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RESEARCH ARTICLE
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Performance Comparison of Narrow Tine Implement Under Various Tillage Systems at Mosul District

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ABSTRACT
A field experiment was conducted at Hamdaniya district, about 30 km East of Mosul to evaluate the performance of a type of narrow point seeder (used for conservation agriculture farming system) under two tillage approaches (zero tillage and minimum tillage), the test was done under two soil structures (heavy clay and light sandy soils). The study measured how these factors effected the draft force, grain yield, and yield components, including, Thousand Grain Weight (TGW), number of spikes per m2, and number of grains per spike were also quantified. The results indicated that the minimum tillage system resulted in lower draft force values. In comparison, the zero-tillage system achieved higher values in grain yield, TGW, and number of grains per spike. Light sandy soil also recorded the lowest draft force values, but heavy clay soil gave higher values in grain yield, TGW, and number of grains per spike. From above, using a narrow point in light soils lowers the power needed, but crop results are not as high as in heavy soils, where productivity is better.

***Keywords*: minimum tillage, zero-tillage, grain yield, TGW, conservation agriculture.**

INTRODUCTION

As the world faces more environmental, social, and economic problems, the idea of sustainable agriculture has become very important. It helps make sure there is enough food for everyone without hurting the environment or using up natural resources. Sustainable agriculture is not just about growing food, rather it's a way of farming that tries to meet today's human needs, while also caring for future generations. It looks at fairness in the environment, society, and economy[1]. This idea came as a reaction to the problems caused by industrial farming companies, which started to spread widely in the mid-1900s. That kind of farming approaches focused intensively on crops productivity, without thinking enough about the damage that could happen to the environment, people's health, and communities. These problems include soil damage, contaminated water, loss of animals and plants, and making small farmers less able to support themselves[2]. Because modern agriculture since the mid-20th century has caused much harm to the environment and led to poor use of resources, it is now very important to understand the idea of sustainability and its main parts[3][4]. This situation shows the need to find better ways of agriculture that are more sustainable and protect the environment[5][6]. One of the most important approaches is conservation agriculture, especially zero-tillage/no-tillage[7]. It helps the soil by keeping moisture, reducing erosion, and making crop growing easier in different conditions[8]. It also improves how water is used in modern agriculture. The primary aim of zero-tillage is to keep a good balance between sustainable agricultural production and environmental conservation by maintaining soil structure and reducing its disturbance. Leaving crop leftovers on top of the soil helps protect it from bad weather like strong rain or hot sun[9]. This also improves soil health by adding organic matter and helping useful microbes grow, which makes the soil better over time[10]. Also, it helps save water by stopping it from drying too fast and keeping more moisture in the soil. This means farmers do not have to water their fields as often[11]. From an economic point of view, zero-tillage helps save money by using less fuel and lowering work costs, because farmers do not need to plow the land many times[10][12]. It also helps nature by creating good conditions for small living things in the soil, which makes the whole agriculture system healthier[13]. In the end, zero-tillage also helps fight climate change by adding more organic carbon to the soil and reducing harmful gases that come from tilling the land[14].

This study aims to determine how well the narrow tine (point) seeder works in two different types of soil that were prepared in different ways. It focuses on how heavy and wet the soil is and how these factors affect the machine's ability to open the soil and put the seeds at the right depth.

Materials And Methods

Experimental site and design

The experiment was conducted during the winter season of 2023 - 2024 in the AL-Hamdaniya district, about 30 km East of Mosul. The field experimental plot covered an area of 10 dunums and the field was planted with wheat in the seasons preceding the experiment. The field topography was characterized by flatness, and the moisture content was 16%. The soil texture was analyzed and Average rainfall (mm) for The months of 2023-2024 as shown in the tables below. In one of the experimental sites, the soil texture analysis indicated a heavy clayey soil, and the soil type in the other site was light sandy soil. Two Massey Ferguson 285s agricultural tractors (81 hp) were used in the experiment. The front tractor served as the draft power source, while the second tractor was exclusively used for raising and lowering the planter when the gearshift was in neutral. A narrow point seeder was utilized, having a mass of around 1000 kg and an effective design width of 2 m.

Two tillage systems were applied: zero-tillage to represent the conservation agriculture-farming system and minimum tillage to represent the farmer practices. A mechanical spring dynamometer (DILLON) was used to measure the draft force (Equ.1). The experiment was laid out according to a factorial experimental design within a Randomized Complete Block Design (RCBD), as described by Dawood and Elias (1990)[15]. Treatments were performed at a tillage speed of 4.5 km h^{-1}. Consequently, the experiment consisted of 2 factors × 2 levels × 3 replications, resulting in a total of 12 experimental units. The length of each treatment plot within a single replicate was 30 m. Duncan's Multiple Range Test was used to compare means and determine significant differences at a probability level of 0.05.

Soil texture table

Soil texture	Caly	Silt	Sand
Light Sandy soil	18	25	57
Silty clay	42	43	15

The months of 2023-2024	Average rainfall (mm)
December2023	47
2024	
January	58
February	49
March	61
April	64
Total	ملم 279

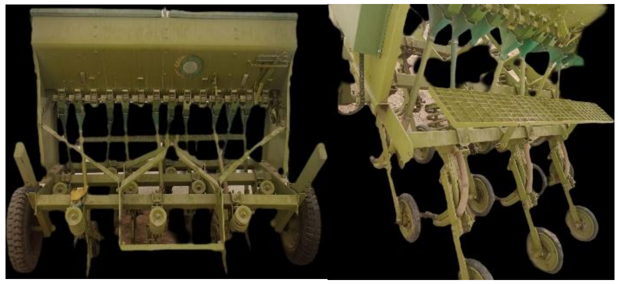
Investigated indicators

1. **Draft Force (kN):** Draft force is the horizontal force exerted by the tractor to move a load through the soil. It is usually measured in kilonewton (kN) or horsepower (hp). The draft force was directly measured using a dynamometer and calculated using the following equation[16].

$$F1 = F_{pm} - F_{rm} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (1)$$

Where:
F1 = required draft force (kN)
Fpm = tractive force at the rear wheels of the front tractor (kN)
Frm = rolling resistance of the rear wheels of the tractor (kN)

2. **Number of Grains per Spike:** Calculated from the average of 10 randomly selected spikes from each experimental unit.
3. **Number of Spikes per m^2:** The number of spikes per square meter was counted randomly for each experimental unit at the maturity stage.
4. **Thousand Grain Weight (TGW) (gm)** Clean grains free from impurities were counted using a seed counter to obtain 1000 grains, which were then weighed.
5. **Grain Yield (Kg ha^{-1}):** The study was performed on all spikes previously harvested from one square meter of the field. Subsequently, the grains were cleaned and weighed in the laboratory to determine the grain yield expressed and converted to kg ha^{-1}.



Front and Rear view of the narrow tine

Draft force measuring device

Results And Discussion

1. Effect of the studied factors and their interactions on draft force (kN)

Table 1 demonstrates a statistically significant difference among the studied factors in terms of draft force (P-value < 0.05). The minimum tillage system resulted in the lowest recorded draft force, averaging 3.19 kN, whereas the zero-tillage system exhibited a higher value of 9.80 kN. This increase is attributed to the undisturbed nature of the soil in zero tillage, which increases soil resistance during furrow opening and seed placement operations.

Soil type also had a significant effect on draft force. Heavy clay soil generated the highest draft force of 7.29 kN, compared to light sandy soil, which recorded a significantly lower value of 5.69 kN. The higher resistance in clay soil is attributed to its greater bulk density and stronger cohesion between fine soil particles, which together increase resistance against tillage tools. Furthermore, the interaction between tillage systems and soil type revealed significant differences. The combination of zero tillage and heavy clay soil resulted in the highest draft force, reaching 11.03 kN, followed by zero tillage with sandy soil, which recorded 8.57 kN. In contrast, the minimum tillage system with sandy soil produced the lowest draft force, measured at 2.82 kN. This was not significantly different from the value recorded under minimum tillage with clay soil (3.56 kN). This is due to the pressure and cohesion between the heavy clay soil particles[17].

Table 1. The effects of the studied factors and all interactions on draft force (kN)

Tillage System	Soil Type		Tillage System
	Heavy Clay Soil	Light Sandy Soil	
Zero-Tillage	11.03 a	8.57 b	9.80 a
Minimum Tillage	3.56 c	2.82 c	3.19 b
Soil Type	7.29 a	5.69 b	

*Different letters mean there is a significant statistical difference between the averages (p-value <0.05).

2. Effect of the studied factors and their interactions on the number of grains per spike

Table 2 reveals statistically significant differences among the studied factors affecting grains per spike. The zero-tillage system produced the highest value of grains per spike, which reached 34 grains, compared to the minimum tillage system, which recorded 31 grains. This improvement is attributed to conservation agriculture's enhancement of water use efficiency and increased soil organic matter content. Similarly, soil type significantly influenced yield, with heavy clay soil achieving the highest number of grains per spike at 33, surpassing the light sandy soil, which recorded the lowest value at 31grains. The superior performance of clay soil is linked to its capacity to retain essential nutrients such as nitrogen, potassium, and phosphorus, which promote vegetative growth and consequently lead to a higher number of spikes and grains. The interaction between tillage system and soil type also showed significant effects. The combination of zero tillage and heavy clay soil yielded the highest value of 35 grains, whereas the minimum tillage with sandy soil produced the lowest yield at 30 grains per spike. This was closely followed by minimum tillage with heavy clay soil, which did not differ significantly from the sandy soil treatment, recording 31 grains per spike. No significant differences were observed between soil types under the zero-tillage system (P-value > 0.05).

This interaction can be explained by the fact that zero tillage helps clay soils stay more stable, allowing them to hold more water and nutrients. In contrast, sandy soils let water pass through quickly and lose moisture faster, making them less productive under the same conditions[18].

Table 2. The effects of the studied factors and all interactions on the number of grains per spike

Tillage System	Soil Type		Effect of Tillage System
	Heavy Clay Soil	Light Sandy Soil	
Zero Tillage	35 a	32 ab	34 a
Minimum Tillage	31 ab	30 b	31 b
Effect of Soil Type	33 a	31 b	

*Different letters mean there is a significant statistical difference between the averages (p-value <0.05).

3. Effect of the studied factors on the number of spikes per m^2

Table 3 reveals that the studied factors had a statistically significant effect on the number of spikes per m^2 ($p<0.05$). The zero-tillage system recorded the highest number of spikes per m^2, reaching 306 spikes, which was significantly higher than that of the minimum tillage system, which recorded about 277 spikes per m^2. This trend may be attributed to the ability of conservation tillage to promote fertile tiller development by mitigating soil moisture loss and reducing excessive soil temperature

A significant difference was also observed with respect to soil type, where heavy clay soil produced the highest number of spikes per m^2 (293 spikes), compared to light sandy soil, which recorded a significantly lower number (≈ 281 spikes). The interaction between tillage system and soil type also showed statistically significant differences. The combination of minimum tillage with sandy soil resulted in the lowest value (259 spikes per m^2), which was significantly lower than minimum tillage with clay soil (276 spikes). Meanwhile, under the zero-tillage system, no statistically significant difference was found between the two soil types ($p > 0.05$). However, in numerical terms, clay soil recorded the highest number (310 spikes per m^2), followed by sandy soil (302 spikes).

This interaction can be explained by the good effect of combining zero-tillage with heavy clay soil. This helps spread moisture better and keeps the temperature stable around the roots, which supports the growth of fertile branches and increases the number of spikes. On the other hand, sandy soil with traditional tillage loses water quickly and gets hotter on the surface, which makes it harder for the plant to grow fertile spikes[19].

Table 3. Effect of the studied factors and all interactions on the number of spikes per m^2

Tillage System	Soil Type		Tillage System
	Heavy Clay Soil	Light Sandy Soil	
Zero-Tillage	310 a	302 a	306 a
Minimum Tillage	276 b	259 c	267.5 b
Soil Type	293 a	280.5 b	

*Different letters mean there is a significant statistical difference between the averages (p-value <0.05).

4. Effect of the Studied Factors and all interactions on TGW (gm):

As shown in Table 4, there were no statistically significant differences among the studied factors with respect to the number of spikes. The zero-tillage treatment recorded the highest TGW at about 33 g, whereas the minimum tillage treatment showed the lowest value of TGW (31 g). This difference is attributed to the ability of conservation tillage to enhance soil moisture retention during the grain-filling stage. Similarly, no significant differences were observed between soil types. The heavy clay soil recorded a higher weight of 1000 grains (≈ 33 g), compared to the light sandy soil (≈ 31 g). This can be explained by the improved photosynthetic efficiency and nutrient retention in the root zone associated with clay soils during the grain-filling phase.

However, the interaction between tillage type and soil type showed statistically significant differences under the minimum tillage system (p-value <0.05). The light sandy soil under minimum tillage recorded the lowest TGW at 29.23 g, followed by the heavy clay soil under the same tillage system (32.13 g). In contrast, no significant differences were observed under zero tillage between soil types, though numerically, heavy clay soil produced the highest value of TGW (33.11 g), followed by the light sandy soil (32.10 g).

This interaction happens because clay soils with zero-tillage can hold more water and nutrients, which enhances grain weight. In contrast, sandy soils have bigger pores and lose water faster, especially when traditional tillage is used[17].

Table 4. Effect of the studied factors and all interactions on TGW (g)

Tillage System	Soil Type		Tillage System
	Heavy Clay Soil	Light Sandy Soil	
Zero Tillage	33.11 a	32.10 a	32.60 a
Minimum Tillage	32.13 a	29.23 b	30.68 a
Soil Type	32.62 a	30.66 a	

*Different letters mean there is a significant statistical difference between the averages (p-value <0.05).

5. Effect of the studied factors and all interactions on grain yield:

As shown in Table 5, significant differences were observed among the studied factors on the grain yield (p-value<0.05). Zero-tillage farming approach recorded the highest grain yield, reaching 3325 kg ha^{-1}, which was significantly higher than the value recorded under minimum tillage (2555 kg ha^{-1}). This improvement is attributed to the role of conservation agriculture in enhancing soil moisture retention, fertility, and structural stability.

Similarly, the type of soil had a significant influence on the studied indicators (P<0.05). Where heavy clay soil recorded the highest wheat production, which reached 3150 kg ha-1, significantly surpassing the light sandy soil, which recorded the lowest value, 2730 kg ha^{-1}, this is likely due to the clay soil's capacity to retain moisture and nutrients and provide thermal stability, creating a more favorable environment for plant development.

The interaction between tillage system and soil type also revealed significant differences between the treatments. The highest grain yield was observed in heavy clay soil under zero-tillage, recording 3500 kg ha^{-1}, followed by light-sandy soil under the same tillage system, which recorded 3150 kg ha^{-1}. Conversely, the lowest number of grains yield was recorded in light sandy soil under minimum tillage, which was 2310 kg ha^{-1}, followed by heavy clay soil under minimum tillage (2800 kg ha^{-1}). This interaction happens because zero-tillage helps keep the soil structure and reduces water loss, especially in clay soils that naturally hold water and nutrients better. In contrast, sandy soils with minimum tillage often lose their structure and have lower fertility, resulting in reduced grain number per spike, number of spikes per m2, and TGW[20].

Table 5. Effect of the studied factors and their interactions on grain yield (kg ha^{-1})

Tillage System	Soil Type		Tillage System
	Heavy Clay Soil	Light Sandy Soil	
Zero Tillage	3500 a	3150 b	3325 a
Minimum Tillage	2800 c	2310 d	2555 b
Soil Type	3150 a	2730 b	

*Different letters mean there is a significant statistical difference between the averages (p-value <0.05).

Conclusion

The use of conservation agriculture in heavy clay soils proved to be an effective strategy for enhancing agricultural productivity and protecting natural resources. The results showed that zero-tillage recorded higher values in draft force, number of grains per spike, number of spikes per m², and yield by 67%, 8%, 12%, and 23%, in that order. Similarly, heavy clay soil showed higher values in the same types by 21%, 6%, 4%, and 13%, respectively. The study recommends doing more research in the future on different soil types using suitable equipment.

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Conflict Of Interest

The authors declare no conflicts of interest that could influence the research design and methodology, data collection or\and interpretation, or results presentation in this study.

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مقارنة اداء الباذرة السكينية (Narrow tine) تحت نظم زراعية مختلفة في قضاء الموصل

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الخلاصة

أجريت تجربة حقلية في منطقة الحمدانية على بعد 30 كم شرق الموصل لمقارنة أداء الباذرة السكينية تحت نوعين من نظم الزراعة: الزراعة بدون حراثة ***Zero-Tillage*** والزراعة مع حراثة سابقة ***Minimum Tillage***، وفي نوعين من التربة: طينية ثقيلة ورملية خفيفة. وقد تمّت دراسة تأثير هذه العوامل في قوة السحب التي تُعد من متطلبات القدرة للساحبة، بالإضافة إلى تأثيرها في صفات مكونات الحاصل (كمية الحاصل، وزن 1000 حبة، عدد السنابل، وعدد البذور في السنبلة). أظهرت النتائج أن الزراعة مع حراثة سابقة ***Minimum Tillage*** أعطت قيماً أقل في قوة السحب، بينما سجلت الزراعة بدون حراثة ***Zero-Tillage*** قيماً أعلى في كمية الحاصل ووزن 1000 حبة وعدد البذور في السنبلة. أما التربة الرملية الخفيفة فقد سجّلت أقل قيم في قوة السحب، في حين أعطت التربة الطينية الثقيلة قيماً أعلى في كمية الحاصل ووزن 1000 حبة وعدد البذور في السنبلة.

الكلمات المفتاحية: الزراعة مع حراثة مسبقة، الزراعة بدون حراثة، محاصيل الحبوب، وزن الف حبة، الزراعة الحافظة.