Comparison between No-Tillaga and Conventional Farming Systems and their Impact on Some Performance Indicators and Wheat Yield

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Received: 12 December 2024 | Revised: 18 January 2025 and 26 January 2025 | Accepted: 29 January 2025

 DOI: https://doi.org/10.48084/etasr.9933

ABSTRACT

A field study was conducted in loamy agricultural soil of Baghdad Governorate, Tarmiyah District, during the 2021-2022 growing season. The research aimed to evaluate the feasibility and impacts of no-tillage wheat planting systems on plant growth and yield. The experiment examined three factors: tractor operational speed, seed rate, and seeder configurations. Three speed levels 4.23, 6.54, and 8.37 km/h, two seed rates 100 and 140 kg/ha, and three seeder setups were tested. The indicators evaluated included operational productivity, draft force, soil bulk density, and 1000 grain weight. The Randomized Complete Block Design (RCBD), with a nested arrangement and three replicates, was employed. The mean comparisons carried out used the Least Significant Difference (LSD) at the 0.05 significance level. The highest operational productivity of 1.87 ha/h and 1000-grain weight of 48.7 g were achieved with the 8.37 km/h speed, 140 kg/ha rate, and the Z seeder. Conversely, the 4.23 km/h speed, 100 kg/ha rate, and Z seeder resulted in the lowest draft force of 125.76 kgf and soil bulk density of 1.030 mg/m³.

Keywords-draft force; operational productivity; operational speed; bulk density

I. INTRODUCTION

The agricultural industry plays a pivotal role in the economy. Agricultural mechanization represents a crucial and essential component for attaining optimal agricultural production. It enables the achievement of maximum productivity at the lowest economic cost and highest quality, while minimizing harm to humans, machinery, and soil. This focus has driven efforts to innovate and enhance the design of tractors and agricultural equipment, which are foundational to the agricultural revolution. Mechanization reduces the required labor force and accelerates the completion of agricultural tasks, thereby decreasing production costs. For instance, in the past, 60-65 workers were needed per hour to manage wheat cultivation. With mechanization, only three workers are now required per hour, illustrating how mechanization saves both time and cost. The use of sowing and planting equipment has led to significant improvements in work speed, planting accuracy, and cost reduction, making such equipment indispensable in agricultural mechanization. Equipment productivity depends on three key factors: the effective working width of the equipment, the operational speed, and the area covered per unit of time. Actual productivity is typically lower than theoretical estimates, even when adhering to operational guidelines. This discrepancy arises from various factors, including field shape and condition, preparation techniques, machine status, and driver skill.

The productivity of any agricultural operation is a critical economic indicator, achievable by optimizing the tractor's maximum capacity and performance in the field. The draft force requirements for any implement depend on factors, such as soil resistance, moisture content, the coefficient of friction, operational speed, tillage depth, and the implement's angle of inclination [1]. Focusing on these results, it was observed through the comparison between conservation agriculture and conventional agriculture systems that this research relied on identifying the optimal selected speed and the best seeding rate. These factors aim to improve mechanical characteristics and crop growth traits, which are essential for enhancing overall productivity. This would facilitate the dissemination of the research findings to research departments and institutions related to the agricultural sector, promoting the application of no-till farming systems and determining the ideal speed and seeding rate for achieving better productivity in agricultural fields. By understanding and optimizing these variables, farmers and researchers can work towards maximizing the efficiency and profitability of their agricultural operations.

II. MATERIALS AND METHODS

A field experiment was conducted during the 2021-2022 growing season in one of the fields situated in Tarmiyah district, Baghdad province. The purpose of the study was to investigate the feasibility of utilizing no-tillage farming systems for wheat planting and their influence on plant growth and yield. The process commenced with clearing the field of weeds and debris, followed by leveling the land using a grader. Earthen embankments, measuring 20 cm in height, were constructed around the field, and the land was then flooded for saturation to ensure adequate soil moisture for tillage within the experimental plots, preparing the soil for planting. The researchers aimed to explore the potential benefits of no-tillage farming, such as improved soil structure, moisture retention, and reduced labor and fuel requirements, to determine its suitability for wheat cultivation in the region.

The land was divided into three sections to conduct the experiment and compare replicates. Primary tillage was carried out using a moldboard plow with three furrows across 36 experimental units, followed by secondary tillage using a rotary tiller rotavator to refine the soil. This process was applied to 36 experimental units, including 18 units planted with a broadcaster seeder CT and 18 units planted with the Ozduman combined planter and fertilizer applicator ZT after tillage. Additionally, 18 experimental units were designated for conservation agriculture using the Ozduman planter without prior tillage, enabling comparisons with other experimental setups.

The experiment involved three factors: tractor operational speed, seed quantity, and seeding equipment. Three speeds were utilized: 4.23 km/h, 6.54 km/h, and 8.37 km/h, representing the tractor's operational speed. Two seed rates were evaluated: 100 kg/ha and 140 kg/ha. Furthermore, three types of machinery were employed: the Osduman seeder and fertilizer system without tillage, the Osduman seeder and fertilizer system with tillage, and the Broadcaster Seeds system. The experimental area was 30 m² with 15 m spacing between units to stabilize the tractor's operational speed. A total of 54 units were randomly distributed across three replicates in a 5000 m² field, as depicted in Figure 1.

Fig. 1. Distribution of experimental units in the field.

Productivity is a critical metric for evaluating machinery performance efficiency. The soil bulk density, influenced by tillage and seeding equipment, was measured using a locally manufactured device. The device collected cylindrical soil samples via a core sampler lever, dried them in a microwave to remove moisture, and calculated the bulk density, as shown in Figure 2. This measurement of soil bulk density provides valuable insights into the compaction and porosity of the soil, which are key factors in understanding the effectiveness of agricultural machinery and its impact on the soil ecosystem.

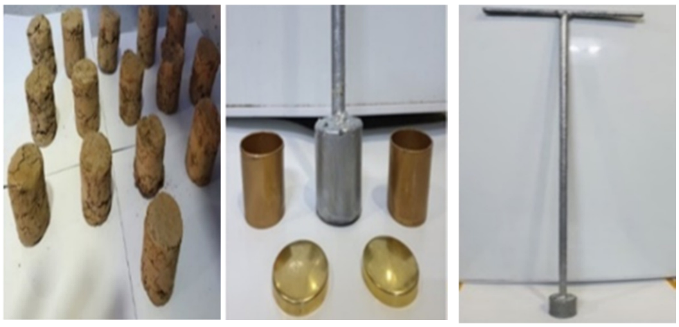

Fig. 2. Soil samples and the core sampler for measuring soil bulk density.

Draft force was measured to assess planter performance, which is crucial for identifying the appropriate tractor type and power required for planting, fertilizing, and other agricultural operations. A Dillon dynamometer, a mechanical-electronic device measuring force and tension, was connected between the towing machines to record the draft force, as illustrated in Figure 3. The 1000-grain weight parameter is a significant indicator of seed quality, as it provides insights into the overall productivity and efficiency of grain production.

Fig. 3. Dynamometer to measure draft force.

III. STUDIED TRAITS

The operation productivity was calculated following the method described in [2]:

$$P_p = 0.1 \times V_p \times W_p \times F_{tp} \quad (1)$$

where V_p is the operational speed, W_p is the actual working width, and F_{tp} is the time utilization factor set at 0.73.

The draft force was calculated according to [3]:

$$F_t = F_{pm} - F_{rm} \quad (2)$$

where F_{pm} is the rear wheel driving force of the front tractor and the F_{rm} the rolling resistance of the rear tractor's wheels.

Measurements were collected from the apparatus when the pull chain was taut, and both vehicles were advancing. The apparatus display provided a moderately consistent reading. A series of measurements was obtained for each replicate, and the mean was computed subsequently, omitting any fluctuations in the display before it stabilized. The device's readings were in kN and were converted to kgf using:

$$kgf = \frac{9.81}{1000 \times measurment} \quad (3)$$

The bulk density was calculated deploying the Core method at the end of the growing season, using [4]:

$$P_p = \frac{M_s}{V_t} \quad (4)$$

where M_s is the mass of the dry sample and V_t the sample volume.

The weight of 1000 grains was determined using a sensitive balance from the yield of each experimental unit, following the method described in [5]. The calculation was performed at 12% moisture content [6].

IV. RESULTS AND DISCUSSION

A. Practical Productivity

Significant differences were observed in practical productivity ha/h due to varying mechanical unit speeds. The third speed 8.37 km/h recorded the highest practical productivity at 1.76 ha/h, compared to the first speed 4.23 km/h and the second speed 6.54 km/h, which recorded 0.90 ha/h and 1.31 ha/h, respectively. An increased operating speed diminishes the time needed to complete the task, thereby expanding the area covered, which suggests a direct correlation between speed and productivity. These results align with the findings of [7]. Additionally, a seed quantity of 140 kg resulted in the highest practical productivity of 1.34 ha/h compared to 100 kg, which recorded the lowest productivity of 0.90 ha/h.

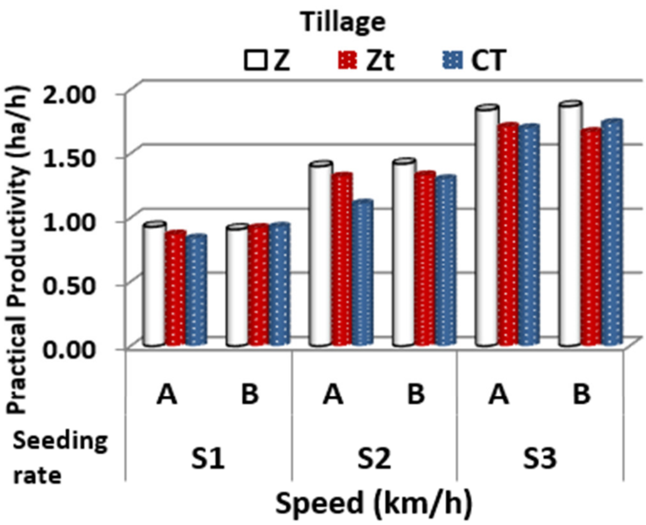

Fig. 4. The effect of forward speed, seed quantity, and seeding machine settings on practical productivity.

The settings of the seeding machines also had a significant impact on practical productivity. Machine Z achieved the highest productivity of 1.40 ha/h, followed by machines Zt and Ct, which recorded lower but similar productivity levels of 1.30 ha/h and 1.27 ha/h, respectively. The interaction between speed and seed quantity showed increased practical productivity at the third speed 8.37 km/h combined with 140 kg of seeds, resulting in 1.76 ha/h. In contrast, the lowest productivity of 0.88 ha/h was recorded at the first speed 4.23 km/h combined with 100 kg of seeds. The interaction between speed and seeding machine settings revealed significant differences. The combination of the third speed 8.37 km/h with machine Z resulted in the highest productivity of 1.86 ha/h, whereas the first speed 4.23 km/h with machine Ct recorded the lowest productivity of 0.89 ha/h.

Furthermore, the interaction between seed quantity and seeding machine settings showed that 140 kg of seeds with machine Z achieved the highest productivity of 1.40 ha/h, while 100 kg of seeds with machine Ct resulted in the lowest productivity of 1.22 ha/h. Finally, the three-way interaction between speed denoted as S1, S2, and S3, seed quantity indicated as A and B, and seeding machine settings highlighted a significant effect on practical productivity. The combination of the third speed 8.37 km/h, 140 kg of seeds, and machine Z resulted in the highest productivity of 1.87 ha/h. In contrast, the combination of the first speed 4.23 km/h, 100 kg of seeds, and machine Ct recorded the lowest productivity of 0.84 ha/h.

B. Draft Force

The first speed 4.23 km/h recorded the lowest draft force at 152.39 kgf, compared to the second speed 6.54 km/h and the third speed 8.37 km/h, which recorded 211.87 kgf and 227.73 kgf, respectively. The observed rise in draft force with an increasing tractor speed is attributed to greater soil acceleration on the plow, which in turn leads to higher draft forces. These findings are consistent with prior research in [8, 9]. Furthermore, the seed quantity of 140 kg resulted in the highest draft force of 201.30 kgf, compared to 100 kg, which recorded a lower draft force of 193.37 kgf.

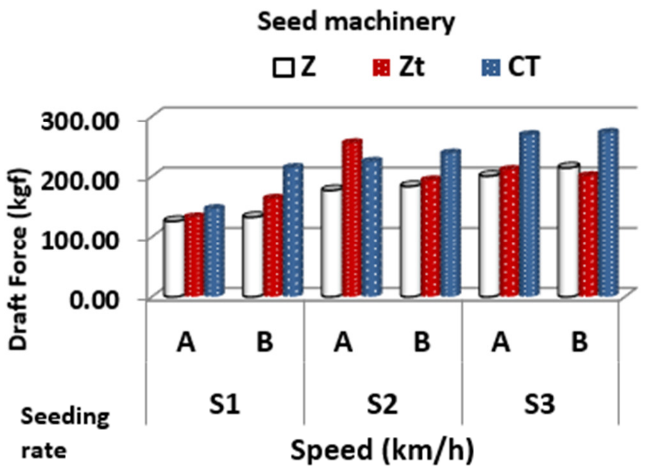

Fig. 5. The effect of forward speed, seed quantity, and seeding machine settings on draft force.

Seeding machine settings also had a significant impact on draft force. Machine Z recorded the lowest draft force of 172.22 kgf, while machine Ct recorded the highest at 227.17 kgf. The interaction between speed and seed quantity showed an increase in draft force at the third speed 8.37 km/h with 140 kg of seeds, recording 228.87 kgf. In contrast, the first speed 4.23 km/h combined with 100 kg of seeds recorded the lowest draft force at 134.83 kgf. The combination of the first speed 4.23 km/h with machine Z resulted in the lowest draft force at 129.16 kgf, while the third speed 8.37 km/h with machine Ct recorded the highest draft force at 270.22 kgf. Similarly, the interaction between seed quantity and seeding machine settings demonstrated that 100 kg of seeds with machine Z resulted in the lowest draft force at 167.68 kgf. In contrast, 140 kg of seeds with machine Ct recorded the highest draft force at 241.33 kgf.

Lastly, the three-way interaction among speed denoted as S1, S2, and S3, seed quantity indicated as A and B, and seeding machine settings revealed a significant impact on draft force. The combination of the first speed 4.23 km/h, 100 kg of seeds, and machine Z resulted in the lowest draft force at 125.76 kgf. Conversely, the combination of the third speed 8.37 km/h, 140 kg of seeds, and machine Ct recorded the highest draft force at 271.92 kgf.

C. Bulk Density

The first speed 4.23 km/h recorded the lowest bulk density at 1.227 mg/m^3, compared to the second speed 6.54 km/h and third speed 8.37 km/h, which recorded 1.274 mg/m^3 and 1.349 mg/m^3, respectively. The increase in bulk density can be attributed to the observation that higher operating speeds result in the rapid expulsion and fragmentation of soil aggregates, producing smaller soil particles that fill the interstitial spaces within the soil matrix. This in turn leads to enhanced soil compaction, greater overall weight, decreased porosity, and consequently, an increase in bulk density. There were no significant differences observed in seed quantity, where 100 kg recorded the lowest bulk density at 1.281 mg/m^3 compared to 140 kg, which recorded the highest bulk density at 1.286 mg/m^3.

Machine Z recorded the lowest bulk density at 1.155 mg/m^3, followed by machine Zt and machine Ct, which recorded higher values of 1.341 mg/m^3 and 1.354 mg/m^3, respectively. The interaction between speed and seed quantity showed an increase in bulk density at the third speed 8.37 km/h combined with 140 kg of seeds, recording 1.350 mg/m^3. In contrast, the lowest bulk density was recorded at the first speed 4.23 km/h with 100 kg of seeds, at 1.210 mg/m^3.

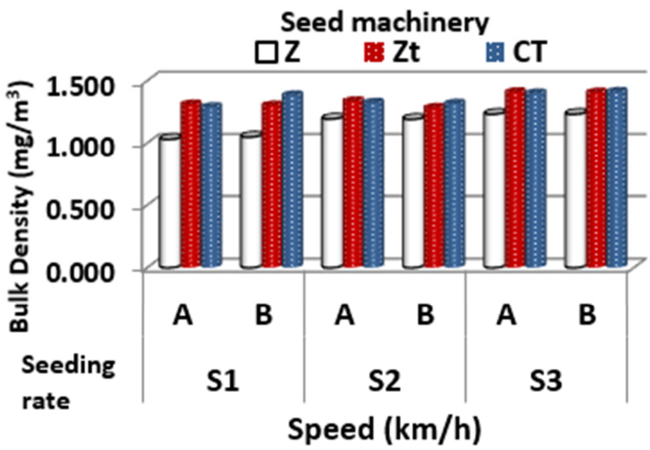

Fig. 6. The effect of forward speed, seed quantity, and seeding machine settings on bulk density.

The interaction between speed and seeding machine settings did not show significant differences. The combination of the first speed 4.23 km/h with machine Z recorded the lowest bulk density at 1.039 mg/m^3, while the third speed 8.37 km/h with machine Zt recorded the highest bulk density at 1.408 mg/m^3. Similarly, the interaction between seed quantity and seeding machine settings showed that 100 kg of seeds with machine Z resulted in the lowest bulk density at 1.152 mg/m^3, while 140 kg of seeds with machine Ct recorded the highest bulk density at 1.371 mg/m^3.

Finally, the three-way interaction among speed, seed quantity, and seeding machine settings did not show a significant effect on bulk density. The combination of the first speed 4.23 km/h, 100 kg of seeds, and machine Z resulted in the lowest bulk density at 1.030 mg/m³. In contrast, the combination of the third speed 8.37 km/h, 140 kg of seeds, and machine Ct recorded the highest bulk density at 1.412 mg/m3.

D. Seed Weight 1000

The third speed of 8.37 km/h recorded the highest 1000 seed weight at 41.3 g, compared to the first speed 4.23 km/h and second speed 6.54 km/h, which recorded 34.4 g and 38.2 g, respectively. There were also significant differences in the average seed rate. The 140 kg seed quantity recorded the highest 1000-seed weight at 39.1 g, compared to 100 kg, which recorded the lowest 1000 seed weight at 36.6 g. These results are in agreement with the findings of [10, 11]. Machine Z recorded the highest 1000 seed weight at 44.4 g, followed by machine Zt and machine Ct, which recorded lower values of 37.7 g and 31.8 g, respectively.

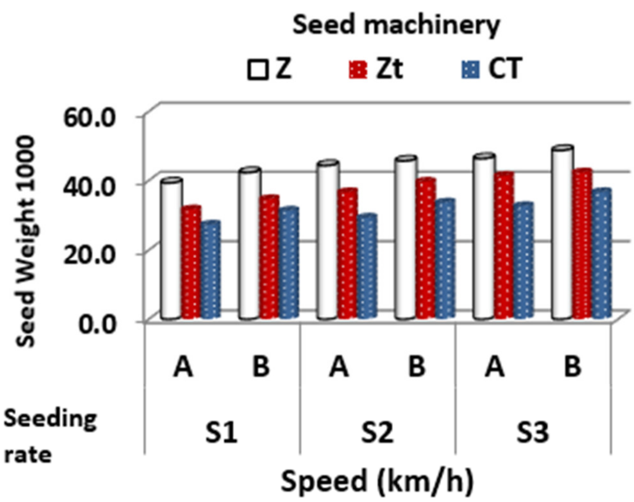

Fig. 7. The effect of forward speed, seed quantity, and seeding machine settings on the weight of 1000 seeds.

The interaction between speed and seed quantity displayed no significant differences in 1000 seed weight. The third speed 8.37 km/h with 140 kg of seeds recorded 42.6 g, while the lowest weight was recorded at the first speed 4.23 km/h with 100 kg of seeds, at 32.8 g. The interaction between speed and seeding machine settings also showed no significant differences. However, the combination of the third speed 8.37 km/h and machine Z recorded the highest 1000 seed weight at 47.5 g, while the first speed 4.23 km/h with machine Ct recorded the lowest weight at 29.3 g. In the interaction between seed quantity and seeding machine settings, 140 kg of seeds with machine Z recorded the highest 1000 seed weight at 45.6 g, while 100 kg with machine Ct recorded the lowest at 29.8 g.

Finally, the three-way interaction between speed, seed quantity, and seeding machine settings demonstrated no significant differences in thousand-seed weight. The combination of the third speed 8.37 km/h, 140 kg of seeds, and machine Z recorded the highest thousand-seed weight at 48.7 g, while the combination of the first speed 4.23 km/h, 100 kg of seeds, and machine Ct recorded the lowest weight at 27.3 g.

V. CONCLUSION

The experiment examined three speed levels of 4.23 km/h, 6.54 km/h, and 8.37 km/h. Two seed rates of 100 kg/ha and 140 kg/ha, and three seeder setups were tested. The indicators evaluated included operational productivity, draft force, soil bulk density, and 1000 grain weight. The highest operational productivity of 1.87 ha/h and 1000-grain weight of 48.7 g were achieved with the 8.37 km/h speed, 140 kg/ha rate, and the Z seeder configuration. Conversely, the 4.23 km/h speed, 100 kg/ha rate, and Z seeder configuration resulted in the lowest draft force of 125.76 kgf and soil bulk density of 1.030 mg/m³.

Examining no-till farming can provide insights into boosting wheat productivity and reducing costs, while preserving soil and water resources, preventing erosion, and maintaining moisture in arid regions. No-till also enhances biodiversity, stabilizes organic matter, reduces emissions, and promotes sustainable agriculture. This investigation can identify the potential for implementing these systems to achieve environmental and economic benefits, aligning with economic standards for long-term sustainability. Future studies should explore seeder performance and its impact on technical, physical, and yield indicators.

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