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DETERMINATION OF SELECTED PARAMETERS THAT INFLUENCE PLANTING SPACE UNIFORMITY ON MAIZE SEED

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ABSTRACT
In order to realize optimum plant population for profitable maize production, there is to obtain uniform plant spacing. The objective of this study was, therefore, to determine certain planting parameters that influence uniformity in plant-to-plant and row-to-row spacing. To achieve this, a 4-row animal-drawn planter was used to plant SAMMAZ 14 maize variety in the Experimental Farm of Ahmadu Bello University, Zaria. Treatment factors varied were hopper seed quantity with three levels: 25, 50 and 100 %, three levels of ground speed: 0.6, 0.8, and 1 m/s, and two levels of planting depth: 1.5 and 2.5 cm. Results obtained shows that the multiple index, miss index, feed index and precision index were seen to be affected by planting speed with the best multiple, miss and precision index were achieved at planting speed of 0.8 m/s except for feed index whose best value was achieved at 1 m/s. Similarly, multiple and precision index were both affected by seed hopper quantity but no effect on Miss and Feed index. It was also observed that the best mean values were obtained at 100 % seed hopper quantity. All the indexes were never affected by planting depth while the performance of the planter on seed uniformity indexes improve with moderate planting speed and increasing seed quantity in the hopper. Therefore, planting at 0.8 m/s planting speed and 100 % seed hopper full result in uniform crop establishment for a profitable crop production.

Keywords: Ground Speed, Plant Population, Planting Depth, Precision Index, Spacing Uniformity

INTRODUCTION

Planting of seed with proper placement is significant to ensure adequate germination percentage for optimum and profitable crop production (Badua *et al.*, 2021). This would minimize seed wastage, avoidable thinning, irregular plant population density, poor plant establishments and low yield. Planters are machines that ensure uniformity of seed placement including seed spacing uniformity, seeding depth precision and alignment of the seedling in the row (Ahmed *et al.*, 2021 and Saleh *et al.*, 2022). Thus, precision method of planting must ensure a consistently high seedling emergence under the variety of microclimate and soil condition which are encountered from year to year during planting period, Murray *et al* (2006).

Speedy planting operation results in difficult seed placement control as well as causing seeds to bounce around seed tube and trench in the row units (Staggenborg *et al.*, 2004) which could reduce the gauge wheels rolling resistance due to inadequate application of downforce, consequently resulting in uneven spacing. Planter seed hopper quantity is the key performance parameter that highly influences uniform seedling emergence. Finding optimum down force could be challenging in terms of providing just enough load to prevent loss of ground contact of row units at varying soil conditions and at increasing speeds. Previous researches have demonstrated the negative effects of applying excessive load on the depth and emergence of crops. Planting with excessive load could compact the soil excessively (Hannah, 2009) while not enough load could result in a shallower seeding depth (Karayel *et al*, 2011). Both situations could result in poor root development (Raper and Kirby, 2006) and uneven plant emergence (Karayel *et al*, 2011, Hannah *et al*, 2010, and Gratton *et al*, 2003).

Adequate downforce selection is essential to maximize planter performance (Hanna *et al.*, 2010), with proper downforce providing sufficient force on the soil to achieve targeted seeding depth, while appropriately firming the soil within the seedbed to provide optimum seed-to-soil contact. Proper downforce should not create excessive soil load to cause side-wall compaction that can reduce early root development of seedlings and crop yield potential (Raper and Kirby, 2006). Downforce has normally been applied using mechanical springs, but recent technology includes the use of pneumatic or hydraulic actuators that provide consistent downforce through the full motion range of the row-unit and the capability to control downforce on row-units in real-time during field operation (Morrison, 1988; Zielke and Cannon, 2013; Sauder and Hodel, 2014). As the desire for increase food production necessitates the increase in scale of production, then establishment of uniform plant stand is required. To address these challenges, there is need to vary the planting speed, seed hopper quantity (downforce) and planting depth on the seed spacing uniformity to obtain appropriate plant stand. The aim of this study is therefore, to assess the influence of planting speed, seed hopper quantity (as downforce) and planting depth on seed spacing uniformity to bridge the gap observed

MATERIALS AND METHODS

Equipment Set up and Instrumentation

A locally developed four animal-drawn maize precision planter using two sets of bulls was used in planting SAMMAZ 14 maize variety (Plates 1 and 2). The 4 rows of the planter were spaced 750 mm apart. The planter was drawn on each treatment in an experimental plot of 2.25 × 5 m marked with a labeled wooden peg using a 100 m steel measuring tape. A graded maize seed variety of SAMMAZ 14 was poured in the hopper at varying quantity of 25, 50 and 100 % hopper full with the planter furrow opener set a different depth of 1.5 and 2.5 cm to run the experiment. A Casio stop watch was used for timing the planting process at determined speeds of 0.6, 0.8 and 1m/s). The planter units were labeled P1, P2, P3 and P4, and their respective observations were recorded. The effect of the above-mentioned variables on the average seed spacing uniformity was then determined. The study was conducted in the department of Agricultural and Bio-resources Engineering, Ahmadu Bello University Zaria.

Plate 1: The Developed planter

Plate 2: Planter in operation

Experimental Design and Statistical Analysis

Randomized Complete Block Design (RCBD) in a 3 × 3 × 2 experimental design with three replications was adopted in evaluating the planter while the slope of the field is the blocking factor. The experiment comprised of three levels of planting speed (S1 = 2.16 km/h, S2 = 2.88 km/h, and S3 = 3.6 km/h), three levels of seed quantity (W1 = 25%, W2 = 50%, W3 = 100%) and two levels of planting depth (D1 = 1.5 cm and D2 = 2.5 cm). The planter was designed to discharge seed at intra row space of 250 mm. Each whole plot was equivalent to one whole planter pass (5 × 2.25m) as adopted by Badua (2021). Data obtained from the experiment was subjected to analysis of variance ANOVA using Statistical Analysis System (SAS) software. Mean differences were tested using Duncan Multiple Range Test (DMRT) to determine the significance of variables.

Data Collection

Data collection and performance evaluation of the planter was carried out on the field by adopting the following procedures:

Plant spacing **-** Plant spacing was measured after emergence was considered complete as adopted by Badua (2021). A 10 m standard measuring tape was laid out along the 5 m strip and accumulated spacing readings were recorded. Theoretical plant spacing was calculated based on the seeding rate applied during planting and spacing of planter's rows. Using this data, the equivalent theoretical plant spacing (S_t) was 250 mm. Thus, measurements of plant-spacing uniformity used in this study were in accordance with indices defined by ISO 7256/1-1984(E). These indices are multiples index, miss index, quality of feed index and precision index:

Multiple Index **-** Multiples index (D) specifies the number of spacing's on each experimental unit (EU) less than or equal to 0.5 times the theoretical spacing. This was calculated using equation (1):

$$D = \frac{N_d}{N} \quad (1)$$

where:

D = Multiple Index

N_d = Number of measured plant spacing that are less than or equal to 125 mm

N = Total number of spacing measured on each experimental unit.

Miss Index **-** Miss Index (M) indicates the number of spacing on each EU that are greater than 1.5 times the theoretical spacing. This index was calculated using equation (2):

$$M = \frac{N_m}{N} \quad (2)$$

where:

M = Miss Index

N_m = Quantity of measured distance between successive plants that are greater than 375 mm.

Quality of Feed Index **-** Quality of feed index (A), sometimes referred as singles, is used to determine the proportion of measured spacing on each EU that are within 0.5 and 1.5 times the theoretical spacing. The quality of feed index defines how close the measured spacing is to the nominal spacing (Kachman and Smith, 1995), with greater values indicating better planting performance (Fallahi and Raoufat, 2008). Equation (3) was used to calculate this index:

$$A = \frac{N_a}{N} \quad (3)$$

where:

N_a = Number of measured plant spacing that are within 125 –375 mm.

Precision Index **-** Precision index (C) quantifies the variability of plant spacing after skips and doubles are removed, or spacing that are considered singles. Lower values of precision index indicate lower spacing variability and better performance of the planter (Fallahi and Raoufat, 2008). It was calculated using equation (4) as suggested by Kachman and Smith (1995).

$$C = \frac{S_a}{S_t} \quad (4)$$

where:

C = Precision index

S_a = Standard deviation (SD) of N_a

S_t = Theoretical spacing

RESULTS AND DISCUSSION

Seed Spacing

The ANOVA result on the second level of interaction effects among planting speed, seed quantity and planting depth on seed spacing was presented on Table 1. At 0.8 m/s planting speed with seed quantity of 25% and planting depth of 2.5 cm, the highest seed spacing of 23.92 cm which was almost the same as 23.87 cm seed spacing at 0.8 m/s with 50% and 1.5 cm was obtained. The least seed spacing of 19.37 cm at 1 m/s, 100% and 2.5 cm was recorded. This indicate that the best seed spacing could be obtained at moderate planter forward speed and seed quantity with a shallow soil penetration as lower weight of soil is opened. This conforms to the result obtained by Panning *et al.* (2000).

Table 1: Effect of Interaction between Planting Speed, Seed Quantity and Planting Depth on Seed Spacing

Mean Seed Spacing (cm)			
Planting speed(m/s)	**Seed quantity (%)**	**Planting depth (cm)**	**Seed spacing (cm)**
	25	1.5	21.02g
		2.5	23.50a-d
	50	1.5	22.59de
0.6		2.5	22.89b-e
	100	1.5	23.18a-e
		2.5	23.72abc
	25	1.5	23.13a-e
		2.5	23.92a
	50	1.5	23.87ab
		2.5	23.39a-e
0.8	100	1.5	23.57a-d
		2.5	23.11a-e
	25	1.5	21.49fg
		2.5	22.80cde
	50	1.5	22.40ef
1.0		2.5	21.55fg
	100	1.5	23.00a-e
		2.5	19.37h
SE±			0.302

Means followed by same letter(s) in the same column are not different significantly at *P=0.05* using DMRT

Results obtained while considering the main effects of ground speed and seed hopper, quantity (downforce), planting depth, first and second level of interactions of the variables for the experiment were given in Table 2. There was no significant effects (p>0.05) on the first level of interaction of planting speed/seed quantity, planting speed/planting depth, seed quantity/planting depth as well as second level of interaction of planting speed/seed quantity/planting depth on multiple index, miss index, feed index and precision index. However, there was significant differences in multiple, miss, feed and precision index across planting speed. The highest mean for multiple and feed index were obtained at 0.6 and 0.8 m/s, respectively; while for both miss and precision index were obtained at 1 m/s. The lowest mean result for these indexes were obtained at 0.8 m/s except for feed index whose lowest mean result was obtained at 1 m/s. The result also shows that with lower planting speed, better outcome are likely to be obtained. This is also in agreement with the result obtained by Badua (2021).

Significant differences were also observed in multiple and precision index but not in miss and feed index across seed hopper quantity. The highest mean value of multiple index and precision index were obtained at 25 % and 50 % seed hopper quantity respectively, indicating that poor performance of the planter is likely to occur with decrease in downforce. The least mean multiple and precision index were both obtained at 100 % seed hopper quantity. This may be attributed to the possibility of obtaining better result with increase in download from hopper quantity. No any significant differences were, however, obtained in multiple, miss, feed and precision index across planting depth.

Table 2: Effect of planting speed, seed hopper quantity and planting depth

	Index			
Treatment	**Multiple**	**Miss**	**Feed**	**Precision**
Planting speed S (m/s)				
0.6	0.019a	0.016b	0.964a	0.117b
0.8	0.001b	0.012b	0.987a	0.105b
1.0	0.005b	0.102a	0.893b	0.147a
SE±	0.0045	0.0088	0.0108	0.0053
Seed quantity Q (%)				
25	0.017a	0.038	0.945	0.121ab
50	0.009ab	0.044	0.947	0.136a
100	0.000b	0.048	0.952	0.111b
SE±	0.0045	0.0088	0.0108	0.0053
Planting depth D (cm)				
1.5	0.010	0.035	0.955	0.123

2.5	0.008	0.051	0.941	0.123
SE±	0.0037	0.0072	0.0088	0.0043
Interaction				
S*Q	NS	NS	NS	NS
S*D	NS	NS	NS	NS
Q*D	NS	NS	NS	NS
S*Q*D	NS	NS	NS	NS

Means followed by the same letter(s) are not different statistically at *P=0.05* using DMRT NS= Not significant

CONCLUSION

The performance evaluation of the home-developed four-row animal drawn precision seed planter was conducted at the selected planting speed of 0.6, 0.8 and 1 m/s; hopper seed quantity of 25, 50 and 100 %; and planting depth of 1.5 and 2.5 cm. The multiple index, Miss Index, Feed index and precision index were seen to be affected by planting speed with the best multiple, miss and precision index were achieved at planting speed of 0.8 m/s except for feed index whose best value was achieved at 1 m/s. similarly, multiple and precision index were both affected by seed hopper quantity but no effect on Miss and Feed index. The best mean values were obtained at 100 % seed hopper quantity. All the indexes were never affected by planting depth while the performance of the planter on seed uniformity indexes improve with moderate planting speed and increasing seed quantity in the hopper. Therefore, planting at 0.8 m/s planting speed and 100 % seed hopper full result in uniform crop establishment.

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