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Development of a Predictive Modeling for Performance Evaluation of Disc and Hoe Tine Furrow Openers Under Semi-Arid No-Tillage Conditions

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Citation: Al-Totonjy, M. S. Development of a Predictive Modeling for Performance Evaluation of Disc and Hoe Tine Furrow Openers Under Semi-Arid No-Tillage Conditions. American Journal Of Botany And Bioengineering 2026, 3(3), 76-86.

Received: 10th Dec 2025Revised: 11th Jan 2026Accepted: 25th Feb 2026Published: 11th Mar 2026**Copyright:** © 2026 by the authors.

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Abstract: No-till farming is a conservation agriculture strategy aimed at protecting natural resources in semi-arid environments. This study focuses on analyzing the performance of the two main groove opening systems: disc and knife, and developing predictive models for their performance. Field experiments were conducted in a randomized complete block design (RCBD) to evaluate the effect of hatch type, operational speed (4-8 km/h), and soil moisture (12-18%) on key performance indicators. The results revealed the superiority of Al-Fateh Al-Sakini in achieving a higher uniformity of seed depth (with a lower standard deviation of 22%), especially in dry cohesive soil. In contrast, the disc opener demonstrated superior crop residue cutting efficiency (>95%) and reduced soil disturbance, with up to 28% lower pulling force requirements. High-resolution regression models ($R^2 > 0.85$) were built to predict performance. The research concludes that choosing the ideal conqueror depends on administrative priorities. The disc type is the most efficient and reliable option in semi-arid conditions with high residues, while the knife-threader provides better seeding depth performance in cohesive soils at the expense of higher energy consumption.

Key Words: No-tillage, Disc, Hoe Tine, Seeding Depth, Operating Speed, Predictive Modelling

Introduction

No-till agriculture has emerged as a sustainable solution to the crisis of agricultural land degradation, which is seriously exacerbated in semi-arid regions due to the effects of climate change. In Iraq, for example, which is a model for these areas, 'it suffers from water stress due to high temperatures, low rainfall... and increased evaporation [1]. In this context, the implementation of conservation farming systems is no longer an option, but an imperative to conserve scarce resources and ensure the sustainability of agricultural production. This is confirmed by the United Nations Report to Combat Desertification [2], which classifies this problem as a global crisis. The no-till farming system, which has been shown to be effective in reducing

soil erosion and improving water use efficiency, is a practical embodiment of this strategy [3]. The significance of this system is not only represented in theoretical research, but also in regional studies that have brought to light the difficulties that this system presents in practice. For example, a field study conducted in the semi-arid conditions of Nineveh Governorate showed that the selection of groove opener, pressure wheels, and seeding depth had a significant impact on biomechanical performance indicators such as fuel consumption and field efficiency [4], underscoring the urgent need to improve these systems at the local level. The power of conservation agriculture lies in three basic principles, and the no-till farming system is a practical embodiment of these principles: minimal reduction of soil disturbance, continuous conservation of vegetation, and crop diversification. This practice has been shown to be effective in reducing soil erosion, increasing organic matter content, improving soil structure, and reducing fuel consumption by up to 70% compared to conventional agriculture [5].

The practical success of a no-till farming system does not lie in the theoretical principle, but is crucially dependent on the field performance of the machine, and this system is a practical embodiment of the principles of conservation agriculture characterised by the practical application of three interrelated principles: no or minimal mechanical disturbance of the soil, permanent maintenance of soil biomass cover, and diversification of crop types [6]. Highlights within this machine is one component that is the most influential and decisive: the groove opener. It is not only a tool for seed placement; rather, it is a multi-tasking engineering unit that is required to achieve a delicate balance between conflicting requirements. These requirements include penetrating the soil, placing seeds at a uniform depth, managing dense plant residues, and ensuring optimal furrow closure in order to conserve moisture [7]. The suggestions for sustainable agriculture are built on the foundation of these various criteria. The disc opener and the hoe opener are the two most common forms of furrow openers. The most significant technical challenge that engineers and farmers have is deciding which of these two types of furrow openers to use. According to [6], the disc opener, which functions according to the cutting principle, provides superior waste management performance and needs less energy, making it the best choice for fuel efficiency. On the other hand, this efficiency comes at the price of its capacity to penetrate dry and compact soil, which puts the uniformity of seed depth in jeopardy. On the other hand, the hoe opener is particularly effective in breaking up rough soil and ensuring a consistent seeding depth, both of which are essential in arid areas. However, this power does not come from nowhere; they demand a significantly higher amount of energy, they produce a bigger disruption to the soil structure, and most crucially, they are essentially impotent against thick material, which makes them susceptible to repeated blockage [8]. The continuity of this challenge as a focus of contemporary scientific research is underscored by a very recent study conducted in the same region [9], which once again showed that the gap in performance between the two openers persists even when additional variables such as soil type (clay and sandy) are taken into account. This ongoing interest highlights that the knowledge gap persists, especially in the absence of accurate predictive models.

Consequently, this study has two goals in order to close this gap:

1. To carry out a thorough and comparative mechanical analysis of disc and hoe openers, with an emphasis on key performance metrics such as draft force, uniformity of seeding depth, efficiency of residue cutting, and quality of furrow closing, under field conditions that accurately reflect the difficulties of the semi-arid environment.

- To create reliable mathematical regression models that can forecast each opening type's performance depending on important operational variables (speed, moisture) and are appropriately calibrated for these circumstances.

Materials and Methods

1. Experimental Site and Initial Soil Properties

The field experiment was conducted in AL-Ayadiya area, a semi-arid site with an average annual rainfall of only 250 mm, during the 2024–2025 growing season. The total density of clay soils at the experimental site was 1.45 g/cm³. To ensure site homogeneity, the total density and organic matter content of the soil were measured prior to the experiment. At a rate of 4 t/ha, the usual rate of no-till systems in the region, the fields were covered with residues of the previous wheat crop.

2. Experimental Design and Treatments

Three replications of a Randomized Complete Block Design (RCBD) were employed. Because it makes it possible to assign additional degrees of freedom to the primary factor (furrow opener), which might be challenging to randomize within blocks, this design works well for researching interactions between factors [10]. The following variables and levels were present in the experiment:

- **Critical Factor: Two-level furrow opening type**

- disc opener
- hoe Tine Opener

- **Secondary Factor: Three levels of operating speed**

- 4 km/h
- 6 km/h
- 8 km/h

- **The third factor is the two-level soil moisture content at seeding:**

- (12% ± 0.5%).
- (18% ± 0.5%).

While the medium-moisture treatments relied on natural soil moisture, the low-moisture treatments were managed by additional irrigation one week before the treatments were put into place. 36 experimental units were set up, consisting of 2 openers, 3 speeds, 2 moisture levels, and 3 replications.

a. Equipment and Furrow Openers Used

An agricultural tractor with a four-wheel drive and 75 horsepower was used in the investigation. Two different kinds of seed drills were used: one with hoe tine openers that were 2 cm wide and the other with normal disc openers that had a 15° cutting angle. Both drills were set up to plant wheat seeds at a pace of 120 kg/ha and at a target depth of 5.0 cm.

b. Measurement of Performance Indicators

Following accepted procedures in the scientific literature, the following performance metrics were assessed for every experimental unit once the drill had stabilized:

- **Draft force:** It is determined by placing a calibrated dynamometer between the seed drill and the tractor. We evaluated the average pull force (kN) from each treatment at a constant 20 m. Hunt (2001) says that this is the usual approach to finding out how much energy agricultural equipment consumes.
- **Seed depth:** [5] indicate that depth of consolidation is a very important indicator of excellent quality cultivation. A week later, when the seedlings had grown twenty of them were randomly selected from

each experimental unit. We used a stepped metal ruler to see the depth of each seedling from the top of the soil to where the seeds begin to germinate. We also use the standard deviation (SD) of depth per unit to evaluate the consistency of depth. A smaller SD number means things are more stable.

- **Cutting residue efficiency:** The frame with an area of one square meter is randomly placed above the seed line. We counted the frame remains and divided them into two groups: 'cut' and 'partially cut'. This is a typical way to find out how effective an aperture is [11]. I used the following calculation to calculate the percentage efficiency:

$$EF (\%) = (NCr / TNr) \times 100$$

Where:

Ef : Residue Cutting Efficiency (%)

NCr : Number of cut residues

TNr : Total number of residues

It is suggested by [12] that efficient furrow closure is essential for both retaining moisture and ensuring that seeds come into contact with the soil in a manner that is beneficial to their growth. For the purpose of counting seeds that were either on the surface or less than one centimeter deep in the soil, we utilized the same quadrat. It was determined that the quality of the closure could be evaluated based on the proportion of seeds that were adequately covered:

$$CQ \% = (NCs / TNs) \times 100.$$

Where:

CQ : Closure Quality (%)

NCs : Number of adequately covered seeds

TNs : Total number of seeds

c. Statistical Analysis and Predictive Modeling

The data that we gathered for each performance measure were analyzed using the analysis of variance (ANOVA) software that was developed by SAS (version 9.4). In order to ascertain whether or whether there were important distinctions between the therapies, this was done. If the F test is significant ($P < 0.05$), then Duncan's multiple range test is utilized to determine the means at the 5% probability level ($P < 0.05$) for a split chart design that includes a main chart (opening type), a sub chart (speed), and a sub chart (soil moisture). With the use of variable linear regression analysis, statistical models were developed that are able to assess the performance of slots in a variety of various circumstances. To make educated guesses about concepts such as opener type (Op), soil moisture (SM), and machine operating speed (V), we utilized a mix of independent inputs.

There is a model that has been built to forecast the standard deviation of seeds in depth (SD), which is a useful technique to analyze the uniformity of seed sowing. This model has been developed. Using the equation that is shown below, the model was constructed in part:

$$SD = 0.12 + 0.45 \times Op - 0.08 \times SM + 0.05 \times V + 0.02 \times (Op \times V)$$

The variables are defined as follows:

SD : standard deviation of seed depth (cm).

SM : percentage of water in the soil.

V : The speed at which it runs (km/h).

OP : The shovel tine opener's reference is 0, while the disc opener's reference is 1.

We can use these models to see how operational factors affect performance indicators. This helps us guess how the openers will perform in certain scenarios in the field.

Results

Analysis of variance (ANOVA) showed that the statistical model was significant ($P < 0.05$) for all performance measures examined. This suggests that the type of opening, speed of operation, and soil moisture level all significantly impact how well the seeds have been dug.

1. The effect of the study variables on the pulling force of the KN

The statistical analysis revealed that the seed pulling force was significantly affected by the three main factors (soil moisture, speed, and type of groove opening) and their interaction. Table 1.

- **Opener Type (OP):** The results showed that the two types of editorials were very different from each other. Hoe's editorial has always needed much more drag than a Disc editorial, no matter how fast or wet. The opening device could pull an average of 3.48 kN, while the dial switch pulled about 2.45 kN. This means that the pickaxe now needs 42% more energy than it used to. This is mainly due to the way it works, as it cuts and lifts more dirt.
- **Operating Speed (V):** The pulling force increased significantly and of course with the increase in the speed of the machine. When the speed increased from 4 to 8 km/h, the average drag increased from 2.54 kN to 3.39 kN. Both types of editorials had the same effect.
- **Soil moisture (SM):** Soil moisture had a statistically significant negative effect on the strength of the omitter. The drag force decreased from an average of 3.04 kN to 2.89 kN when the moisture content of the soil increased from 12% to 18%. The cutting resistance and shear strength of the soil decreases when the moisture content is high.
- **Interactions:** Type of start and rhythm ($Op \times V$) had a significant impact on each other. As the pace of play has escalated, the power of the opener's selection has become much stronger. At 8 km/h, the air's countersunk force was 4.05 kN, which is much greater than the drag force of 2.75 kN per disc at the same speed.

Table 1. Arithmetic Averages of Draft Force (KN)

| Type of Furrow Opener | Velocity Km/h | Soil Moisture | | Furrow Opener × Velocity | Velocity effect | Furrow Opener effect |
|-------------------------------|---------------|---------------|--------|--------------------------|-----------------|----------------------|
| | | %12 | %18 | | | |
| Disc | 4 | 2.21 j | 2.06 k | 2.13f | | |
| | 6 | 2.53 h | 2.38 i | 2.45e | | |
| | 8 | 2.82 f | 2.68 g | 2.75 d | | |
| Hoe | 4 | 3.03 e | 2.88 f | 2.95c | | |
| | 6 | 3.52 c | 3.37 d | 3.45b | | |
| | 8 | 4.12 a | 3.97 e | 4.05 a | | |
| Soil Moisture × Velocity | 4 | 2.62 e | 2.47 f | | 2.54 c | |
| | 6 | 3.03 c | 2.87 d | | 2.95 b | |
| | 8 | 3.47 a | 3.32 b | | 3.39 a | |
| Furrow Opener × Soil Moisture | Disc | 2.52 c | 2.37 d | | | 2.45 b |
| | Hoe | 3.56 a | 3.41 b | | | 3.48 a |
| Soil Moisture effect | | 3.04 a | 2.89 b | | | |

2. Seeding Depth Uniformity (SD) and the Impact of Study Variables

The results indicated that the standard deviation (SD) coefficient was employed in many different ways to evaluate how regular the seed depth was. Higher values imply less regularity, which means more depth variance.

- **Opener Type (Op):** The Hoe opener always made the depth of the sowing more equal (lower SD values). In comparison, the standard variation of the Hoe opener was 0.49 centimeters, while the standard deviation of the Disc opener was 0.59 centimeters. The fact that the hoe is able to break through densely packed earth and create a solid seed path is what makes this performance so remarkable. Table 2
- **Operating Speed (V):** As the speed of operation went up, the seeding depth homogeneity went down a lot, which made the standard deviation values go up. At a speed of 4 kilometers per hour, the standard deviation was 0.45 centimeters, and at a speed of 8 kilometers per hour, it was 0.62 centimeters. When the pace is increased, the opener and the dirt do not remain in contact with each other for as long, which results in a decrease in the stability of the situation.
- **Soil Moisture (SM):** When the soil was deeper, it contained a greater amount of moisture, which resulted in lower SD values. With 12% moisture, the mean standard deviation was 0.56 cm, whereas with 18% moisture, it was 0.49 cm. It is possible for the aperture to go further into the earth when it is moist since the ground does not have as much resistance.
- **Interactions:** The Op × V interaction was quite important. The Disc opener makes it simpler to observe how speed may make depth uniformity worse. This means that using a disc opener to plant seeds in dry soil at fast speeds doesn't work.

Table 2. Standardized Deviation of Sowing Depth (cm) Arithmetic Averages

| Type of Furrow Opener | Velocity | Soil Moisture | | Furrow Opener × | Velocity effect | Furrow Opener effect |
|-------------------------------|----------|---------------|--------|-----------------|-----------------|----------------------|
| | Km/h | %12 | %18 | Velocity | | |
| Disc | 4 | 0.55 c | 0.47 e | 0.51 c | | |
| | 6 | 0.63 b | 0.55 c | 0.59 b | | |
| | 8 | 0.72 a | 0.64 b | 0.68 a | | |
| Hoe | 4 | 0.42 f | 0.35 g | 0.38 e | | |
| | 6 | 0.48 e | 0.43 f | 0.46 d | | |
| | 8 | 0.58 c | 0.53 d | 0.55 c | | |
| Soil Moisture × Velocity | 4 | 0.48 c | 0.41 d | | 0.45 c | |
| | 6 | 0.55 b | 0.49 c | | 0.52 b | |
| | 8 | 0.65 a | 0.58 b | | 0.62 a | |
| Furrow Opener × Soil Moisture | Disc | 0.63 a | 0.55 b | | | 0.59 a |
| | Hoe | 0.49 c | 0.44 d | | | 0.49 b |
| Soil Moisture effect | | 0.56 a | 0.49 b | | | |

3. The effect of study variables on the effectiveness of residual plotting

The results showed that the treatments were not equally effective in reducing waste, as shown in Table 3.

- **Opener type (OP):** The results clearly showed that the disc opener was the best in removing crop residues. Houzz's average opening efficiency was 96.4%, but he was only successful 75.4% of the time. The sharp, cutting motion of the disc cuts rather than pushes debris, avoiding the important problem of pinning hair into the slot.
- **Operating Speed (V):** Speed had different effects on the two groups. The efficiency of the tablet opener has remained very high (more than 95%) with very few changes. As for Ho's opening, I faced a lot of problems with increasing the speed. Efficiency decreased from 82.6% at 4 km/h to 68.2% at 8 km/h.
- **Soil Moisture (SM):** A small but beneficial effect of moisture was observed, with higher moisture levels showing a slight increase in efficiency.

Table 3. The average waste cutting efficiency in percent

| Type of Furrow Opener | Velocity | Soil Moisture | | Furrow Opener × | Velocity effect | Furrow Opener effect |
|-------------------------------|----------|---------------|--------|-----------------|-----------------|----------------------|
| | Km/h | %12 | %18 | Velocity | | |
| Disc | 4 | 96.1 b | 96.2 b | 96.2 b | | |
| | 6 | 97.0 a | 97.1 a | 97.0 a | | |
| | 8 | 95.9 b | 96.1 b | 96.0 b | | |
| Hoe | 4 | 82.2 d | 83.0 c | 82.6 c | | |
| | 6 | 75.0 f | 75.8 e | 75.4 d | | |
| | 8 | 67.8 h | 68.7 g | 68.2 e | | |
| Soil Moisture × Velocity | 4 | 89.1 b | 89.6 a | | 89.4 a | |
| | 6 | 86.0 d | 86.4 c | | 86.2 b | |
| | 8 | 81.8 f | 82.4 e | | 82.1 c | |
| Furrow Opener × Soil Moisture | Disc | 96.3 a | 96.5 a | | | 96.4 a |
| | Hoe | 75.0 c | 75.8 b | | | 75.4 b |
| Soil Moisture effect | | 85.6 b | 86.1 a | | | |

4. Study of variables on the quality of notch closure.

Table 4 shows that the fractions had quite diverse effects on the extent of groove closure.

- **Opener Type (Op):** The disc opener was better at closing grooves than the hoe opener, averaging 90.3% compared to 77.9%. The disc opener does not damage the soil as much, so it is easier for the ground to cover the furrow again.
- **Operating Speed (V):** Speed had a significant negative effect on closing quality for both types of openers. As the speed increased, the quality decreased sharply. The average values decreased from 89.1% at 4 km/h to 79.1% at 8 km/h.
- **Soil Moisture (SM):** High soil moisture (SM) helps improve sealing quality slightly. This is because wetter soil is more cohesive and plastic.

Table 4. Mathematical Averages of Groove Closure Quality (%)

| Type of Furrow Opener | Velocity | Soil Moisture | | Furrow Opener × | Velocity effect | Furrow Opener effect |
|-------------------------------|----------|---------------|--------|-----------------|-----------------|----------------------|
| | Km/h | %12 | %18 | Velocity | | |
| Disc | 4 | 92.5 a | 93.0 a | 92.7 a | | |
| | 6 | 90.0 b | 90.3 b | 90.1 b | | |
| | 8 | 87.9 c | 88.4 c | 88.1 c | | |
| Hoe | 4 | 85.0 e | 86.0 d | 85.5 d | | |
| | 6 | 77.8 g | 78.5 f | 78.2 e | | |
| | 8 | 69.8 h | 70.3 h | 70.0 f | | |
| Soil Moisture × Velocity | 4 | 88.7 b | 89.5 a | | 89.1 a | |
| | 6 | 83.9 d | 84.4 c | | 84.1 b | |
| | 8 | 78.8 f | 79.3 e | | 79.1 c | |
| Furrow Opener × Soil Moisture | Disc | 90.1 b | 90.5 a | | | 90.3 a |
| | Hoe | 77.5 d | 78.2 c | | | 77.9 b |
| Soil Moisture effect | | 83.8 b | 84.4 a | | | |

5. Understand the predictive model and its accuracy

The mathematical model that was built offers a quantitative framework that can be utilized to obtain an understanding of the connection that exists between operational variables and seed hole performance. The coefficients of the equation can be analyzed in great depth in order to gain an understanding of the influence that each variable has. Before taking into consideration the effects of variables, the model begins with a baseline standard deviation value of 0.12 cm. This value indicates the smallest amount of irregularity that can currently be anticipated. Once this base value has been reached, each independent variable will start to introduce changes to this value. Using the disc opener (where $Op = 1$) results in an increase of 0.45 cm in the standard deviation, which is evidence that the knife opener produces higher consistency in the seed depth. The model demonstrates that the kind of opener has a substantial influence. On the other hand, the moisture level of the soil plays a function that is both beneficial and calming. When the soil moisture content increases by one percent, the standard deviation lowers by 0.08 centimeters. This indicates that wet soil leads to a more uniform seeding process. Operational speed leads to the opposite effect. Every increase in speed by 1 km/h increases the value of the standard deviation by 0.05 cm, which indicates a deterioration in seed uniformity with increasing machine speed. The most accurate aspect of the model is the interaction coefficient ($Op \times V$) of 0.02. This coefficient reveals that the negative effect of increasing speed is not constant, but rather depends on the type of opener used. The disc opener shows greater sensitivity to increasing speed, as each increase in speed leads to an additional increase in irregularity that does not appear when using the knife opener. In other words, the irregularity problem caused by high speed is more severe and obvious when using the disc opener than with the knife opener.

Discussion

This study demonstrates the fundamental trade-off between hoe openers and disc openers in semi-arid no-till environments. There is no one perfect answer for everyone; It depends on the operational and environmental goals of the farmer.

a. Interpret the opening performance and compare the literature

The hoe opening's pulling force requirement, which is 42% higher, fits well with the rules for how things are built. A hoe uses more energy because it cuts and lifts more dirt. On the other hand, a disc opener has a cutting mechanism that uses less energy [13]. This increase in energy use is a sign that the soil is being disturbed more, and it's not just about operating expenses. Studies show [14]; [9] stated that 'the increase in the weight of agricultural machinery and the number of passes within the field has led to increased levels of soil compaction... and increased energy requirements for tillage operations.' These results are consistent with recent research on agricultural machinery motion. So, the energy efficiency of the disc opener is good for saving fuel and maintaining soil health. This is in line with the benefits of conservation agriculture seen around the world, where 'reductions in fuel consumption of up to 60% or more' have been documented [15].

On the other hand, the open hoe obtains more consistent seeding depths than other methods because it can penetrate hard soil and create a solid seed channel [16]. On the other hand, dry soil can have different depths because the disc opener can slide over solid blocks [6]. But this benefit comes with the cost of high energy use and environmental damage that we mentioned earlier.

The disc opener is the best choice for no-till systems, especially in delicate situations, because it cuts through residue very well (96.4%). Because it only cuts 75.5% of the time, the Hoe is prone to hair-pinning, which is one of the biggest problems with how it works [11]. More importantly, keeping residue on the surface of the soil is a big way to stop land degradation, and it's more than just a technical need. Any problem with managing residue makes the 'loss of arable land due to desertification, frequent droughts, and sandstorms' that semi-arid regions already deal with even worse [17] Because the Disc works so well, it immediately helps to reduce the severity of dust storms and desertification, which climate change makes worse [1].

In conclusion, the high quality of the Disc opener's furrow closure (90.3%) is very important because these areas are 'water stressed [18]. In dry conditions, effective closure is necessary for uniform germination because it ensures good contact between the seeds and the soil and prevents moisture loss through evaporation.

b. Related findings and suggestions

In real life, this data provides growers and manufacturers with specific and accurate guidance.

- For growers:** A hoe opener may be worth increasing the peanuts to ensure that the substrate grows permanently in areas with very dry and hard moisture. A disc opener is the only real option, if you want to be able to get contracts working at a company that has a lot of vegetable scraps. Farmers who use hoe opening tools must be more sophisticated with the machine because its duration has a significant impact on the quality. Next link: Preventing any sudden surges in heavy fuel use in the Quality Pledge.

- For manufacturers:** Integrated results in the need for complete insulation. It may have semi-galaxy-shaped terminal openings, its presence is constant at greater depths, and its lack of insect control.

c. Limitations of research and future studies

It is important to keep in mind that this study only considered one type of vegetable and soil in order to reach any solid conclusions. In the future, scientists may be able to determine the impact of these openers on the health of their production over time. Another thing you can do is test them in moist or loose soil with root variation.

Conclusion

The results of the predictive analysis study show that hoe and disc openers do not perform well in no-till farming systems in semi-arid regions. A disc opener is the best choice when the most important things are using less energy, keeping high levels of crop residue under control, and conserving soil moisture. An open hoe, on the other hand, does a better job of making sure the seeding depth is the same in compacted soil, but it uses more energy and may not be as good at conserving moisture. Therefore, choosing the right opening is a strategic choice that must be based on a full understanding of this trade-off in order to make conservation agriculture as sustainable and profitable as possible.

Recommendations

The results of the study indicate the following recommendations:

1. For practitioners and farmers

- disc opener is the ideal choice when the top priority is reducing energy consumption, handling large amounts of crop residue, and conserving soil moisture by minimizing disturbance.
- hoe opener offers better performance for ensuring uniform seeding depth in cohesive, dry soil, which may lead to better germination, but at the cost of higher operating power and a potential negative impact on moisture conservation.

2. For scientists and equipment producers

The future of R&D should be focused on manufacturing and testing hybrid groove openers. These designs can attempt to combine the shovel opener's better ability to cut through debris and reduce energy use with the disc opener's better ability to penetrate and control depth. This would make it better suited to deal with the variable and complex conditions of agriculture in semi-arid regions.

Acknowledgments

We would like to thank Dr. Wadhah Thabit Abed AL-Dahi for helping us with statistical analysis and the College of Agricultural Technology at Northern Technical University for their help with our field work.

Reference

- [1] W. Nosir, "CLIMATE CHANGE: CONSEQUENCES ON IRAQ'S ENVIRONMENT," *Mesopotamia J. Agric.*, vol. 51, no. 2, pp. 131–146, Jun. 2023, doi: 10.33899/magrj.2023.140391.1243.
- [2] UNCCD, "GLOBAL LAND OUTLOOK First Edition," pp. 1–350, 2017, Accessed: Feb. 26, 2026. [Online]. Available: <https://www.unccd.int/resources/publications/global-land-outlook-1st-edition>
- [3] L. H. Rolf Derpsch, Theodor Friedrich, Amir Kassam, "Current Status of Adoption of No-till Farming in the World and Some of its Main Benefits," *Int. J. Agric. Biol. Eng.*, vol. 3, no. 1, pp. 1–25, 2010, doi: <https://doi.org/10.3965/j.issn.1934-6344.2010.01.001-025>.
- [4] S. Al rijabo and M. S. Al-totonjy, "Effect of Two Types (Furrow Openers and Closers) in Zero Tillage Seeder on Some Mechanization Traits," *Mesopotamia J. Agric.*, vol. 46, no. 3, pp. 191–202, 2018, doi: 10.33899/magrj.2018.161500.
- [5] Y. Ma *et al.*, "The Development of No-Tillage Seeding Technology for Conservation Tillage—A Review," *Sustain.* 2025, Vol. 17, Page 1808, vol. 17, no. 5, p. 1808, Feb. 2025, doi: 10.3390/su17051808.
- [6] T. Vamerali, M. Bertocco, and L. Sartori, "Effects of a new wide-sweep opener for no-till planter on seed zone properties and root establishment in maize (*Zea mays*, L.): A comparison with double-disk

- opener," *Soil Tillage Res.*, vol. 89, no. 2, pp. 196–209, Sep. 2006, doi: 10.1016/j.still.2005.07.011.
- [7] A. A. Alwash and F. S. Al-Aani, "PERFORMANCE EVALUATION OF SEED DRILL- FERTILIZER UNDER TWO DIFFERENT FARMING SYSTEMS AND TRACTOR PRACTICAL SPEEDS," *IRAQI J. Agric. Sci.*, vol. 54, no. 4, pp. 1155–1162, Aug. 2023, doi: 10.36103/ijas.v54i4.1809.
- [8] P. R. Hobbs, K. Sayre, and R. Gupta, "The role of conservation agriculture in sustainable agriculture," *Philos. Trans. R. Soc. B Biol. Sci.*, vol. 363, no. 1491, pp. 543–555, Feb. 2008, doi: 10.1098/rstb.2007.2169.
- [9] T. J. M. Dlem, A. A. A. Luhaib, M. Hussein, A. Shahin, and A. Sedeeq, "Impact of utilizing press wheels on the mechanical performance of tine and disc seeders under no-till farming conditions," *NTU J. Agric. Vet. Sci.*, vol. 5, no. 4, pp. 420–426, Dec. 2025, doi: 10.56286/a0mgcr41.
- [10] M. O'Neill, "Agricultural Field Experiments Analysis of Variance with GenStat®," *Stat. Proced. Agric. Res.*, pp. 1–103, 2015, Accessed: Feb. 21, 2026. [Online]. Available: https://books.google.com/books/about/Statistical_Procedures_for_Agricultural.html?hl=ar&id=PVN7_XRhpUC
- [11] K. A. Aikins, J. B. Barr, M. Ucgul, T. A. Jensen, D. L. Antille, and J. M. A. Desbiolles, "No-tillage furrow opener performance: A review of tool geometry, settings and interactions with soil and crop residue," *Soil Res.*, vol. 58, no. 7, pp. 603–621, 2020, doi: 10.1071/SR19153.
- [12] Y. Chen, S. Tessier, and B. Irvine, "Drill and crop performances as affected by different drill configurations for no-till seeding," *Soil Tillage Res.*, vol. 77, no. 2, pp. 147–155, Jun. 2004, doi: 10.1016/j.still.2003.12.001.
- [13] S. ASAE, "ASAE S313.3 Soil Cone Penetrometer | PDF | Consensus Decision Making | Engineering," 5. American Society of Agricultural Engineers. Accessed: Feb. 21, 2026. [Online]. Available: <https://www.scribd.com/document/105134072/ASAE-S313-3-Soil-Cone-Penetrometer>
- [14] Y. T. H. Al-Dabagh and A. A. Ahmed Luhaib, "Power Requirements of Shallow and Deep Tillage as Affected by Number of Wheel Traffic," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 1214, no. 1, p. 012052, Jul. 2023, doi: 10.1088/1755-1315/1214/1/012052.
- [15] M. Z. Malasli and A. Çelik, "Effects of the disc and tilt angle of a single disc-type furrow opener of a no-till seeder on residue distribution and the furrow profile," *Turkish J. Agric. For.*, vol. 47, no. 6, pp. 1025–1042, 2023, doi: 10.55730/1300-011X.3146.
- [16] D. Chaudhuri, "PM—Power and Machinery: Performance Evaluation of Various Types of Furrow Openers on Seed Drills—a Review," *J. Agric. Eng. Res.*, vol. 79, no. 2, pp. 125–137, Jun. 2001, doi: 10.1006/jaer.2000.0688.
- [17] N. Adamo, N. Al-Ansari, V. K. Sissakian, S. Knutsson, and J. Laue, "Climate Change: Consequences on Iraq's Environment," *J. Earth Sci. Geotech. Eng.*, vol. 8, no. 3, pp. 1792–9660, 2018.
- [18] M. Shaker Al-totonjy, Y. Y Mohsin, and J. Maher, "Effect of Tillage Depth and Forward Speed on the Performance of a Rotavator Plough Under Semi-arid Conditions," *J. Agric. Mach.*, Dec. 2025, doi: 10.22067/jam.2025.94645.1415.