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# Comparison of disc seeder performances under zero and minimum tillage systems

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## I. Abstract:

A field experiment was conducted in Bashiqa District, Nineveh Governorate, during the season of 2024–2025 to compare the performance of the disc seeder in two farming systems: Zero-Tillage and Minimum Tillage, under heavy clay soil (H.C.S.) and light sandy soil (L.S.S.). Both fields were planted with wheat in the previous season using conservation agricultural practices. The study assessed the impact of these factors on draft force, which represents the tractor's energy requirements, as well as their effect on crop components such as thousand-grain weight (TGW), number of spikes, Grain Number per spike, and total grain yield. The results showed that minimum tillage resulted in the lowest draft force at (7.20 kN), while zero-till resulted in the highest values for Grain Number per spike (33.5 grains.spike$^{-1}$), Spike Number per m-2 (336 spike.m$^{-2}$), and total grain yield (3674 kg.ha$^{-1}$). The light sandy soil (L.S.S.) reported lower values of draft force (9.02 kN). In contrast, the heavy clay soil (H.C.S.) reported higher values in Grain Number per spike (33.5 grain.spike$^{-1}$), Spike Number per m$^2$ (308.5 spike.m$^{-2}$), TGW (33.5 g), and grain yield (3475.5 kg.ha$^{-1}$). Which therefore, using conservational agriculture technique under heavy soil is more productive than utilizing this system in a light soils.

***Keywords :*** *Conservation Agriculture, Disc Seeder, Wheat, Heavy Soil, Light Soil.*

## II. Introduction:

Conservation Agriculture is considered one of the modern approaches in sustainable management of agricultural resources. It is based on three main principles: reducing soil disturbance, keeping crop residues on the soil surface, and diversifying crop rotations (FAO, 2023). This system aims to improve the physical, chemical, and biological properties of the soil, reduce soil erosion, and decrease fuel and energy consumption compared with conventional agriculture, which depends on intensive and repeated tillage. Many studies have indicated that reducing tillage operations can increase soil organic matter, improve moisture retention, and reduce production costs in the long term (Khan et al., 2023).

The disc seeder is one of the most important machines used in conservation agriculture systems because it can open a narrow furrow in the soil and place seeds at a uniform depth with minimum disturbance to the soil surface. There is increasing interest in studying its performance under Zero-Tillage and Minimum Farming approaches, because soil resistance and crop residues can affect mechanical performance indicators such as draft force, fuel consumption, seeding depth uniformity, and germination percentage (Sugirbay et al., 2023). Research published in Mesopotamia Journal of Agriculture also showed significant differences in some growth and yield traits when reduced farming approaches were applied compared with conventional tillage (Antar et al., 2025).

The mechanical requirements of the disc seeder vary depending on the farming approach used. Studies indicate that draft force and fuel consumption are usually higher in the zero-till system because of higher soil resistance and the presence of crop residues on the soil surface, compared with the Minimum Tillage system which provides partial soil loosening and reduces penetration resistance (Sugirbay et al., 2023). The farming approach also directly and indirectly affects yield components, which include Spike Number per m-2, Grain Number per spike, thousand-grain weight, and total grain yield. In the Zero-

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Tillage system, maintaining crop residues and reducing soil disturbance can improve soil moisture storage and increase organic matter over time. This may positively affect plant density and increase the Spike Number per m-2 when proper seeding management is used (FAO, 2023). However, poor seed penetration in heavy soils may reduce plant density if the seeding machine is not suitable (Zhang et al., 2022).

In the minimum tillage system, shallow soil disturbance improves seed–soil contact and helps more uniform germination, which may increase the Spike Number per m-2 during the first seasons compared with Zero-Tillage, especially in compact soils (Zhang et al., 2022). Regarding the Grain Number per spike, studies have shown that reduced tillage systems such as zero-till and minimum tillage can improve root environment and maintain soil moisture during critical growth stages, which supports grain formation in the spike. However, the effect may vary depending on climate conditions and soil type (Khan et al., 2023).

The thousand-grain weight is related to the grain filling stage and the availability of water and nutrients. Some studies have shown that the zero-till system can maintain soil moisture during dry periods, which helps improve grain weight in dry environments. In contrast, the difference may not be significant in humid environments or under well-managed Minimum Tillage (Zhang et al., 2022). Finally, the combined effect of these yield components influences the total grain yield. Scientific reviews indicate that the differences between zero-Till and minimum tillage in yield may be small or not significant in the short term, but they tend to favor zero-till in the long term due to improved soil properties and sustainability (FAO, 2023; Khan et al., 2023). Therefore, selecting the most suitable system depends on soil type, climate conditions, and the efficiency of the seeding machine used.

The objective of this study is to determine the efficiency of the conservation agriculture system using a disc seeder in improving agricultural productivity and reducing energy requirements compared with conventional agriculture, in order to achieve productive, economic, and environmental sustainability.

## III. Materials and Methods:

The experiment took place during the 2024–2025 winter season in Bashiqa District, located approximately 12 km northeast of Mosul. The total field area used in the experiment was 2 hectares. The field had a flat topography and the soil moisture content was 15%. The experiment was carried out using two tractors of the Massey Ferguson 285S model. One tractor supplied the traction power necessary to pull the seeder, while the other tractor was used solely to control the lifting and lowering of the machine with the transmission kept in neutral. In this study, a disc seeder was used. The capacity of the seed and fertilizer tank was 500 kg each. The effective working width of the machine was 3 m, the number of discs was 20 discs, and the distance between planting rows was ≈15 cm. Two farming approaches were used: Zero-till and Minimum Tillage, and two soil types were studied: heavy clay soil (H.C.S.) and light sandy soil (L.S.S.). A mechanical spring dynamometer (DILLON) was used to measure draft force. The experiment was statistically designed utilizing a Factorial Experimental Design within a Randomized Complete Block Design (RCBD) according to Dawood and Elias (1990). The two tillage regimes were applied in each experimental site (soil type), with three replications for each treatment, resulting in 12 experimental units. The length of each treatment in each replicate measured 30 meters. To evaluate differences among means, Duncan's Multiple Range Test was employed at a significance level of 0.05.

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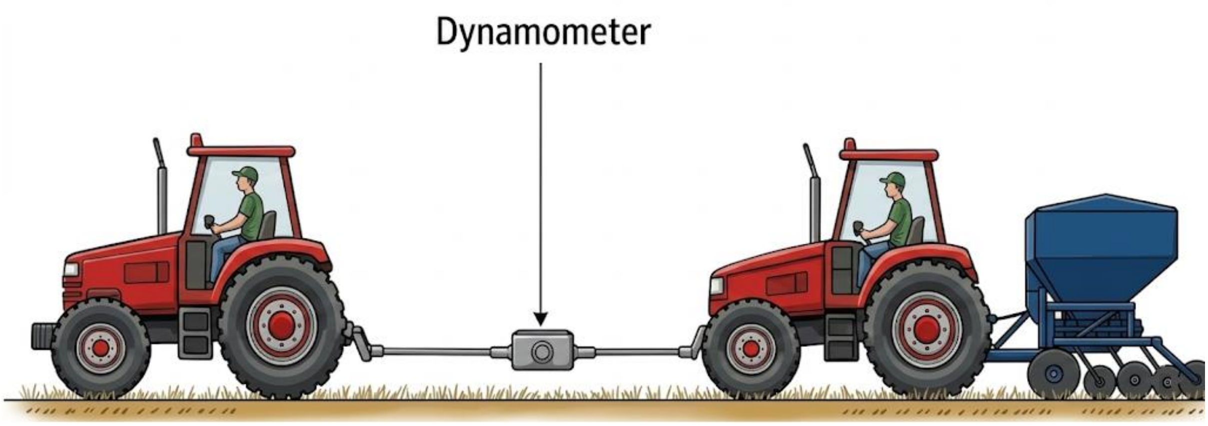


**Figure 1. How the draft force was measured using dynamometer**

**Studied Indicators:**

1. **Draft Force (kN)**
Draft force is defined as the horizontal force generated by the tractor to pull and move the load across the soil surface. It is measured in kN. The draft force value was obtained using a dynamometer and then calculated using the following equation (Hamid, 2023):

$$F_1 = F_{pm} - F_{rm}$$

Where:
$F_1$ = required draft force (kN)
$F_{pm}$ = pushing force of the rear wheels of the front tractor (kN)
$F_{rm}$ = rolling resistance of the rear tractor wheels (kN)

2. **Grain Yield (kg ha$^{-2}$)**
Grain yield was estimated by collecting all the ears of grain within a one-square-meter area sown using the disc seeder. After being transported to the laboratory, the ears were threshed, the grains were cleaned of impurities, and then weighed. The yield was expressed in gm m$^{-2}$ and then converted to kg ha$^{-1}$.

3. **Thousand Grain Weight (gm)**
This was determined using clean, impurity-free grains. A seed counter was used to count thousand grains, which were then weighed to obtain their weight in grams.

4. **Number of Spikes per m$^2$**
The Spike Number per m$^2$ was calculated randomly from each experimental unit at the time the plants reached maturity.

5. **Grain Number per Spike**
This was estimated by calculating the average Grain Number in ten spikes randomly selected from each experimental unit within the experiment.

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**Table 1. Temperature and rainfall during the winter season of 2024–2025 in Bashiqa Sub district (data obtained from the Meteorological Office in Nineveh).**

| Month | Rainfall (mm) | Min. Temperature (°C) | Max. Temperature (°C) |
|---|---|---|---|
| November 2024 | 46 | 9 | 20 |
| December 2024 | 71 | 5 | 14 |
| January 2025 | 69 | 3 | 12 |
| February 2025 | 74 | 5 | 15 |
| March 2025 | 80 | 8 | 20 |
| April 2025 | 68 | 13 | 26 |
| May 2025 | 27 | 18 | 33 |
| **Total Rainfall during the season** | 435 | | |

## IV. Results and Discussion

It is clear from Table 2 that there are significant differences between the factors for draft force. Minimum Tillage reported the lowest draft force of 7.20 kN, while Zero-till reported a higher draft force of 12.01 kN. This is because in Minimum Tillage, the soil is previously tilled, which reduces soil resistance.
There was also a significant effect of soil type on draft force. Where, H.C.S. reported the highest draft force (10.20 kN), while L.S.S. reported a lower draft force (9.02 kN). This is due to the higher bulk density and cohesion between fine soil particles in clay soil (Hamza & Anderson, 2005).
With regard to the interaction between tillage type and soil type, significant differences were observed. Zero-till in H.C.S. reported the highest draft force (12.75 kN), followed by L.S.S. under the same farming approach (11.27 kN). The lowest draft force was reported for L.S.S. with minimum tillage (6.76 kN), which was not significantly different from H.C.S. under minimum tillage (7.65 kN). The higher draft force under zero-till is due to the soil not being previously loosened, which increases soil resistance against the disc seeder penetration, especially in clay soils with high cohesion (Lal, 2015).

**Table 2. Influence of the investigated factors on draft force (kN)***

| Farming approach | Soil Type | | Farming approach |
|---|---|---|---|
| | H.C.S. | L.S.S. | |
| **Zero Tillage** | 12.75 a | 11.27 b | 12.01 a |
| **Minimum Tillage** | 7.65 c | 6.76 c | 7.20 b |
| **Soil Type** | 10.20 a | 9.02 b | |

***The lower value is better**

Table 3 reported that there are significant differences between the factors for the Grain Number per spike. Zero tillage reported the highest Grain Number per spike (33.5), which was significantly higher than Minimum Tillage, which reported the lowest number (31). This is because zero-till helps retain water due to crop residues left on the soil and reduces evaporation loss, increasing the Grain Number per spike.
Soil type also showed significant differences in the Grain Number per spike. Where, H.C.S. reported the highest number (33.5), significantly higher than L.S.S., which reported the lowest number (31). The lower number in sandy soil is due to its low water-holding capacity, which causes plant stress during critical growth stages (Lal, 2015).
The interaction between zero-till and H.C.S. reported the highest Grain Number per spike (35), higher than L.S.S. under the same farming approach (32). The lowest number was reported in L.S.S. under minimum tillage (30), which was not significantly different from H.C.S. under the same tillage (32). This is due to the availability of moisture and nutrients during flowering and grain formation stages (Hobbs et al., 2008).

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**Table 3. Influence of the investigated factors on the Grain Number per spike**

| Farming approach | Soil Type | | Farming approach |
|---|---|---|---|
| | H.C.S. | L.S.S. | |
| **Zero Tillage** | 35 a | 32 b | 33.5 a |
| **Minimum Tillage** | 32 b | 30 b | 31 b |
| **Soil Type** | 33.5 a | 31 b | |

Table 4 showed that there are significant differences between the factors for the Spike Number per m-2. Zero-till reported the highest number of spikes (336), while minimum tillage reported the lowest (240). This is because Zero-till reduces soil disturbance and moisture loss, which increases germination and tillering.
There was also a significant effect of soil type on the number of spikes. Where, H.C.S. reported the highest number (308.5), while L.S.S. reported the lowest (267.5). This is because clay soil provides a more suitable environment for root growth.
As for the combined effect of tillage type and soil type, H.C.S. under zero-till reported the highest number of spikes (357), followed by L.S.S. with the same farming approach (315). The lowest number was reported for L.S.S. under minimum tillage (220), followed by H.C.S. under the same tillage (260). This is attributed to better germination and seedling survival due to stable surface moisture and reduced soil disturbance, which increases plant density (Kassam et al., 2019).

**Table 4. Influence of the investigated factors on the Spike Number per $m^2$**

| Farming approach | Soil Type | | Farming approach |
|---|---|---|---|
| | H.C.S. | L.S.S. | |
| **Zero Tillage** | 357 a | 315 b | 336 a |
| **Minimum Tillage** | 260 c | 220 d | 240 b |
| **Soil Type** | 308.5 a | 267.5 b | |

It is clear from Table 5 that there were no significant differences between farming approaches for Thousend Grain Weight statistically. Numerically, Zero-till reported the highest weight (32.5 g), while Minimum Tillage reported the lowest (31.5 g).
There was a significant effect of soil type on Thousand Grain Weight. Heavy Clay Soil (H.C.S.) reported the highest weight (33.5 g), significantly higher than Light Sandy Soil (L.S.S.), which reported the lowest (30.5 g). This is because low moisture in sandy soil shortens the grain-filling period, reducing the final grain weight (Hobbs et al., 2008).
A significant difference was also observed in the interaction between tillage type and soil type. Minimum tillage with L.S.S. reported the lowest weight (29 g), significantly lower than H.C.S. under the same tillage (34 g). However, no significant differences were observed between the soil types under Zero-till statistically. Numerically, H.C.S. reported the highest weight (33 g), followed by L.S.S. (32 g).
This is because grain weight mainly depends on the efficiency of grain filling during maturity, and clay soil provides higher water storage, which supports continuous photosynthesis and carbohydrate transfer to the grains (Hamza & Anderson, 2005).

**Table 5. Influence of the investigated factors on thousand grain weight**

| Farming approach | Soil Type | | Farming approach |
|---|---|---|---|
| | H.C.S. | L.S.S. | |
| **Zero Tillage** | 33 a | 32 ab | 32.5 a |
| **Minimum Tillage** | 34 a | 29 b | 31.5 a |
| **Soil Type** | 33.5 a | 30.5 b | |

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It is clear from Table 6 that there are significant differences between the factors for grain yield. Zero Tillage reported the highest yield (3674 kg $ha^{-1}$), higher than Minimum Tillage, which reported (2371 kg $ha^{-1}$). This is because Zero-till retains more soil moisture, stabilizes the soil surface, and reduces nutrient loss.
There was also a significant effect of soil type on grain yield. Heavy Clay Soil (H.C.S.) reported the highest yield (3475.5 kg $ha^{-1}$), significantly higher than Light Sandy Soil (L.S.S.), which reported the lowest (2569.5 kg $ha^{-1}$). Sandy soils have higher permeability and faster moisture loss, which reduces productivity.
The combined effect of tillage type and soil type showed significant differences as well. Zero Tillage with H.C.S. reported the highest yield (4123 kg $ha^{-1}$), followed by L.S.S. under the same tillage (3225 kg $ha^{-1}$). The lowest yield was reported for Minimum Tillage with L.S.S. (1914 kg $ha^{-1}$), followed by H.C.S. under minimum tillage (2828 kg $ha^{-1}$). The higher performance of zero-till in clay soil is due to the integration of yield components (higher number of spikes and grains) as well as improved water use efficiency and reduced evaporation loss (Kassam et al., 2019).

**Table 6. Influence of the investigated factors on grain yield**

| **Farming approach** | **Soil Type** | | **Farming approach** |
|---|---|---|---|
| | **H.C.S.** | **L.S.S.** | |
| **Zero Tillage** | 4123 a | 3225 b | 3674 a |
| **Minimum Tillage** | 2828 c | 1914 d | 2371 b |
| **Soil Type** | 3475.5 a | 2569.5 b | |

## V. Conclusions :

The study showed a trade-off between mechanical efficiency and productivity. The Minimum Farming approach can reduce draft force by 66%, while the zero-till system increases the Grain Number per spike, Spike Number per $m^2$, and grain yield by 8%, 40%, and 54%, respectively. The study also showed that Light Sandy Soil (L.S.S.) reported lower draft force by 13%, while Heavy Clay Soil (H.C.S.) reported higher values for the Grain Number per spike, Spike Number per $m^2$, thousand grain weight, and grain yield by 8%, 15%, 9%, and 35%, respectively. The study recommends adopting zero-till to increase productivity, while considering the available tractor power and operational requirements for the disc seeder.

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