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A Study on the Working Efficiency of a Disc Opener for a Zero-Tillage Seeder and its Effect on Specific Mechanization and Agronomic Indicators under Varying Environmental Conditions

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I. Abstract

This study was aimed to determine the effect of a seeder equipped with disc openers on some mechanical indicators and grain yield under different environmental conditions. The field study was conducted in three different sites located within Ninawa Governorate, which were Tel Kaif (A), Mahlabiyah (B), and Zummar (C), during the winter season of 2024-2025 through utilizing a zero-tillage seeder with disc opener seeder. This seeder was investigated under 15% and 20% soil moisture contents. The soil texture of the fields in the three sites were silty loam, sandy loam, and clay loam in site A, B and C, respectively. The experiment was designed using a Randomized Complete Block Design (RCBD) with a split-plot arrangement with three replications for each treatment. The studied traits included Draft Force, Noise, Vibration, and Total Grain Yield. The interaction between site C and the highest moisture content recorded the highest significant values for Draft Force (13.02 kN) and Noise (92.00 dB). Conversely, the same site with both moisture contents recorded the highest vibration values (3.5, 3.00 m sec^{-2}, respectively). However, site A with both moisture contents recorded the highest total grain yield (4213, 4020 kg ha^{-1}, respectively).

Keywords: No-tillage, Disc Openers, Draft Force, Noise, Vibration, Grain Yield.

Introduction

The recent era has witnessed increased attention in developing countries to the use of modern mechanization techniques in agriculture, focusing on the development of furrow openers that work to open the seed line. These openers come in various forms, including single-disc, double-disc, notched, wavy, chisel, and hoe types, as well as the T-shaped geometry and different angles for the opener shape. Adapting the use of the opener to different soil conditions, particularly their moisture content, and reaching the necessary adjustments in the actual time of use for these no-tillage seeders is crucial. The goal is to increase the seeding rate and obtain a uniform seed line, which prepares a good seedbed for the seed to achieve the highest percentage of emergence, keeping pace with the climatic changes that have affected the agricultural sectors in countries like Iraq, especially Nineveh Governorate.

The use of no-tillage seeders has been applied in rainfed fields after its success and experience in irrigated fields. Farmers are striving to adopt no-tillage seeding for grains, moving away from costly traditional cultivation methods that increase

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inputs and reduce returns [1] found that the high speed used in the seeder is one of the influential factors on the ability of the disc opener to penetrate the soil, especially when passing through hard soil clods, which changes the path of the seed and prevents its descent into the seed line [2] showed that using a damping tongue between the disc opener resulted in a higher seeding rate compared to no cover, leading to the desired depth. [3] found that the highest Draft Force and vertical force for the seeder, where double disc openers operate in opening the seed lines in unplowed fields, were recorded. [4] confirmed that the use of forward speed for the seeder and the type of opener used in opening the seed line are among the most important factors affecting Draft Force, and the variation in readings and increases is due to this [5] observed in a laboratory experiment using a disc opener in unplowed soil that the Draft Force increased with an increase in depth (30, 60, 90 mm) and three forward speeds (0.1, 0.2, 0.3 m/s), recording (648.9, 737.2, 784.6 N, respectively). [6] concluded that the forces acting on the opener, which comes in various shapes (single smooth disc, notched, double, or T-shaped geometry), work to open the seed line in unplowed soil. As the moisture content decreases, the Draft Force decreases, and the percentage of compaction at different depths is reduced. [7] concluded that the possibility of improving mechanization techniques for no-tillage agriculture depends on adapting to the appropriate moisture content, which in turn depends on factors such as the geometry of the designed opener and the degree of soil wetting, as well as the speed used in seeding. This is crucial for obtaining a uniform seeding depth, which plays a vital role in achieving the highest percentage of emergence. [8] found that the disc plow recorded the lowest vibration value (2.605 m/s^2), while the noise trait recorded (89.45 dB) due to the use of fuel improvers for the diesel engine and the quality of combustion. This led to better results for disc plows compared to non-disc plows, which is attributed to the speed of the tractor for the disc plow. The agricultural tractor is considered the most common source of noise because it contains an internal combustion engine. [9] showed that the Draft Force and vibration/noise increased as the depth increased, especially for the drawn or semi-mounted agricultural implements with rotary or knife-shaped openers, depending on the shape of the disc opener and the depthl. [10] mentioned that the use of the no-tillage system, compared to the local and traditional cultivation system under environmental conditions such as drought, provides balanced amounts of water. This resulted in an increase in the vegetative area, which in turn led to an increase in field emergence and thousand grain weight, thus achieving the highest grain yield (31.87, 16.33, 78.30, and 25.1764 kg ha^{-1}, respectively). The main objectives of this study were to select the optimal environmental and soil conditions for the zero-tillage seeder with disc openers to achieve better working efficiency in terms of mechanical and agronomic indicators.

II. Materials and Methods

This study was conducted in three different sites: Tel Kaif ("A"), Mahlabiyah ("B"), and Zummar ("C"), all located in Nineveh Governorate. Three sites with different soil textures were chosen: Site "A" had silty loam soil, Site "B" had sandy loam soil, and Site "C" had clay loam soil. The work was carried out during the agricultural season (2024–2025). The experimental design used was the Randomized Complete Block Design (RCBD) with a split-plot arrangement for a single run. The first factor (main plots) included the three field sites with different soil textures. The second factor (sub-plots) included two moisture contents, one at 15% (natural) and the other at 20% above natural. A Massey Ferguson tractor

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(Turkish-made, S-285 model, four-wheel drive) was used to pull the SAKALAK disc seeder (Turkish-made, no-tillage type), which was calibrated in the laboratory first, then in the field (Figure 1).

Figure (1) The disc drill seeder (zero-tillage seeder)

Calculating the Studied Parameters

1- Draft Force (kN):

Two four-wheel-drive Massey Ferguson tractors were utilized. The first end of a flexible steel wire (1.5 m long) was connected to the rear drawbar of the first tractor "a." The other end of this first wire was connected to the front of a mechanical Draft Force measuring device (Dillon type dynamometer). Meanwhile, the other end of the Draft Force device was connected to one end of the second steel wire (1.5 m long), and the other end of this wire was connected to the hitch point of the second tractor "b," which was used to pull the Disc Grain Seeder. Three different readings were taken for each replicate to measure the total Draft Force of the rear tractor connected to the seeder during operation.

Figure (2)Dillon type dynamometer

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2- N oise (d B):

A Sound Level Meter (Model UT315A) was used to measure noise. The electronic device was held by an individual located in the tractor cabin, excluding the driver. This individual worked in a position that allowed him to take readings without dropping the device, ensuring accurate measurements without obstruction while the tractor was in motion. The front end of the device contains a sound-capturing component (microphone) that detects extraneous sounds resulting from the vibration of the tractor and its components, converting them into readings displayed on a digital screen. The device automatically recorded data and readings during operation, and three readings were taken for each experimental unit (Figure 3).

Figure (3) Sound Level Meter UT315A

3- Vibration (m sec^{-2}):

An (UNI-T UT315A) vibration measuring device was used. This device is utilized to measure acceleration and displacement in rotating and reciprocating mechanical agricultural machinery and implements. It is beneficial for taking operational status readings and identifying abnormal vibrations, which may potentially lead to technical faults if these vibrations increase. The device was taken from the Department of Agricultural Machinery and Equipment at the College of Agriculture and Forestry/University of Mosul. The device consists of a sensor with a magnetic end connected to a wire. The magnetic end is attached to the seeder in a place that allows the individual to take readings without obstruction while the tractor is in motion. The device also has a digital screen that displays the different readings transmitted through the sensor. The device converts the vibration sounds into data for reading during operation. Three replicates were taken for each experimental unit in each field site (Figure 4).

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Figure (4) Vibration Meter UNI-T UT315A

4- Total Grain Yield (kg ha^{-1}):

After the wheat reached the drying stage on 15th of May 2025, a wooden square frame with dimensions of one square meter was used. The plants enclosed within the frame were harvested to take samples randomly. The samples were cleaned, weighed, and compared with international measurements for grain weight (in grams). Samples were taken from the beginning, middle, and end of the field in a random manner for each experimental unit. The data were analyzed using the SAS statistical system to determine the effects between sites and their moisture content, as well as the interaction of the factors [11]; [12).

III. Results and Discussion

Effect of Site Factor on the Studied Parameters

Table (1) shows the effect of the sites used in the field experiment on the studied parameters. Site "C" recorded the highest significant values ($P < 0.05$) for both Draft Force (12.28 kN) and Vibration (3.03 m sec^{-2}), and Noise (91.25 dB), respectively. The reason is attributed to the soil being clay loam, and the effect of these parameters depends primarily on the mechanical properties of the soil, such as cohesion, internal friction, and the force of penetration, which affected the working efficiency of the disc openers. The adhesion of some clay clods to the openers in the clay soil caused difficulty in opening the seed furrow correctly. Meanwhile, Site "B" recorded the lowest Draft Force value (9.63 kN), which is considered suitable for this parameter. This is due to the soil being sandy loam, which facilitated the movement of the drawn seeder with double disc openers smoothly. This was also found by the researcher [4].

Meanwhile, Site "A" recorded the highest significant value ($P < 0.05$) for the yield trait, registering a value of 4116 kg ha^{-1}. The reason is attributed to the field being cultivated with a disc seeder that operates without tillage, which is beneficial for preserving the residues of previous crops in the field. This provided adequate moisture, which led to an increase in field

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emergence, thus producing the highest grain yield. The use of the no-tillage system, compared to the local and traditional cultivation system under environmental conditions such as drought, provides balanced amounts of water. This resulted in an increase in the vegetative area, which in turn led to an increase in the number of plants and a high emergence rate. This led to an increase in field emergence and thousand grain weight, thus achieving the highest grain yield, a finding consistent with [10].

Table (1): Effect of Site on the Studied Parameters.

Site	*Draft Force (kN)*	*Noise (dB)*	*Vibration (m sec $^{-2}$)*	*Total Grain Yield (kg ha $^{-1}$)*
A	11.53 B	86.25 C	2.03 C	4116 A
B	9.63 C	89.25 B	2.53 B	3187 C
C	12.28 A	91.25 A	3.03 A	3653 B

Effect of Moisture Content (%) on the Studied Parameters

Table (2) shows the effect of moisture content on the studied parameters. The first moisture content (15%) recorded the highest significant value for the Vibration trait (2.55 m sec^{-2}). Meanwhile, the second moisture content (20%) recorded the highest significant difference for the Noise trait (89.67 dB). No significant differences were observed for both moisture contents in the traits of Draft Force and Total Grain Yield.

Table (2): Effect of Moisture Content on the Studied Parameters.

Moisture Content (%)	*Draft Force (kN)*	*Noise (dB)*	*Vibration (m sec $^{-2}$)*	*Total Grain Yield (kg ha $^{-1}$)*
15%	10.60 A	88.17 B	2.55 A	3678 A
20%	11.69 A	89.67 A	2.50 B	3888 A

Effect of the Two-Way Interaction between site and soil moisture content on the tested parameters

Figure (1) shows the effect of the two-way interaction between the sites and the moisture content on the Draft Force trait. The highest significant values ($P < 0.05$) were recorded at Site "C" with the second moisture content, reaching 13.02 kN. This is attributed to the increase in moisture content in the clay loam soil, which clearly affected the working efficiency of the double disc openers due to the adhesion of a quantity of clay to the discs, leading to an increase in the Draft Force of the tractor and the seeder. This is consistent with the findings of Ali et al. (2024) [7]. Conversely, Site "B" with the first moisture content recorded the lowest Draft Force value (9.55 kN). This is attributed to the soil type being sandy loam, which facilitated the operation of the disc seeder that works without tillage in this soil, as well as the shapes of the seed furrow (smooth, notched, or double), which in turn work to open the seed line. Furthermore, as the moisture content decreases, the percentage of soil compaction at different depths is reduced. This was noted by the researcher [7].

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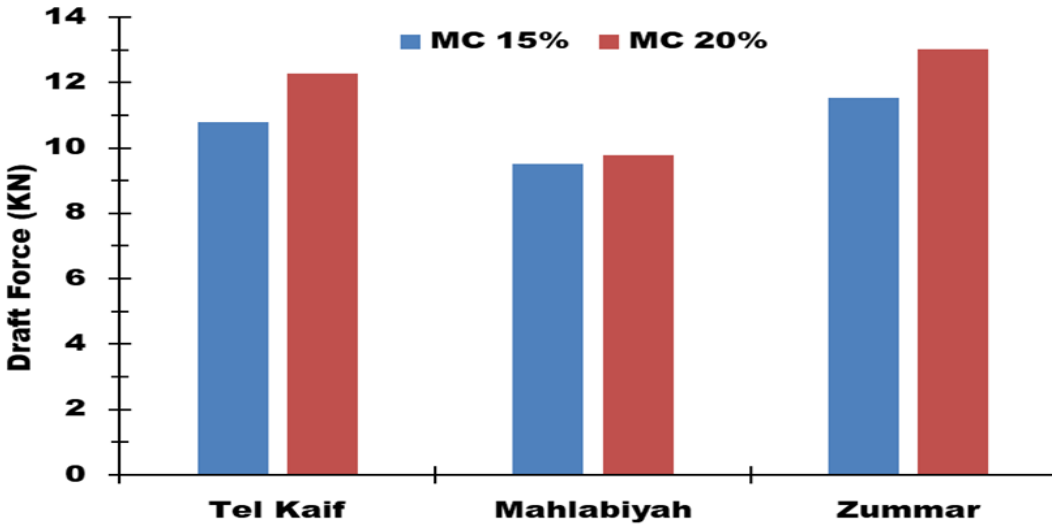

Figure 1. Effects of sites and soil moisture content on draft

Figure (2) shows the effect of the two-way interaction between the sites and the moisture content on the Noise trait. The highest significant values ($P < 0.05$) were recorded at Site "C" with the second moisture content, reaching 92.00 dB. This is attributed to the increase in moisture content, which led to the cohesion of soil particles, making the soil clay loam, which clearly affected the working efficiency of the double disc seeder. This resulted in an increase in noise recorded through the sensors, which is converted into readings of vibrations and instability, which in turn is caused by the direct contact of the openers and the seeder with the soil. This is consistent with the findings of. [9]. Conversely, Site "A" with the first moisture content recorded the lowest Noise value (85.5 dB). This is attributed to the soil type at this site being silty loam, which facilitated the passage of the disc seeder without the adhesion of soil clods to the discs, allowing it to operate optimally.

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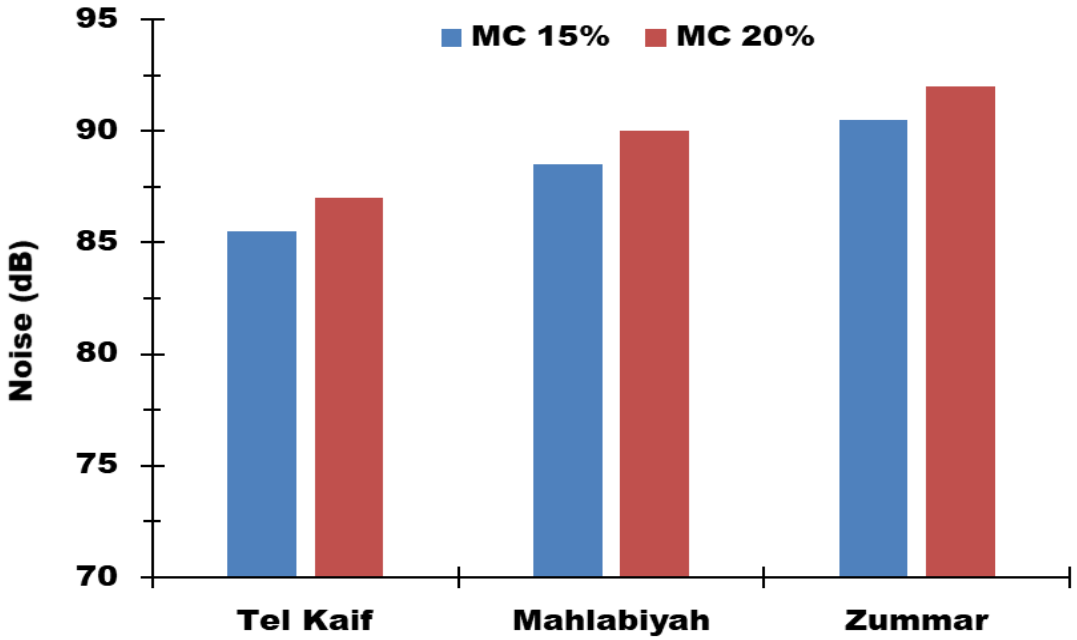

Figure 2: Noise Level as affected by the interaction between Sites and soil moisture content

Figure (3) illustrates the effect of the two-way interaction between the sites and the moisture content on the vibration characteristic. The highest significant values ($p < 0.05$) were recorded at Site C under the first and second moisture content levels. The corresponding vibration values were 3.5 and 3.00 m sec^{-2}, respectively. The reason is attributed to the site's soil type (clay loam), where the moisture content clearly impacted the operational efficiency of this type of double disc opener seeder. This led to increased vibration and instability, coupled with the unsuitability of the shape and type of the disc furrow opener used for opening the seed trench. Furthermore, an increase in the tractor speed during seeding may have contributed to the occurrence of vibrations. This resulted in significant values, increasing the instability of both the tractor and the seeder unit, a finding consistent with [13]. Conversely, at Site "A", the vibration values for both moisture content levels were 2.0 and 2.05 m sec^{-2}, respectively. These values are considered the lowest, which is attributed to the soil type at this site being silty loam. This facilitated the passage of the disc opener seeder through the soil without the adhesion of soil clods to its discs, allowing it to operate optimally.

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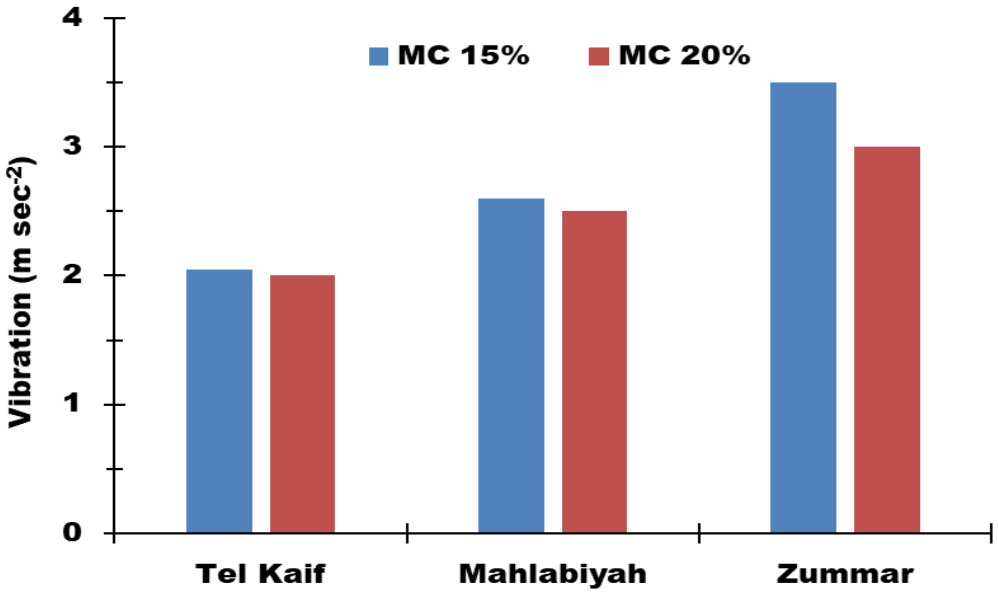

Figure 3. Vibration as affected by the Studied factors

•Total Grain Yield (kg ha^{-1}): Figure (4) shows the extent of the two-way interaction effect between the sites and the moisture content on the grain yield. The highest significant values ($P < 0.05$) were recorded at site "A" for both moisture contents, registering 4213 and 4020 kg ha^{-1}, respectively. The reason for this is attributed to the soil at this site being good, possessing a silty loam texture that retains the appropriate moisture content, which provided an ideal seedbed for the seeder. Furthermore, this site has been cultivated for several years using modern Zero Tillage seeders. Due to the lack of soil compaction resulting from the single pass of the tractor and seeder, and the preservation of the soil structure through repeated cultivation using this modern system over previous and continuous years, a field with fertile soil was prepared. This resulted in an increase in the number of spikes (heads), which led to an increase in the number of tillers (branches), thereby achieving an increase in the number of grains per spike. This produced the highest grain yield compared to the other sites used in the experiment, which were cultivated with the same previous crop but under the conventional tillage system (plowed land). This aligns with the findings of [14].

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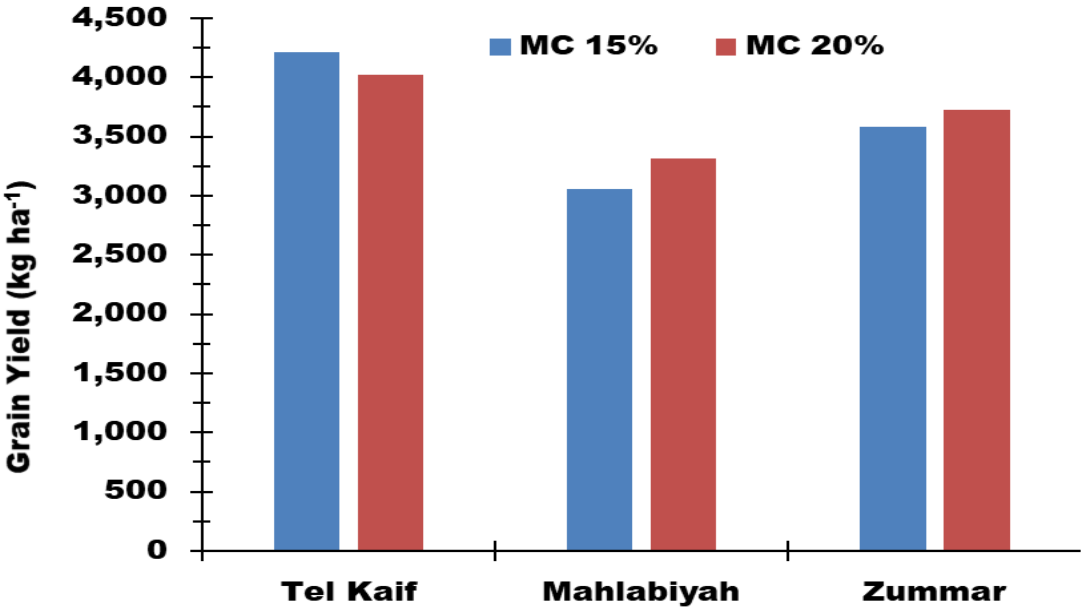

Figure 4. The effects of studied factors on total grain yield

Conclusions

1- The study investigated the performance of disc opener seeders/planters in different soil types under varying moisture conditions. Results indicated that the operation of disc opener seeders/planters was found to be inefficient in clayey soils when the soil moisture content exceeded a critical threshold of 15%.

2- Furthermore, the experimental site at Ramaz, characterized by its clay loam soil, exhibited the highest statistically significant values for key operational parameters, specifically draft force, noise, and vibration.

3- Conversely, the Taklif site, which possesses a silty loam soil composition, demonstrated superior performance in terms of crop output, achieving the highest total grain yield across both tested soil moisture content levels. These findings underscore the critical interaction between soil texture, moisture, and the efficiency of agricultural machinery.

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