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Studying Various Speeds and Depths Using Precision Planter (ÖZDUMAN) And Its Mechanical and Field Effects on Corn (*Zea Mays L*)

Thakir J. M. Dlem[1], Rafea A. M. Nori[2], Mahmood A. Hussein[1*]

[1]Center for Arid Farming and Conservation Agriculture Research's (C.AFCAR), University of Mosul, Mosul, Iraq

[2]Department of Agricultural Machines and Equipment, College of Agriculture and Forestry,University of Mosul, Mosul, Iraq

ABSTRACT

This study aimed to clarify the effect of planting speeds and depths on the mechanical and field performance indicators of a corn crop (*Zea mays L.*) using a precision planter operating with vacuum pressure. The field experiment was conducted at the autumn season of 2024-2025 in Bashiqa district, 12 km Northeast of Mosul, Ninawa, Iraq. The precision planter (ÖZDUMAN) was evaluated in this study. The soil was characterised as silty clay with detailed texture. The Randomised Complete Block Design (RCBD) split-plot was used in the analysis of the data. The experiment concentrated to investigate the effects two main factors, which were planting speeds at three levels (2.6, 4.5, and 2.6 km h^{-1}), and planting depth (3 and 5 cm) on the efficiency of furrow opener operation (%), planting depth deviation (cm), seed distribution uniformity (%), and some other field indicators represented by kernel weight ($kg.m^{-2}$), plant density (plant m^{-2}), and total grain yield ($ton.ha^{-1}$). The results showed that the interaction between slow speed and the second depth (5 cm) recorded the best values in seed distribution uniformity (97%), furrow opener operation efficiency (97%), and total grain yield (11.23 $ton.ha^{-1}$). Meanwhile, the interaction between high speed and the depth of 3 cm recorded the best value in the dry weight of kernels (3.899 $kg.m^{-2}$). Significant differences were also observed in both tested depths and all speeds used in the experiment in plant density ($P<0.05$). The lowest values in planting depth deviation were at the first depth with the first speed (0.14%).

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KEYWORDS: Precision agriculture, grain yield, seeding uniformity

Corresponding Author: **Mahmood A. Hussein**

INTRODUCTION

Precision agriculture is a modern technology in planting maize (*Zea mays* L.), as well as has a significant impacts on crop production, uniformity, and ultimately, grain yield (Kachman and Smith, 1995). The precise placement of seeds in optimal spacing and depth ensures uniform germination, seedling emergence, and plant development, minimizing intra-row competition and maximizing resource capture (Pathak, et al., 2022). Increased operational speed can be provide some advantages by reducing operational times, labour and probably other operational costs (Karayel, et al., 2006; Badua, et al., 2021). However, excessive forward speed of precision planter often compromises seeding accuracy, seed spacing uniformity, and the consistency of seeding depth placement (Virk, et al., 2020; Wang, et al., 2024) Additionally, vibrations intensify at higher speeds, causing seed defection within the seed tube and irregular seed release from the metering unit, leading to skips, doubles or even more, and uneven plant stands (Quanwei, et al., 2017). This non-uniformity directly translates to reduced potential grain yield of maize (Farooq, et al., 2019).

Seeding depth has also a significant effects on soil-seed contact, moisture content, temperature systems during germination, and the anchorage of the seminal root system (Nemergut, et al., 2021). Planting in a very shallow depth risks low soil moisture content and vulnerable seed placement, while excessive depth occurred late emergence, reduce seedlings and final stand establishment due to depleted seed reserves before reaching the surface (Assefa, et al., 2016; Awal, et al., 2019). Optimal depth varies with soil type, moisture conditions, and residue cover (Siemens and Gayler, 2016). While the general effects of speed and depth are widely acknowledged, the specific mechanical performance (e.g., seed spacing uniformity, depth consistency, emergence force requirements) and subsequent field responses are highly dependent on the design and implement adjustment (Kroulík, et al., 2009). The ÖZDUMAN precision planter is a significant technology used in certain regions, yet comprehensive data evaluating its mechanical performance and resultant crop responses across a defined range of operational speeds and seeding depths under controlled field conditions remains limited.

Understanding the intricate interplay between operational parameters (speed, depth) and the specific mechanics of the ÖZDUMAN planter is essential for optimizing its field performance. There is a need to quantify how varying speeds affect its metering accuracy and depth placement precision (mechanical effects), and how these mechanical outcomes, combined with different depth settings, subsequently influence maize emergence dynamics, stand establishment, and early growth characteristics under consistent environmental conditions. Therefore, the objectives of this study were to investigate the mechanical performance and the subsequent field effects of a precision planter (ÖZDUMAN) when planting maize (*Zea mays* L.) across a range of forward travel speeds and seeding depths. By evaluating these parameters concurrently under the same experimental conditions, this research seeks to provide actionable recommendations for optimizing ÖZDUMAN planter adjustments to achieve higher crop establishment and maximize yield potential.

MATERIALS AND METHODS

The field study was conducted during the summer agricultural season of 2024 in the Bashiqa district, approximately 12 km northeast of the city of Mosul – the center of Ninawa Governorate – Iraq. The experimental field area was 3500 square meters (0.35 hectares), and the soil at the experimental site was characterized as silty-clay (48% silt, 34% sand, 18% clay). Prior to planting, the soil underwent a series of preparatory operations to ensure its suitability for crop cultivation in the best possible environment. After flood irrigating the field, and allowing the moisture content to reach the optimal ratio (16 %), initial ploughing of the field, previously cultivated with wheat crop, was performed using a disc plough implement to invert and loosen the soil layers to an average depth of approximately 35 cm. Subsequently, vertical disc harrows were also used to refine the soil surface, break down remaining soil clods, and remove weeds before planting. Following this, the soil was levelled using a land levelling implement to achieve a flat and homogeneous surface, which is crucial for ensuring uniform distribution of irrigation water after planting. For the planting phase, a precision planter of the ÖZDUMAN type was utilized, featuring three furrow openers with a working width of 210 cm, operating via vacuuming in the disc feeding mechanism, which derives its motion from the ground wheels (Figure 1). This machine was tested both in the field and mechanically under ideal research conditions by planting corn (*Zea mays* L.) in mid-July 2024. Regarding fertilization, two main types of fertilizers were applied: Urea [$CO(NH_2)_2$] as a nitrogenous fertilizer, and DAP [$(NH_4)_2HPO_4$], which supplies the soil with both nitrogen and phosphorus in specific ratios according to the crop's varying growth requirements throughout the planting season. As previously indicated, the conventional irrigation system was adopted in this experiment, with intensive irrigation operations carried out before planting to prepare suitable soil moisture for germination, and continued after planting according to the crop's water needs and critical growth stages, taking into account the characteristics of the silty-clay soil and its water retention capacity.

Figure 1. Precision planter (ÖZDUMAN) utilised and tested in this study.

This project included clarifying the extent of the effects of seeding forward speed (as main plots) at three levels (2.6, 4.5, 6.2 km hr^{-1}), and seeding depth (sub-plots) at two levels (3, 5 cm) on some mechanical indicators, which were, (1) Seed distribution uniformity (%); (2) Opener working efficiency (%); and (3) Seeding depth deviation (cm). Additionally, some field indicators were also measured, and they were (4) Kernel weight (kg m^{-2}); (5) number of plant per m^2; and (6) Grain yield (ton ha^{-1}).

Calculations and Analyses

1. **Seed distribution uniformity (SDU)** – (Silva, et al., 2015)

Practical seeding rate

$$SDU\ (\%) = \frac{Practical\ seeding\ rate}{Theoretical\ seeding\ rate} \times 100 \qquad (1)$$

Theoretical seeding rate

2. **Opener Efficiency (Oef)** - (Bertonha, et al., 2015)

Practical depth (*cm*)

$$Oef\ (\%) = \frac{Practical\ depth\ (cm)}{Theoretical\ depth\ (cm)} \times 100 \qquad (2)$$

Theoretical depth (*cm*)

3. **Seed Depth deviation (S.D.d)** – (Karayel, and Özmerzi, 2008)

$$S.D.d\ (cm) = \sqrt{\frac{\sum(di - D)^2}{n - 1}} \qquad (3)$$

$$D\ (cm) = \frac{\sum \mathrm{di\ (cm)}}{\mathrm{n}} \qquad (4)$$

Where:

D: average practical seed depths (cm)

di: practical seed depth

n: number of replications

4. Yield and Yield components

Upon maturity of the corn crop, kernels were manually harvested from the central longitudinal row of each replication, as this row exhibits the highest competitiveness in terms of light, water, and nutrients compared to other rows. Subsequently, the kernels were dried until they reached a storage moisture content of 15%, as per (Elsahookie, and Wuhaib, 1990). After calculating the plant density, kernels weight (kg m^{-2}), and grain yield per sample (kg m^{-2}), the numbers were converted to the standard units (ton ha^{-1}).

A factorial data were analysed using SAS software with a Randomized Complete Block Design (RCBD) of the split-plot type. Differences between treatment means were tested using Duncan's Multiple Range Test at a 5% probability level.

RESULTS AND DISCUSSION

Uniformity of seed distribution (%):

Figure (2) shows a significant effect on this indicator (p-value < 0.05), as the second depth (5) cm with the first speed (2.6) km.h^{-1} achieved the highest uniformity in seed distribution, which was recorded at (97%). As for the first depth (3) cm with the third speed (6.2) km.h^{-1}, there was the least significant difference in the uniformity of seed distribution, which was recorded at (80%). The stability of the planter is evident at the first speed and its role in the efficient operation of the furrows in reducing the roll of the seeds in the seed line is reflected when compared with the remaining speeds and depths. The relationship between speed and uniformity is not linear, but rather follows a predictable degradation pattern beyond certain thresholds. Most conventional planters exhibit noticeable reductions in spacing consistency when speeds exceed 4 - 5 km hr^{-1}, with exponential deterioration occurring beyond 7 km hr^{-1} [7].

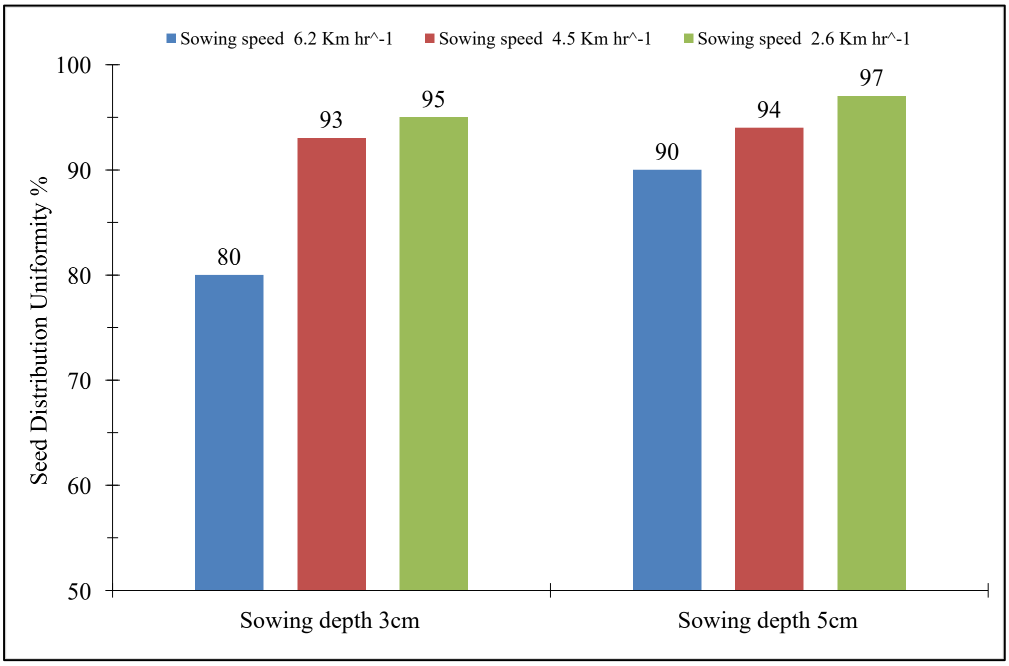

Figure 2. Seed distribution uniformity using precision planter (ÖZDUMAN)

Efficiency of furrow opener (%)

The figure (3) indicates there are presence of a significant difference, as the first and second depths (3 and 5) cm recorded their interaction with the first speed (2.6) km.h^{-1}, which was the highest percentage for the furrow work efficiency (97%) for the two depths. While the same two depths with the third speed (6.2) km.h^{-1}, recording the lowest percentage in this characteristic, which was (81% and 83%), respectively. This difference in ratios is due to the increased forward speed of the cultivator from its ground wheels, which exposes it to soil resistance forces, i.e. soil reaction resulting from land preparation operations. Thereby, affected the regularity of the penetration depth of the furrows into the soil, which was reflected in the efficiency of the furrows' operation.

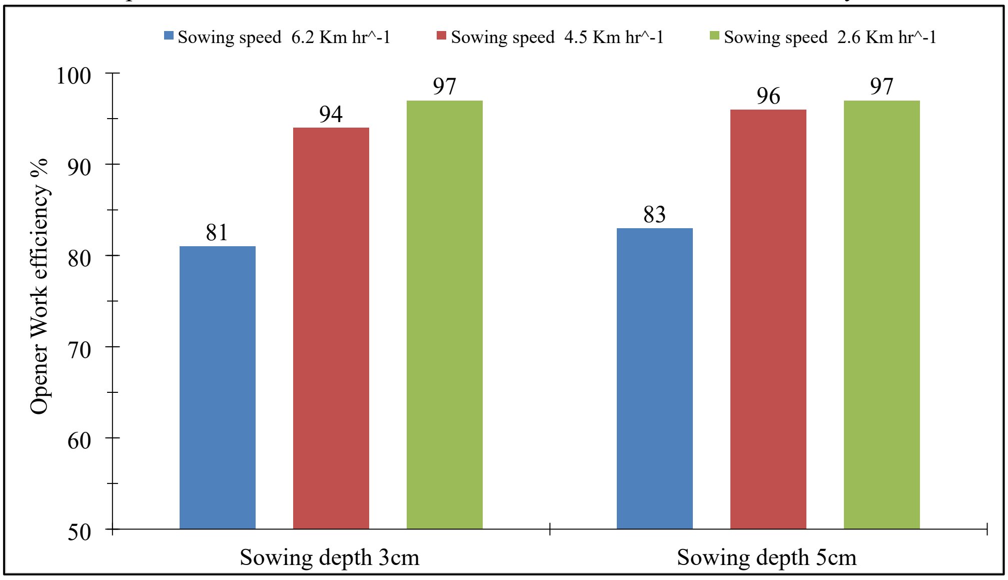

Figure 3. Opener work efficiency for the planter (ÖZDUMAN).

Deviation of sowing depth (cm)

Throughout the figure (4), third speed (6.2) km.h^{-1} significantly outperformed in both depths (3 and 5) cm, recording the highest values (0.52 and 0.73) cm, respectively. While the first speed (2.6) km.h^{-1} with both depths recorded the lowest significant value in seed depth deviation, reaching (0.14 and 0.18) cm, respectively. This is attributed to the increase in ground speed affecting the seed line made by the creeping residential gaps, which is affected by soil resistance. The reason is clear that with the increase in the speed of the puller, the vibration of the working parts of the seed increases, especially the gaps, which is directly responsible for opening the seed line that controls the achieved depth.

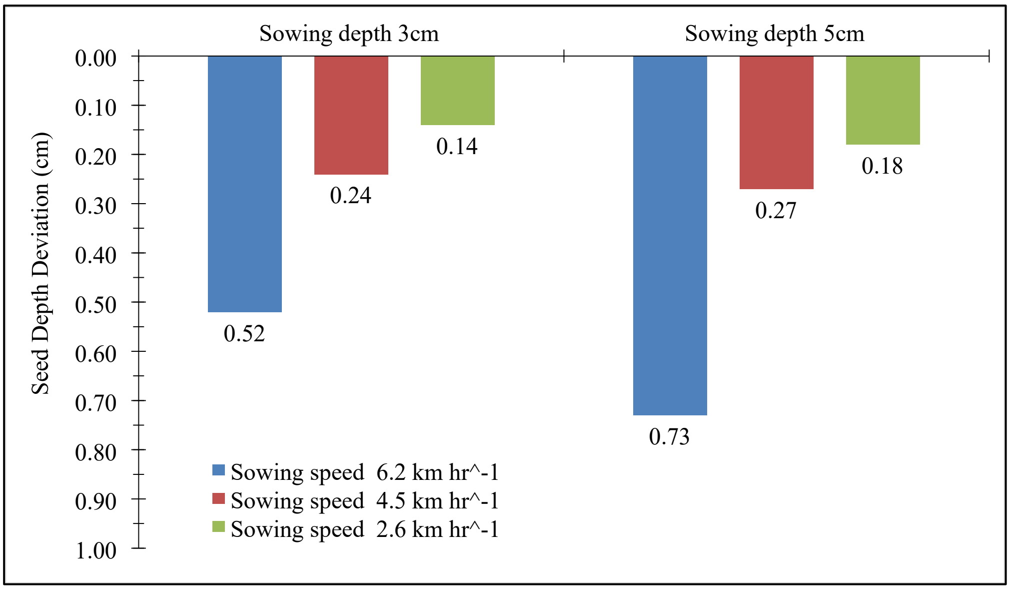

Figure 4. Seed depth deviation for maize planted by the planter (ÖZDUMAN).

Maize kernels weight (kg.m^{-2}) and plant density (plant m^{-2})

The maize kernels weight illustrated in figure (5 - top). The first depth (3) cm with the third speed (6.2) km.h^{-1} recorded the highest significant difference amounting of kernel weight (3.899) kg.m^{-2}. While the second depth (5) cm with the second speed (4.5) km.h^{-1} achieve the lowest significant difference value in this characteristic, recording (3.433) kg.m^{-2}. In general, the values were close despite the divergence in forward speeds. However, the tested seeding depths were close, which was the reason for reducing the difference in kernels weights values by using the precision planting (ÖZDUMAN). The superiority recorded at high speeds might be due to the lower number of plants per m^2 compared to other tested speeds ($p<0.05$), as shown in Figure (5 – bottom). This reduction in plant density when practicing high-speed treatments decreased competition among plants, increasing each plant's opportunity to obtain sufficient nutrients and light, which positively reflected on kernels weight.

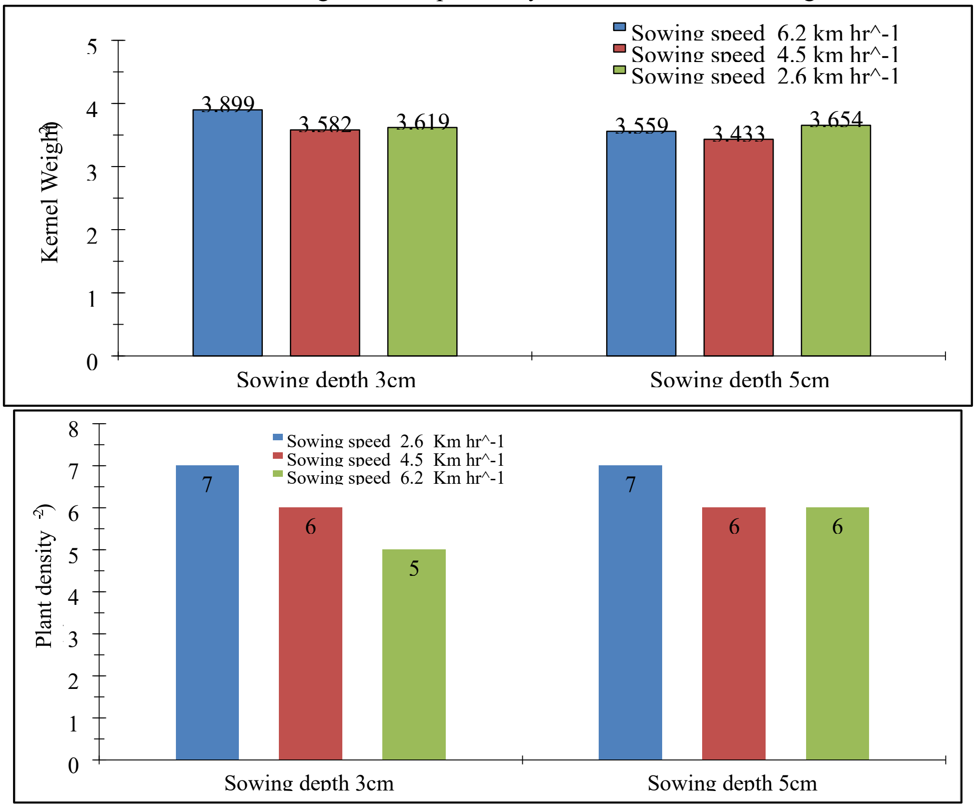

Figure 5. Dried weights of maize kernels reported after harvesting (top); and (bottom) plant density (plant m-2) as affected by speed and depth

Total yield (tons.ha^{-1})

As shown in Figure 6, the best significant value for the total grain yield recorded was (11.23) tons.ha^{-1} at the second depth (5) cm with the first speed (2.6) km.h^{-1} in this research. While the first depth (3) cm with the third speed (6.2) km.h^{-1} recorded the lowest significant value in the grain yield of (8.21) tons.ha^{-1}. This is because the stability of the furrow opener means less deviation in seeding depth. Thereby, increase the uniformity of seeding depth and seed distribution, which positively impacts on the plant density and total grain yield amount.

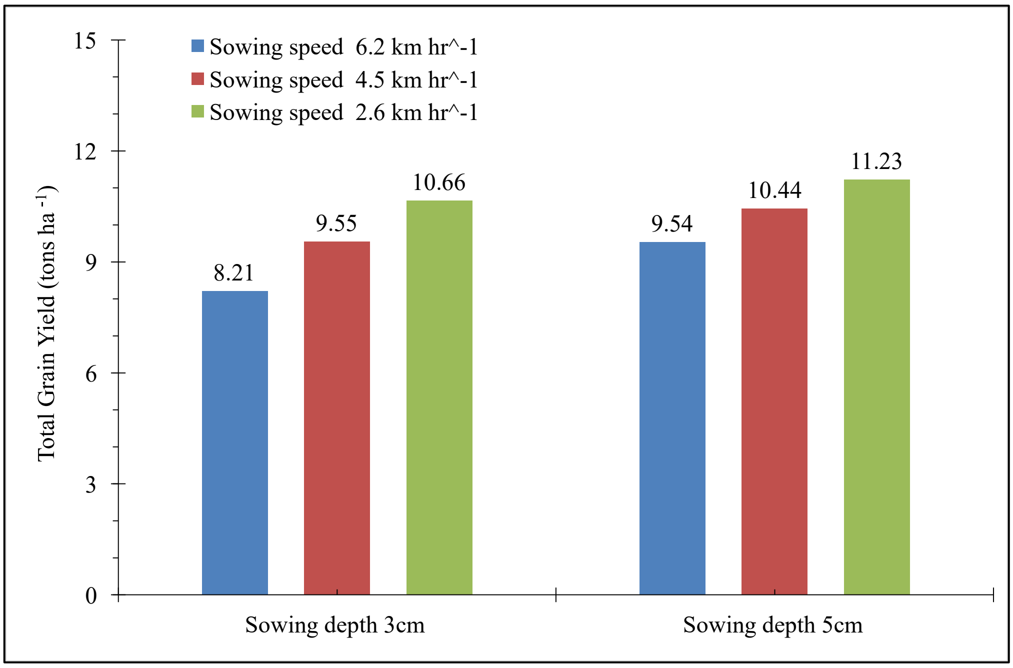

Figure 6. The total grain yield of maize planted by the planter (ÖZDUMAN)

CONCLUSIONS

Both investigated operational parameters (planter forward speed and planting depth) demonstrated statistically significant impacts on all evaluated mechanical and agronomic performance indicators. Specifically, furrow opener work efficiency exhibited instability as forward speed increased from the lowest to highest tested values. This efficiency decline was approximately 16% at the shallowest planting depth (3 cm) and 14% at the 5 cm depth.

Forward speed exerted a more influence than planting depth on maize mechanical and some agronomic indicators. These were included seed distribution uniformity, furrow opener efficiency, seed depth deviation, plant density and grain yields. On the other hand, planting depth demonstrated a stronger effect on specific plant development and physiological indicators. This was particularly evident in measurement such as maize kernel weight, where depth variations caused more significant changes compared to adjustments in forward speed.

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CONFLICT OF INTEREST

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

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