PERFORMANCE EVALUATION OF SEED DRILL- FERTILIZER UNDER TWO DIFFERENT FARMING SYSTEMS AND TRACTOR PRACTICAL SPEEDS

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ABSTRACT

This study was aim to investigate performance of seed drill - fertilizer (GIL-SAX multisem18) was evaluated under two different farming systems (till and no-till) and tractor speeds (5.28, 7.76 and 8.30 km.h^{-1}). The characteristics were measured including draft force, wheel slip, seed delivery rate, and germination rate. The experiment was organized as a randomized complete block design (RCBD). The significant difference was examined using the least significant difference tests at a P≤0.05. The results showed a minimum draft force and wheel slip under the till system and tractor speed of 5.28 km.h^{-1} interaction. The lowest seed delivery rate was found when no-till was practiced with a speed of 5.28 km.h^{-1}. Adopting the no-till system with the speed of 7.76 km.h^{-1} achieved the highest germination rate. The till system achieved the lowest fuel cost in economic analysis 8395 IQD. ha^{-1} at a speed of 8.30 km.h^{-1}, while the no-till system achieved the lowest cost of seeds 65066 IQD. ha^{-1} and sowing operation cost 36079 IQD. ha^{-1} at speed 5.28 km.h^{-1}. Irrigation and agronomy indicators should be addressed in the further work.

Keywords: draft force, wheel slip, seed delivery rate, germination rate.

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تقييم أداء باذرة مسمدة تحت نظامين مختلفين للزراعة وسرع جرار عملية

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المستخلص

هدفت الدراسة تقييم أداء باذرة مسمدة (GIL–SAX multisem18) تحت نظامين للزراعة (الحرث وبدون حراثة) و سرع جرار (5.28،7.76 و 8.30 كم.ساعة$^{-1}$). المعاملات تضمنت حساب قوة السحب، النسبة المئوية لانزلاق العجلات ، معدل البذور الواصلة و معدل الانبات. تم تنظيم الحقل بتصميم القطاعات العشوائية (RCBD) .تم اختبار النتائج بدلالة أقل فرق معنوي عند المستوى P≤0.05. أظهرت النتائج انخفاض قوة السحب ونسبة الانزلاق تحت نظام الحراثة وسرعة (5.28 كم.ساعة$^{-1}$). تم الحصول على اقل معدل للبذور بنظام بدون الحراث مع سرعة (5.28 كم.ساعة$^{-1}$) . حقق نظام بدون الحرث مع السرعة 7.76 كم .ساعة$^{-1}$ أعلى معدل للانبات. فيما يخص التحليل الاقتصادي ، حقق نظام الحرث اقل كلفة وقود 8395 دينار عراقي .هكتار$^{-1}$ عند السرعة 8.30 كم.ساعة$^{-1}$ بينما تميز نظام عدم الحرث في تحقيق اقل كلفة بذور 36079 دينار عراقي.هكتار$^{-1}$ وتكاليف عملية البذار 36079 دينار عراقي .هكتار$^{-1}$ عند السرعة 5.28 كم.ساعة$^{-1}$.

كلمات مفتاحية: قوة السحب، النسبة المئوية للانزلاق، مهعدل البذور ، نسبة الانبات.

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INTRODUCTION

Finding new ways to increase the yield of cereal crop production is a global ambition (1, 18, 27). For instance, identifying new techniques to reduce the impact of pests (2, 9, 13, 26, 28). In Iraq, wheat represents the most crucial strategic food crop. This crop's importance relies on the fact that it is profitable and growing in all Iraqi provinces and contributes to maximizing the national income (39). In addition, the crop plays a role in employing approximately 20% of the Iraqi population (7,39). This is because wheat is suited to Iraqi conditions such as climate circumstances, soil characteristics and water availability (21). Due to the sustainable improvement of farming systems, sowing methods are the dominant factor affecting seeding efficiency and crops performance (32, 36, 46). Farming systems can be categorized in cultivation practices, field traffic, crops, machines utilized for sowing (16, 45). One of the ways to improve crop yields and minimise field inputs is to adopt a farming system that reduces the number of machineries used and traffic (14). In terms of tillage practices, the farming systems employed by wheat farmers globally are broadly classified as either conventional tillage (CT) or no-till (17). Under the CT systems, primary and secondary tillage are used to remove soil compaction, prepare the appropriate seedbeds and provide better seed germination and root growth (13, 37). However, intensive use of primarily tillage equipment (e.g., moldboard, chisel plough, and sub-soiler) can lead to erosion and damage in the soil structure (31). The no-till system was practiced globally with about 111 million hectares since 2009 and continued to increase until it rapidly reached 155 million hectares in 2014 (23). This practice was applied in Northern Iraq to improve wheat crops and sustainability in the rainfed crops since 2005 (21). The key advantages of no-till are to improving water quality, reducing fuel and time and labour saving (6 ,33). However, no-till has been a relatively recent introduction in Iraq, and its adoption rate and effects are still relatively low (20). Several techniques of wheat seeding methods are available worldwide; the wheat drills are typically designed with different operating widths and rows to cover a wider area and provide a uniform plant population on the farm (44). The main advantages of using seed drills are to saving seeds, effort, covering seeds faster, reducing farm input and saving time, and planting seeds at a uniform depth (43). However, the efficiency of drills is significantly affected by the conditions such as tractor speed and the physical properties of the seeds (30). Thus, this paper attempted to evaluate the performance of GIL seed drills - fertilizer under two different farming systems and three - level tractor speeds under Iraqi conditions. The characteristics were measured including draft force, wheel slip, seed delivery rate, and germination rate. The findings of this research may provide significant information for farmers to be more specific in their applications of wheat growing which can be potentially translated to savings in finances and time.

MATERIALS AND METHODS

Site description

A typical site was selected in Abu Ghraib Research Station/ Office of Agricultural Research/ Baghdad (33°19'33.01" N 44°13'21.58" E, 34.1 m above sea level) during the growing season 2021/2022. This site was located about 38 km from the center of Baghdad. In addition, the area was used for cropping wheat maize in rotation. The soil texture was silty clay. The variety of wheat (*Mawada*) is grown yearly in this district due to water availability and suitability of the soil. According to the Agro-meteorological center/ Iraqi Ministry of Agriculture (2021), the location has a moderate climate. Wheat was planted and irrigated on December, 5th, 2021. Flood irrigation was applied in this study.

Experiment design

The field trial was organised as a random complete block design (RCBD) (2*3) with three replications were followed (5). This design allows for identifying the influence of factors and their interactions. The field was divided into two blocks. The first block was employed for conventional tillage and the second was used for no-till. The length of each block was 200 m, while the width was 13.5 m. Each block had 18 treatments. The treatment dimensions were 20 m in length and 3 m in width to correspond to the working width of the seed drill - fertilizer. The treatments were also randomly selected in each block to reduce the chance of biased outcomes. Transects were left between treatments for tractor stability and field measurements were followed (4). The dimensions of the transect (15 m * 3 m). The independent variables were farming system (till and no-till) and tractor speeds (5.28, 7.76 and 8.30 km.h^{-1}). The dependent variables were a draft force, wheel slip, seed delivery rate, and germination rate.

Field work and research studied parameter

Draft force (DF)

As reported above, two tractors were employed in this research. The measurement of DF was done by attaching a dynamometer between two tractors. The first tractor (Renault 630) was used as a pulling tractor, while the second (Valtra 6400) was used as a neutral. As well, the GIL seed drill - fertilizer was attached to the second tractor. A distance of 20 m aligned with the study area was selected for measuring rolling resistance force. The rolling resistance force was obtained when the tractors and drill (furrow openers lifted) passed the distance assigned under three levels of machinery speeds (5.28, 7.76, and 8.30 km. h^{-1}). Furthermore, the pulling force of the machinery unit (tractors & seed drill) was also measured during the sowing operation for all treatments and replications assigned in the study area underneath tractor speeds (5.28, 7.76 and 8.30 km. h-1). The draft force was calculated by using the following equation (29):

$$DF = Fpu - Fm \ldots\ldots. \{1\}$$

Where:

DF: Draft Force (kN), Fpu: Pull force, tractor and seed drill during sowing operation (kN), Fm: Rolling resistance force (kN)

Wheel slip

This study considered the theoretical and practical speeds to calculate wheel slip. The theoretical speeds were measured by assigning a distance of 20 meters outside the study area to obtain the theoretical time consumed by the machinery unit after passing the distance selected. Furthermore, the same process for measuring the theoretical speeds was repeated to calculate practical speed during sowing operation for all treatments and replications. The following equations (2, 3 & 4) were used to calculate the theoretical speeds, practical speeds, and wheel slip (4).

$$\mathcal{VT} = \frac{\mathrm{DT}}{\mathrm{Tt}} \times 3.6 \ldots\ldots. \{2\}$$

Where VT: Theoretical speed (km.h^{-1}); DT: Distance (m); and Tt: Theoretical time (sec).

$$\mathcal{VP} = \frac{\mathrm{DV}}{\mathrm{T}} \times 3.6 \ldots\ldots. \{3\}$$

Where VP: Practical speed (km.h^{-1}); DV: Treatment length (m); and T: actual time consumed (sec)

$$\mathrm{S} = \left(1 - \frac{\mathrm{Vp}}{\mathrm{Vt}}\right) \times 100 \ldots\ldots. \{4\}$$

S: Wheel slip (%).

Seed delivery rate (SR)

The seed delivery rate is a vital indicator of the actual sowing capacity of metering machinery. In this study, the procedure used to calculate seed rate was based on the methodology suggested by Noora et al. (38). A plastic bottle was placed at the end of the seeding tube for one row to calculate seed delivery rate under different sowing speeds and depths. When the sowing operation was completed, seed and fertiliser (DAP) were collected from the bottle used for a single furrow opener selected and then stored in sealed bags. The seeds were separated from fertiliser and weighed by a sensitive scale in the laboratory. Finally, The following equation was used to calculate the seed delivery rate Zilpilwar and Yadav (46).

$$\mathrm{SR} = \frac{\mathrm{Nc} \times \mathrm{W}}{\mathrm{l} \times \mathrm{b}} \times 10 \ldots\ldots. \{5\}$$

Where SR: Seed delivery rate (kg. ha^{-1}); Nc: Number of seeds collected during a length of treatment; W: Thousand seed weight, (kg); l: Length of treatment, (m); and b: Space between seed drill rows (m).

Germination rate (GR)

the number of plants per meter was counted to estimate the germination rate during monitoring wheat growth. Each treatment and replication were conducted using a wood frame (1 metre square). The number of plants (plant.m2) was calculated for each 1 m2 after 30 days of sowing operation. The following equation was used to determine the germination rate (38, 43).

$$\mathrm{GR}\ (\%) = \frac{\text{Number of normal seedlings}}{\text{Total number of seed sown}} \times 100 \ldots\ldots. \{6\}$$

Economic analysis

The economic analysis was carried out by comparing the costs of fuel used, seed, and sowing operation under till practice against the no-till system (24, 41). All the variables were calculated on a per hectare basis (IQD.ha^{-1}).

Statistical analysis

Analysis of variance (ANOVA) was performed to verify differences between variables. Data were analysed statistically using Statistical Package for Social Scientists (SPSS) version 26.0. The significant difference was examined by using the least significant difference (LSD) tests at the P≤0.05 level. The letters (S_1, S_2 and S_3) represent tractor speed (5.28, 7.76 and 8.30 km.h^{-1}). Furthermore, the lowercase letters (a, b and c) in the figures refer to statistical differences between treatments (P≤0.05).

RESULTS AND DISCUSSION

Draft force

The interaction between farming systems and tractor speeds also showed significant differences in DF (Figure 1). The lowest DF was found at 3.33 kN under the till system when the tractor speed was 5.28 km. h^{-1}, while the speed of 8.30 km. h^{-1} under the no-till system showed the highest DF (9.28 kN)(1).

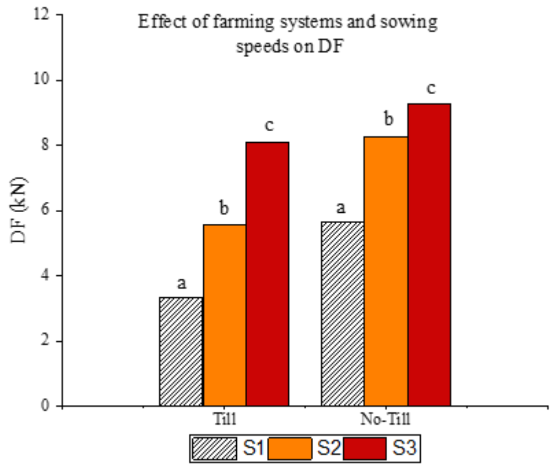

Figure 1. Effect of farming systems and speed tractor on draft force

Wheel slip

The interaction between farming systems and tractor speeds also a significantly impacted on wheel slip (Figure 2). The lowest wheel slip was found at 5.34 % under the till system when the tractor speed was 5.28 km. h^{-1}, whilst, the speed of 8.30 km. h^{-1} under the no-till system showed the highest wheel slip (11.53%). This suggests that working depth and speed are the dominant factors that effectively influence slippage, regardless of the system used (35).

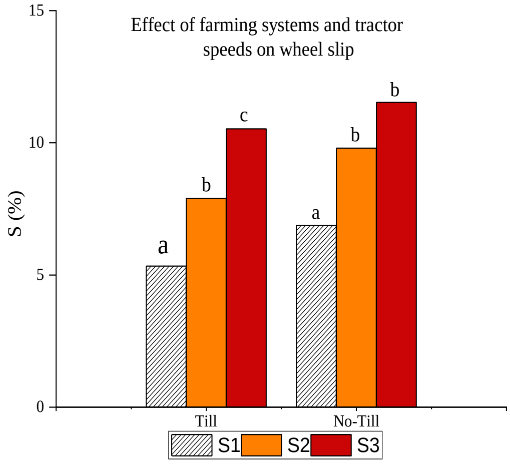

Figure 2. Effect of farming systems and tractor speed on wheel slip

Seed delivery rate

In the same vein, the interaction between farming systems and tractor speeds considerably influenced SR (Figure 4). The lowest SR was found 106.66 under the no-till system when the tractor speed was 5.28 km. h^{-1}, while the speed of 8.30 km. h^{-1} under the till system showed the highest SR (137.77 kg. ha^{-1}). This may suggest that a precision seeding rate was achieved under uniform field conditions, particularly when planting at fast forward speeds (12, 40).

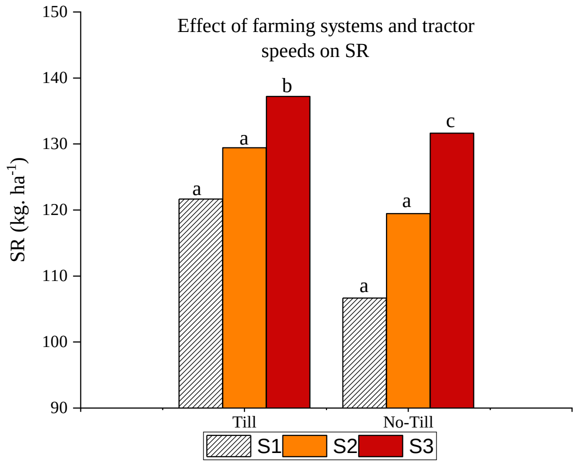

Figure 3. Effect of farming systems and tractor speed on seed delivery rate

Germination rate

The interaction between farming systems and tractor speeds also showed a significant difference in GR (Figure 4). The highest GR was 88% at a speed of 7.76 km. h^{-1} under the no-till system, while the lowest was 77% under the till system at 5.28 km. h^{-1}. This suggests that farming systems and sowing depth are the dominant factors that significantly impact seeding efficiency and germination rate (15).

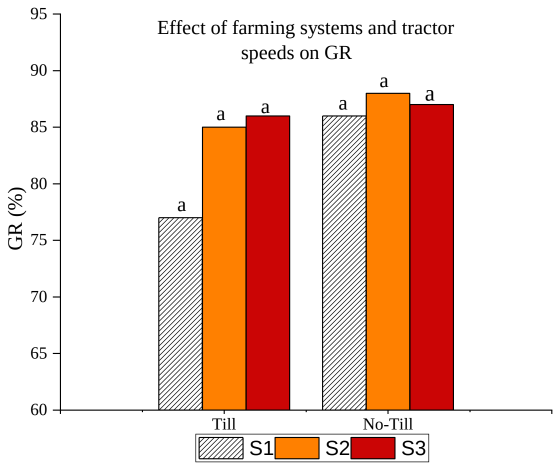

Figure 4. Effect of farming systems and tractor speed on germination rate

Economic analysis

Fuel Costs

The interaction between farming systems and tractor speeds also revealed a significant difference in fuel costs (**Figure 5**). The lowest fuel cost was 8395 IQD. ha^{-1} under the till system when the tractor speed was 8.30 km. h^{-1}, while the speed of 5.28 km. h^{-1} under the no-till system showed the highest fuel cost (14567 IQD. ha^{-1}). These are due to the reduction in the input costs of fuel, labor, tillage machinery, and energy consumed by machinery (23). Thus, a farming system can be efficient when it consumes a minimum number of inputs and provides the maximum outputs by reducing the variable costs (34).

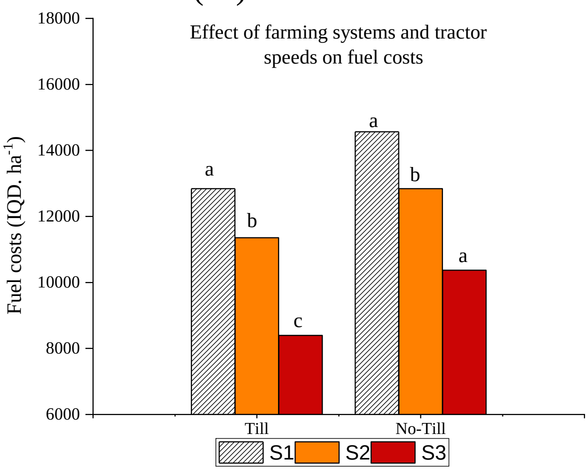

Figure 5. Effect of farming systems and tractor speed on fuel costs

Seed costs (SC)

The interaction between farming systems and tractor speeds also significantly impacts SC (**Figure 6**). The lowest SC was 65066 IQD. ha^{-1} under the no-till system when the tractor speed was 5.28 km. h^{-1}, while the speed of 8.30 km. h^{-1} under the till system showed the highest SC (84044 IQD. ha^{-1}).

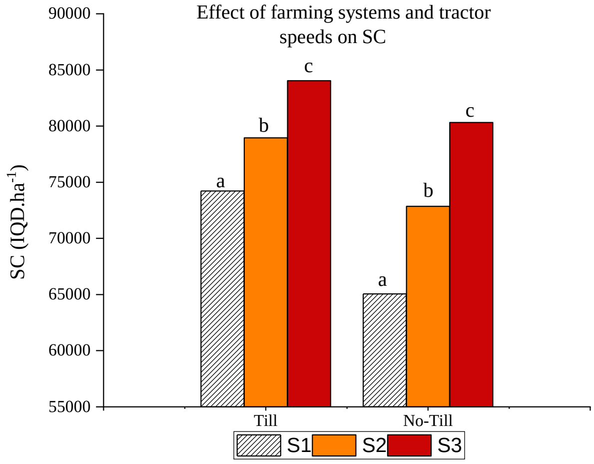

Figure 6. Effect of farming systems and tractor speed on seed cost

Sowing operation cost

The interaction between farming systems and tractor speeds also revealed differences in sowing operation costs (**Figure 7**). The lowest costs were 36079 IQD. ha^{-1} under the no-till system when the tractor speed was 5.28 km. h^{-1}, whereas the speed of 8.30 km. h^{-1} under the till system showed the highest sowing operation costs (140467 IQD. ha^{-1}). This research showed that no-till achieved the lowest sowing operation costs compared to the till farming system at all treatments. This implies farmers who are practicing no-till are superior economically and have a higher net return, as well production costs can reduce compared to conventional tillage farmers (10).

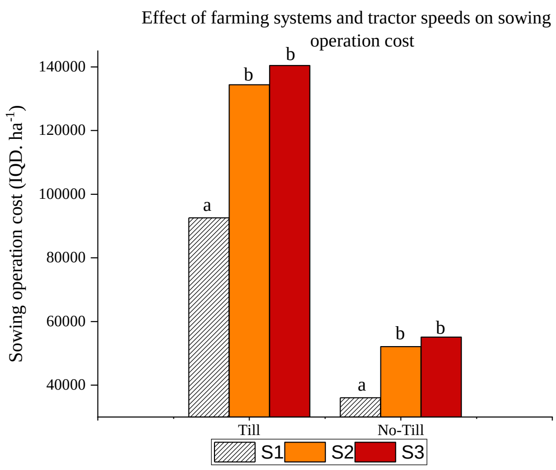

Figure 7. Effect of farming systems and tractor speed on sowing operation cost

Overall, it was also found to have a lower seed rate, seed cost, and sowing operation cost under the no-till system with a speed of 5.28 km.h^{-1} and it also achieved the highest germination rate at a speed of 7.76 km.h^{-1}. These outcomes improve farming systems used for growing wheat crop and may provide better information and knowledge to farmers in regarding saving energy and reducing costs.

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Conflict of interest statement

The authors declare no conflict of interest.

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