5	120	2.894
P1C2	73.2	95.8	147	3.55
DH2	69.3	70.8	118	2.65
P1DH2	74.5	95.8	143	3.257

Table 3: Impact of Tillage Treatments on Post-Harvest Soil Moisture, Bulk Density, Porosity, and Soil Aggregation in Sunflower Cultivation

Treatment	Soil Moisture (%) (Post)	Dry Bulk Density (g/cm³)	Soil Porosity (%)	Mean Weight Diameter (mm)
C2	7.73	1.32	50.19	1.44
P1C2	8.30	1.30	50.94	1.57
DH2	7.10	1.33	49.81	1.41
P1DH2	8.21	1.31	50.57	1.55

Table 4: Effect of Tillage Treatments on Seed Weight, Seed Moisture Content, Head Diameter, and Stalk Diameter of Sunflower

Treatment	1000 Seed Weight (g)	Seed Moisture Content (%)	Head Diameter (cm)	Stalk Diameter (cm)
C2	45.8	8.52	36	4.73
P1C2	60.2	10.44	47	5.83
DH2	43.2	8.47	33	5.23
P1DH2	55.1	11.23	43	5.33

Table 5: Correlation Table: Soil Properties vs Yield and Emergence

Variable	Correlation with Seed Yield	P-value (Seed Yield)	Correlation with Seedling Emergence	P-value (Seedling Emergence)
Soil Moisture	0.948	0.052	0.989	0.011
Dry Bulk Density	–0.997	0.003	–0.913	0.087
Soil Porosity	0.997	0.003	0.915	0.085
Mean Weight Diameter	0.974	0.026	0.891	0.109

© 2025 et al. -Health And Research Insights-Open access under CC BY License (Creative Commons). Freely distributable with appropriate citation.

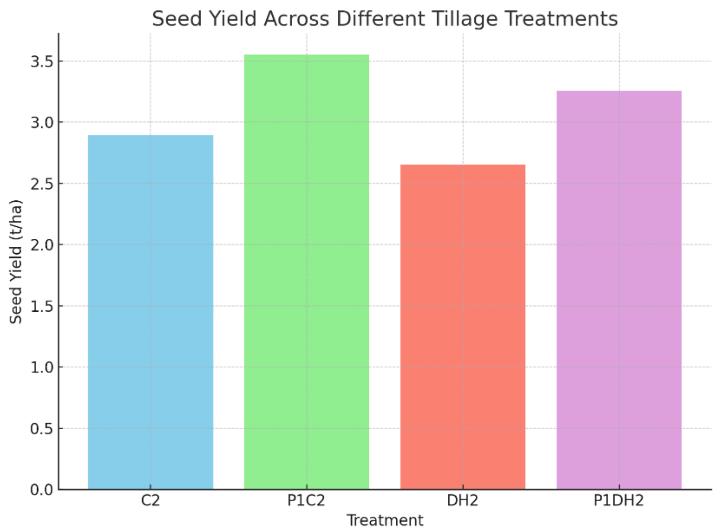

Figure 1 Seed Yield Across Different Tillage Treatments

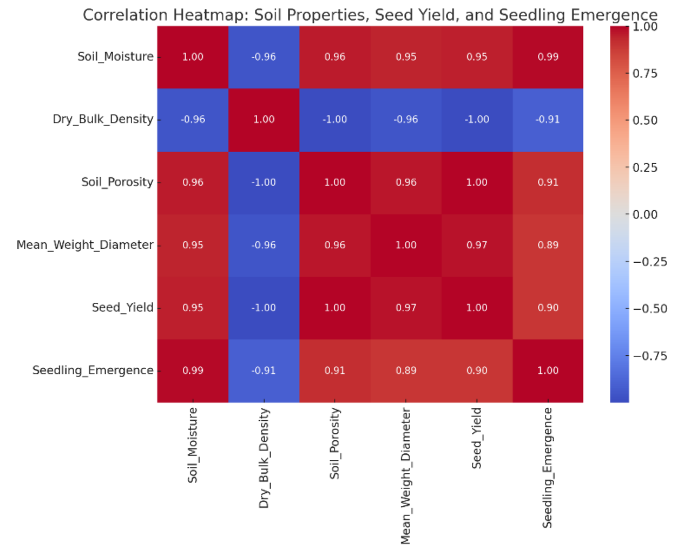

Figure 2 Correlation Heatmap: Soil Properties, Seed Yield, and Seeding Emergency

DISCUSSION

The present study demonstrated that the combination of punj hari followed by disk harrow (P1DH2) resulted in the highest field efficiency, while the cultivator two-pass system (C2) produced the lowest. These findings align with previous research, which concluded that disk harrow operations generally achieve higher field efficiency compared to cultivator-based systems in sandy clay loam soils, with efficiencies around 80.2% for disk harrow and 79.7% for cultivator-based tillage. Comparative investigations of disk harrow, rotavator, and cultivator operations also reported similar patterns of efficiency, attributing these differences to machine design, soil resistance, and operating speeds (15). However, some variations exist in the literature where tine cultivators performed better under specific soil and moisture conditions. These discrepancies underscore the influence of localized soil texture and moisture regimes on implement performance, highlighting a strength of the present study, which directly evaluated operational performance under silt loam conditions. The soil structure parameters were significantly influenced by the different tillage systems. Soil moisture content was notably highest under P1C2 and lowest under DH2 across all sampled depths. This outcome corroborates previous studies reporting that soil tilled with cultivators or deep cutting implements like moldboard plow retained greater moisture due to the enhanced infiltration and reduced surface evaporation (16). Increases in porosity were observed under all treatments, with the highest porosity recorded under P1C2. Similarly, dry bulk density was inversely affected, where P1C2 plots exhibited the lowest bulk density values, indicating improved soil aeration and root penetrability. Soil aggregation, measured through mean weight diameter, also improved most significantly under P1C2, suggesting better soil health and structural resilience. These findings align with existing literature noting that intensive soil disturbance under moldboard or chisel plowing improves aggregation and water retention (17,18). Nonetheless, a potential limitation of the present study is the lack of long-term monitoring, which would be necessary to assess the sustainability of these improvements over multiple cropping cycles.

Growth and yield parameters further emphasized the advantage of P1C2 treatment, which consistently produced superior outcomes in seedling emergence, plant height, head diameter, stalk diameter, 1000-seed weight, seed moisture content, and seed yield. These results are consistent with multiple experimental observations reporting that deep and effective tillage practices enhance soil physical properties, subsequently improving nutrient uptake, water retention, and root development, thereby promoting vigorous vegetative growth and higher yields (19). Furthermore, the positive correlation between soil physical improvements and growth metrics, especially seed yield and emergence, reinforces the critical role of appropriate tillage interventions in sunflower cultivation. Despite these promising results, the study was limited by the absence of detailed soil nutrient profiling, pest and disease surveillance, and climatic data during the growing period. These factors could have contributed to variations in plant growth and final yield but were not explicitly controlled or recorded. Future studies should incorporate comprehensive soil chemical analyses, pest pressure assessments, and microclimate monitoring to isolate the effects of tillage from other agronomic influences. Additionally, while the study utilized randomized complete

© 2025 et al. -Health And Research Insights-Open access under CC BY License (Creative Commons). Freely distributable with appropriate citation.

block design with replication, expanding the experimental duration across multiple seasons would strengthen the reliability and applicability of the conclusions to broader agronomic contexts.

An additional limitation pertains to the short-term evaluation of soil physical properties, without assessing their impact on soil organic matter dynamics or microbial health. Incorporating biological indicators alongside physical parameters would offer a more holistic understanding of soil quality changes due to tillage interventions. The correlation analyses performed between soil structure variables and crop performance offer valuable preliminary insights but warrant more extensive datasets to validate causative relationships. Overall, the findings suggest that employing a combination of punj hari followed by two passes of cultivator (P1C2) significantly enhances soil structure and maximizes the growth and yield of sunflower crops under silt loam conditions. This tillage strategy offers an agronomically superior alternative for sunflower growers aiming to optimize productivity (20). However, in cases where financial constraints limit implement availability, P1DH2 provides a viable, cost-effective option with reasonable improvements in field efficiency and crop outcomes. Future research should focus on multi-year trials, economic cost-benefit analysis of different tillage systems, and the development of site-specific tillage recommendations based on soil health indicators to further enhance sustainable sunflower production.

CONCLUSION

This study concluded that tillage implements exerted a significant influence on soil structure as well as on the growth and yield performance of the sunflower crop. Among the evaluated treatments, the combination of punj hari followed by two passes of cultivator demonstrated the most favorable improvements in soil physical properties, leading to enhanced plant emergence, growth, and final yield outcomes. Although the highest operational efficiency was observed under the punj hari and disk harrow combination, it was the cultivator-based system that most effectively optimized soil conditions for crop productivity. These findings highlight the critical role of appropriate tillage selection in maximizing sunflower production, offering practical guidance for farmers to adopt tillage practices that align soil preparation with crop requirements for sustainable agricultural success.

AUTHOR CONTRIBUTION

Author	**Contribution**
Shafique Ahmed Lakhan	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Barkat Ali Nindwani*	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Noreena Memon	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Ain Ul Abad Syed	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Nadir Ali Rajput	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Asif Ali Noonari	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published

REFERENCES

1. Sobko M, Zakharchenko E, Kolisnyk O, Medvid S, Kysylchuk A, Krokhin S, et al. Yield and energy efficiency of sunflower cultivation under different primary soil tillage methods. Modern Phytomorphology 2024 Vol 18, Issue 6 P 200-204 DOI: 105281/zenodo 200121 (105281/zenodo 2024-18-PDFNo). 2025.

2. Sobko M, Medvid S, Amons S, Zakharchenko E, Nechyporenko V, Masyk I, et al. Weed infestation of winter wheat in organic crop rotation and economic efficiency of its cultivation. Modern Phytomorphology 2023 Vol 17 Issue 5 P 127-131 DOI: 105281/zenodo 200121. 2023.
3. Safiollin F, Minnullin G, Suleymanov S, Loginov N, Trautz D, editors. Techniques for rational use of technical equipment in sunflower oilseeds production. BIO web of conferences; 2020: EDP Sciences.
4. Alkhalidy AA, Nasir AF, Hmoud MS. Studying the effect of a new tillage system on some yield attributes of sunflower crop (Helianthus annuus. L). International Journal of Health Sciences. 2020(I):8217-28.
5. Acquah K, Chen Y. Soil compaction from wheel traffic under three tillage systems. Agriculture. 2022;12(2):219.
6. Nardón GF, Botta GF, Aikins KA, Rivero D, Bienvenido F, Antille DL. Seeding system configuration effects on sunflower seedling emergence and yield under no-tillage. Soil Systems. 2021;5(4):72.
7. Kumar N, Upadhyay G, Choudhary S, Patel B, Naresh, Chhokar R, et al. Resource conserving mechanization technologies for dryland agriculture. Enhancing resilience of dryland agriculture under changing climate: Interdisciplinary and convergence approaches: Springer; 2023. p. 657-88.
8. Milyutkin V, Buxmann V, Meskhi B, Rudoy D, Olshevskaya A, editors. Innovative complex for in-soil fertilizer X TENDER+ CENIUS for Mini-Till technology. XIV International Scientific Conference “INTERAGROMASH 2021" Precision Agriculture and Agricultural Machinery Industry, Volume 1; 2021: Springer.
9. BSh K, SZh B, Tautenov I, Tokhetova L, Makhmadjanov S. Influence of tillage tools on agrophysical parameters of meadow-boggy soil and rice productivity in Kazakhstan. SABRAO J Breed Genet. 2023;55(6):2207-19.
10. Nenciu F, Oprescu MR, Biris S-S. Improve the constructive design of a Furrow Diking Rotor aimed at increasing water consumption efficiency in sunflower farming systems. Agriculture. 2022;12(6):846.
11. Failla S, Pirchio M, Sportelli M, Frasconi C, Fontanelli M, Raffaelli M, et al. Evolution of smart strategies and machines used for conservative management of herbaceous and horticultural crops in the mediterranean basin: A review. Agronomy. 2021;11(1):106.
12. Butnaru C-L, Țenu I. The evaluation of the induced soil compaction and the use of different agricultural equipment on some soil structural indicators and on the sunflower crop. 2022.
13. Orzech K, Wanic M, Załuski D. The effects of soil compaction and different tillage systems on the bulk density and moisture content of soil and the yields of winter oilseed rape and cereals. Agriculture. 2021;11(7):666.
14. Yankov P, Drumeva M. Effects of different main soil tillage methods on the vertical distribution of sunflower seeds in the soil layer and plant development. Yuzuncu Yıl University Journal of Agricultural Sciences. 2021;31(2):396-407.
15. Adalı M, Onder M. Effects of Different Frequencies and Potassium Doses on Yield and Yield Components in Seed Sunflower. Selcuk Journal of Agriculture and Food Sciences. 2021;35(3):218-27.
16. Sajid M, Amjid M, Munir H, Ahmad M, Zulfiqar U, Ali MF, et al. Comparative analysis of growth and physiological responses of sugarcane elite genotypes to water stress and sandy loam soils. Plants. 2023;12(15):2759.
17. Tiwari H, Pandey V, Babu R. Chapter-22 Basic Principles of Crop Production. Kaptan Baboo Syed Tazeen Zaidi Dr Manoj Kumar Mishra Prabhas Kumar Shukla. 2023;298.
18. Zhao J, Wang X, Lu Y, Wei Y, Guo M, Fu J. Biomimetic earthworm dynamic soil looser for improving soybean emergence rate in cold and arid regions. International Journal of Agricultural and Biological Engineering. 2021;14(3):22-31.
19. Tietje RW. Assessment of large vs. small-scale equipment platforms on soil structure and harvest efficiency in corn and soybean rotation cropping systems: The Ohio State University; 2021.
20. Kende Z, Egri N, Birkás M, Jolánkai M, Kunos V, Bozóki B, et al. Assessing Different Stubble Tillage Technologies on Covered and Uncovered Surfaces. Soil Systems. 2025;9(1):13.

© 2025 et al. -Health And Research Insights-Open access under CC BY License (Creative Commons). Freely distributable with appropriate citation.