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# MODIFICATION AND PERFORMANCE EVALUATION OF AN IMPORTED THREE-ROW ANIMAL-DRAWN MAIZE PLANTER FOR PLANTING SOYBEANS

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**ABSTRACT**

Increase in demand of functional and affordable planters and the inability of the peasant farmers in Nigeria to purchase imported planters stressed the need for development of a locally produced planters that could address the challenges encountered in grain planting. A three row imported animal-drawn maize planter was modified having identified its deficiencies. The modified planter consists of hopper, seed metering device, delivery tube, furrow opener, covering device, pressing wheel, frame, handle and traction wheel. It was evaluated in the laboratory and field using maize and Soybean as test crops. Parameters determined are planting speed, seedling emergence, plant to plant spacing, effective field capacity, germination count, planting efficiency, seed delivery rate, number of seeds per hole and percent seed damage. A combination of three planting speeds (2, 1.1 and 0.8m/s) and three seed weights (2.9, 2.2 and 1.1kg) were used for the performance evaluation. Results obtained were analyzed in a Completely Randomized Block Design. It showed that seed delivery rate was 24.8kg/ha and effective field capacity was 0.12ha/ha while the highest germination count of 83% was obtained at 0.8m/s planting speed and 2.9kg seed weight. The best of planting efficiency of 86.4% was obtained at 1.1m/s planting speed and 2.9kg seed weight. Plant to plant distance of 26.4cm was obtained at 2m/s planting speed and 2.2kg seed weight. One seed per hill was obtained at the all combinations. The modified planter has proved to be suitable for eliminating the limitations associated with the imported planter.

**Keywords**: Evaluation, Germination Count, Planter, Planting Efficiency, Planting Speed

## INTRODUCTION

Planting is one of the principal operations of agriculture. It is the process of placing seeds, tubers, cutting at predetermined space and depth in the soil then covers the seeds completely or partly for appropriate germination (Olaye and Bolufawi, 2001). Most farmers in Nigeria still practices traditional manual planting methods which are tedious and time consuming, thus requiring several man–hours per day thereby causing delay in planting operation and thus detrimental to the yield of crop. Similarly, Sultan and Gupta (1994) argued that human labour is becoming more expensive in developing countries besides causing serious back ache for the farmer and limiting the size of field planted. Kyada and Patel (2014) and Abubakar (1994) also reported that with the conventional hand sowing method, planting depth and seed spacing are not controlled as required. However, the fundamental problem associated with most of the existing planters was identified to be seeds crushing by the metering mechanism that leads to poor germination. Other problems observed include soil sticking to the planter when used under wet condition and blocking of the seed passage. Seed spacing is also seen to be erratic in some case which would lead to an overall loss in yield per unit area.

Studies have shown that about 95% of the Nigerian farmers have small land holdings while available seed planters are imported and specifically designed to operate in a large mechanized farm. They are also expensive, difficult to maintain and/or operate and unsuitable to local environmental conditions. It thus, becomes difficult for peasant farmers to acquire and maintain such planters for profitable crop production (Murray *et al*., 2006; Olaye and Bolufawi, 2001). The desire to increase food necessitates that the scale of production most be increased. To achieve this, an appropriate planting mechanism is required. The objective of this paper is, therefore, to modify and evaluate an imported three-row animal drawn planter that would ease the bottle- neck of planting process of the peasant farmers using maize and soybean as test crops.

## MATERIALS AND METHOD

### Description of the Existing Animal Drawn Planter

The planter used for the study is an imported three-row animal drawn maize planter (Fig. 1). It consists of the frame, handle, drive wheel, seed and fertilizer hoppers, inclined seed plate with edge cells, furrow opener, delivery tube and bevel gears as described below:

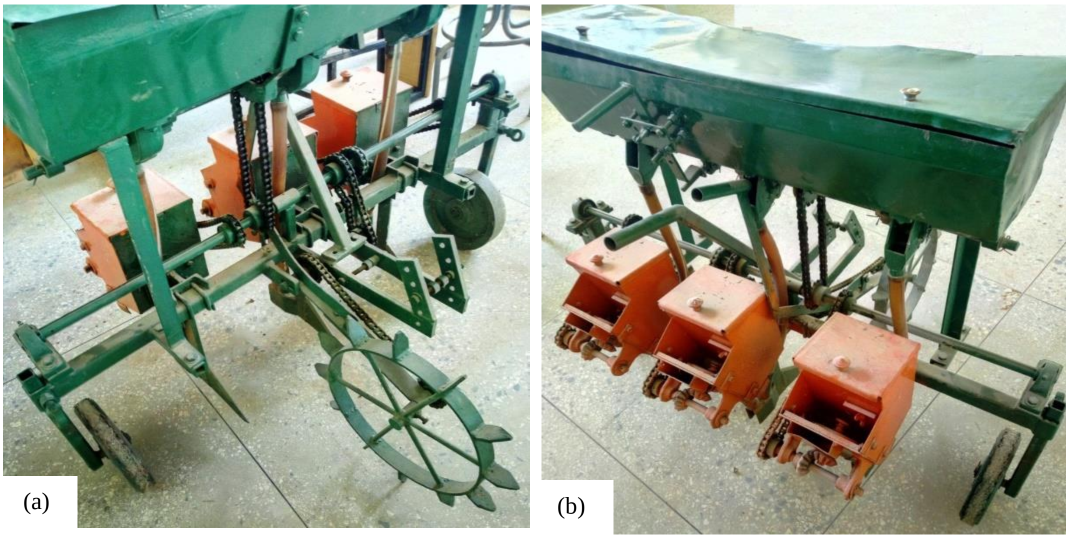

(a) (b)

Figure 1: Pictorial Views of the Three-Row Maize Planter (a) Front and (b) Rear Views

***Frame -*** is the component on which all other components are attached. It was made of mild steel of 40 x 40 mm square pipe. The ***handle*** is made of mild steel pipe with a length of 850 mm whose radius is 2.6 mm. The ***traction wheel*** is made up mild steel of 3 mm with 350 mm diameter. It has 12/six mild steel bars welded on the pipe placed at the center of the traction wheel. There are two traction wheels that were fixed on the sides of the frame. A ***seed hoppe***r is made of mild steel sheet metal of 1.5 mm thickness. It is trapezoidal in shape mounted on top of the frame but slanted at 45° towards the bottom. It has a height of 180 mm. The ***fertilizer box*** is also trapezoidal in shape made of mild steel sheet metal of 1.5 mm thickness. The ***seed metering mechanism*** is a major component in a planter. It is expected to pick the required number of seeds and delivers them into the soil through the delivery tube at a pre-determined depth. This device is made of cast steel of 240 mm diameter and 4 mm thickness with 5 seed cells. The ***furrow opener*** is of shoe type and made of 50 mm mild steel angle iron with a length of 300 mm. ***Seed delivery tube*** is located below the metering casing into which metering plate releases the seeds conveyed and deposit them into the furrow. The delivery tube is made of 15 mm diameter flexible rubber pipe of 100 mm length. The ***Guide Wheel*** is fixed in front of the planter. It is designed to create a path through which the planter follows. It has a 150 mm diameter with 12 mild steel bars welded on its circumference (Figure 1). When the furrow-opening operation is disengaged, the guide and traction wheels supports the weight of the planter. The major function of the ***bevel gears*** is to transmit power at a speed ratio of 1:1. They are made of cast iron and have major and minor diameters of 66 and 33 mm, respectively. The overall length and width of the planter from the upper end are 900 and 240 mm respectively, while the similar dimensions towards the bottom are 900 and 170 mm respectively. It has a maximum height of 160 mm.

***Instrumentation:*** Instruments used for the study are: digital stop watch: for determining time during planting, 100 m measuring tape for measuring distance, 300 mm plastic ruler, 300 mm long wooden peg and a digital weighing balance (100 kg capacity with 0.01 accuracy) for measuring weight of the test crops (maize and soybeans)

***Modifications Considered*****:** After a preliminary test, the followings modifications were considered in the design of the planter for effective maize and soybean planting: Meters a single seed at a predetermined rate/output of 19Kg/ha; Meter the seed with the required accuracy to meet the planting pattern requirements of 15 cm plant to plant distance and 70 cm row to row distance for soybeans as recommended by FAO (1980). It should cause minimal damage to the seed during the metering process as the metering device is expected to allow smooth follow of seeds.

**Determination of Design Parameters**

The following parameters of the planter are determined:

***Determination of number of cells -*** The numbers of the cells were determined using the expression below given by Ibukun *et al* (2014).

Number of cells = $\frac{\pi d_w}{s_c}$ (1)

where: $d_w$= diameter of the planter traction wheel = 350 mm; $s_c$= intra row spacing of the seed = 250 mm; $\pi$ = 3.142

Therefore, the number of cells = 4.

***Determination of seed population-*** The seed population was determined using the equation reported by Soyoye *et al* (2016).

$p_s$ =n$\left[\frac{A}{S_r s_c}\right]$ (2)

where;

$p_s$ = actual number of seed discharge; n = average number of seed discharge; A = area of the field; $s_r$= inter row spacing; $s_c$ = intra row spacing; $n = 1, A = 45\,m \times 9\,m\,,\ s_r = 0.75\,m, s_c = 0.25\,m$

$\therefore\ p_s = 2160\ seeds$

***Seed delivery rate $R_s$ (kg/ha) -*** The seed delivery rate was determined from the equation given below as reported by Deshpande *et al* (1993).

$R_s = \frac{Q_p}{A}$ (3)

where;

$Q_p$ = Quantity of planted seed (kg);

A = Area of planted field (ha);

$R_s$= Seed delivery rate (Kg/ha)

For maize:

$Q_P$ = 1.02kg, A= 0.041 ha; $R_S$ = 24.8 kg/ha

***Seed damage $D_s$ (%) -*** The damage efficiency was determined from the following expression as reported by Deshpande *et al* (1993).

$D_s = \frac{Q_d}{Q_p}$ x 100 (4)

where:
$Q_d$ = Quantity of damaged seed (kg);
$Q_p$ = Quantity of planted seed per unit time (kg)
$D_s$ = Seed damage (%).
The damage efficiency = 0%

***Weight of the planter-*** The weight of the planter is the sum of the weights of the planter components:

$$W_p = W_h + W_f + W_{pw} + W_{sp} + W_H + W_{tw} + Wdt \quad (5)$$

where;
Wp = Total weight of the planter;
$W_h$= Weight of the hopper (49 N)
$W_f$ = Weight of the frame (24.7 N);
$W_{pw}$= Weight of the pressing wheel (38.1 N)
$W_{sp}$ =Weight of the seed plate (1.2 N);
$W_H$= Weight of the handle (17.9 N)
$W_{tw}$ = Weight of the traction wheel (1.2 N);
Wdt = Weight of delivery tube (0.2 N)
Wp = 49 + 24.7 + 38.1 + 1.2 + 17.9 + 1.2 = 132.3 N

**Planter evaluation - The planter was evaluated both in the field and laboratory:**

***Laboratory test -*** This was undertaken to check the number of seed discharged per outlet, and number of damaged seeds, seed rate and seed spacing were noted and recorded. The hopper was loaded with 400g of maize and soybean seeds on separate trials. The planter was suspended on a vice and turning the wheel rotates the metering device. For each trial, the drive wheels were rotated 10 times at low speed. A stop watch was used to record the time taken to complete the revolutions. The seed discharged were weighed on a weighing balance and the procedure was repeated three times.

***Field Test -*** Planting was conducted directly on a plot of 45 x 9 m area (405m$^2$) using maize and soybean seeds as test crops on separate trials. It was ploughed and harrowed to obtain a smooth bed. Planting was carried out using three different levels of speed (2 m/s, 1.1 m/s and 0.8 m/s) and three levels of seed weight (2.9 kg, 2.2kg and 1.1kg) in the hopper to examine the distribution pattern, the number of seeds discharged and planted per plant stand and also observe the missing point along row, seed spacing and percentage of germinations. Three persons were involved in the determination of the field efficiency, one person operated the planter one guides the animals while the other person observed and recorded the time for the activities.

**Experimental Design and Analysis**

A 3 × 3 factor factorial design in a Randomized Complete Block Design (RCBD) was used to analyze the experimental results. The experimental units were replicated three times. However, the performance indication data were subjected to analysis of variance using Statistical Analysis Software (SAS). The effect of variation between the independent variables and their interaction were assessed at 5% and 1% levels of significant. Significant variables were further analyzed using Duncan Multiple Range Test (DMRT).

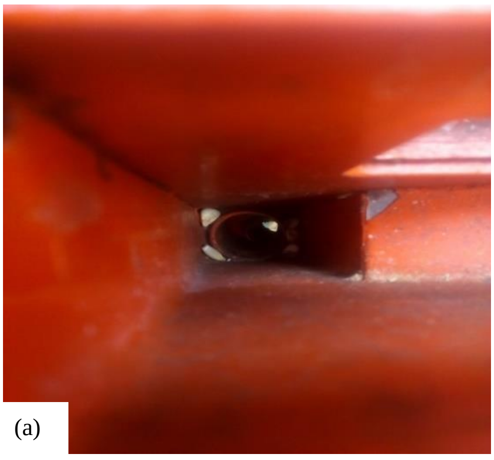
**Modification of the imported planter**

During preliminary test, problems were identified with some of the components of the planter. Therefore, those components were modified and they are as follows;

i. ***Delivery system***: a gap between the delivery tube and the hopper wall was observed which causes the hanging of seed (Figure 2a). It was modified by filling the gap using body filler (Figure 2b).
ii. ***Furrow opener:*** soil stacking that subsequently blocks seed outlet to the furrow was noticed. This component was redesigned to shoe type for free deposition of seeds from delivery tube to the opened furrow (Figure 3).
iii. ***Covering device:*** the planter comes without seed covering device which drags soil to cover deposited seeds in the furrow. This component is very critical for good germination, as part of the modification this component was added to the planter (Figure 4).
iv. ***Press wheel:*** for pressing the soil to provide good contact between seed and surrounding soil was missing. This component was also added to the planter (Figure 5).
v. ***Metering device:*** the planter comes with maize metering device. Another device was designed to plant maize and soybeans.

**Statistical Analysis**

Data obtained from the performance evaluation of the modified animal-drawn planter using maize and soybean as test crops were subjected to analysis of variance using Statistical Analysis Software (SAS). The effect of variation between the independent variables (seed weight and planting speed) and their interaction were assessed at 5% and 1% levels of significant. Significant variables were further analyzed using Duncan Multiple Range Test (DMRT) to validate the results obtained.


(a)

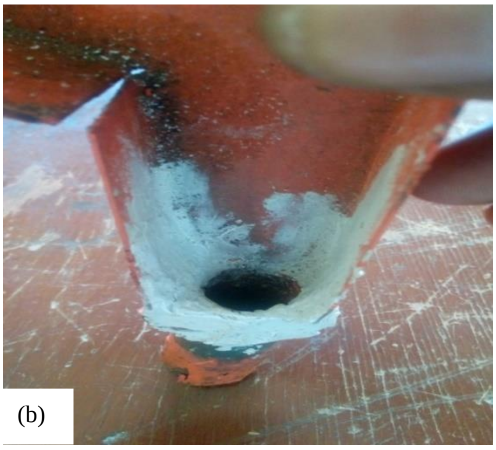

(b)

Figure 2: Pictorial view showing (a) seed hanging during planting and (b) modified delivery system of the imported planter

Fig 3: Pictorial view of in-cooperated Furrow Opener

Fig 4: Pictorial view of the covering device

Fig, 5: Pictorial view of the planter with the press wheel

**RESULTS AND DISCUSSION**

Results obtained from the modified three-row animal-drawn planter as influenced by seed weight and planting speed on number of seed per hill, germination count, planting efficiency and plant to plant distance while planting maize are presented in Table 1. The result indicate that, there was no significant difference in the seed weight on number of seed per hill, germination count, planting efficiency and plant to plant distance at 5% level of significance (P≥0.05) as obtained by Ibukun *et al* (2014), Olaye and Bolufawi (2001) and Soyoye *et al* (2016).. Similarly, no significant difference was observed in the planting speed of the planter on number of seed per hill, germination count, planting efficiency and plant to plant distance. However, there is significant difference of plant to plant distance at the same level of significance. The plant to plant distance decreased from 0.8 m/s to 2.0 m/s planting speed. At 0.8 m/s, the plant to plant distance was 31.7 cm which was significantly different from 27.7 cm and 27.3 cm obtained at 1.1 m/s and 2.0 m/s forward speed, respectively. However, 27.7 cm and 27.3 cm are statistically the same. The plant to plant distance ranges from 27.3 cm to 31.7 cm, thus agreeing with the results obtained by Olaye and Bolufawi (2001).

Results obtained does not also show any significant difference in the interaction between the seed weight and planting speed on the number of seed per hill, germination count, planting efficiency and plant to plant distance at the same level of significance.

**Table 1: Performance of modified imported three-row animal drawn planter as influenced by the selected parameters in planting maize**

| Treatments | No of seed per hole | Germination count | Planting efficiency (%) | Plant to Plant distance (cm) |
|---|---|---|---|---|
| **Seed weight (kg)** | | | | |
| 1.1 | 1.00 | 0.50 | 56.5 | 30.0 |
| 2.2 | 1.00 | 0.46 | 58.4 | 29.1 |
| 2.9 | 1.00 | 0.46 | 48.6 | 27.6 |
| SE+ | 0.00 | 0.031 | 3.745 | 1.206 |
| **Forward speed (m/s)** | | | | |
| 0.8 | 1.0 | 0.51 | 54.5 | 31.7a |
| 1.1 | 1.0 | 0.47 | 53.8 | 27.7b |
| 2.0 | 1.0 | 0.44 | 55.2 | 27.3b |
| SE+ | 0.000 | 0.031 | 3.745 | 1.206 |
| **Interaction** | | | | |
| W*S | NS | NS | NS | NS |

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

The results of the effect of planting speed and seed weight on number of seed per hill, germination count, planting efficiency and plant to plant distance for the modified imported three-row animal drawn planter using soybeans is presented in Table 2. The result obtained also shows no significant different (P≥0.05) on number of seed per hill, germination count, planting efficiency and plant to plant distance of the planter. Similarly, there is no significant different (P≥0.05) effect in the interaction between the planting speed and seed weight on number of seed per hill, germination count, planting efficiency and plant to plant distance.

**Table 2: Performance of modified imported three-row animal drawn planter as influenced by selected parameters in planting soybeans**

| Treatments | No of seed per hole | Germination count | Planting efficiency | Plant to Plant distance |
|---|---|---|---|---|
| **Seed weight (kg)** | | | | |
| 1.1 | 1.00 | 0.56 | 52.9 | 42.7 |
| 2.2 | 1.00 | 0.58 | 56.3 | 37.2 |
| 2.9 | 1.00 | 0.63 | 62.6 | 42.7 |
| SE± | 0.00 | 0.049 | 4.941 | 3.097 |
| **Forward speed (m/s)** | | | | |
| 0.8 | 1.0 | 0.58b | 55.1 | 39.6 |
| 1.1 | 1.0 | 0.73a | 65.5 | 42.8 |
| 2.0 | 1.0 | 0.46b | 51.3 | 40.2 |
| SE± | 0.000 | 0.049b | 4.941 | 3.907 |
| **Interaction** | | | | |
| W*S | NS | NS | NS | NS |

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

Table 3 shows the results obtained while using a constant seed weight of 2.9 kg at varied planting speed. It was observed that the number of seed per hill decreases from two seeds to one seed. The maximum number of seed per hill of two seeds was recorded when 2.9 kg of seed weight and 0.8m/s of planting speed were used, and this was significantly higher ($P \leq 0.05$) compared with the other results obtained by Olaye and Bolufawi (2001) and Soyoye *et al* (2016). Howecer, at constant 1.1 kg seed weight and varying the planting speed the results obtained showed that there is a stable number of one seed per hill throughout the planting process as obtained by Deshpande *et al* (1993), Olaye and Bolufawi (2001) and Soyoye *et al* (2016). Generally, at all levels of interaction between the seed weight and planting speed gave one seed per hill, except for 2.9 kg and 0.8 m/s of seed weight and planting speed with two seed per hill. This implies that the lowest number of seed per hill could be achieved at all levels of interaction except that of 2.9 kg and 0.8 m/s of seed weight and planting speed.

**Table 3: Interaction between seed weight and forward speed on the performance of modified imported three-row animal drawn maize planter on number of seed per hole using maize**

| Treatments | Seed Weight (kg) | | |
|---|---|---|---|
| | **1.1** | **2.2** | **2.9** |
| **Forward Speed (m/s)** | | | |
| 0.8 | 1.00b | 1.00b | 2.00a |
| 1.1 | 1.00b | 1.67a | 1.00b |
| 2.0 | 1.00b | 1.00b | 1.00b |
| SE± | | 0.212 | |

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

Table 4 shows the results of performance of three-row animal-drawn planter as influenced by machine (planter) type, seed weight and planting speed on number of seed per hill, germination count, planting efficiency and plant to plant distance. From the results obtained, the modified three-row animal-drawn planter gives one seed per hill of maize as compared to the imported one, also the highest germination count of 0.20 was obtained from the modified three-row animal-drawn planter as compared to the imported planter with 0.47 germination count. The modified three-row animal-drawn planter has higher planting efficiency of 84.5% with least plant to plant distance of 28.9 cm which is close to the recorded distance by agronomic practice as reported by Ibukun *et al* (2014) and Soyoye *et al* (2016). On the contrary the imported three-row animal drawn planter gives 109.7cm as plant to plant distance for planting maize, which is too large. This indicates that the modified three-row animal drawn planter performs better than the imported three-row animal drawn planter.

However, there is no significant different ($P \geq 0.05$) in the seed weight and planting speed on number of seed, germination count, planting efficiency and plant to plant distance. Also there is no significant difference ($P \geq 0.05$) in the first level of interaction between machine type and seed weight, machine type and planting speed, seed weight and planting speed on germination count, planting efficiency and plant to plant distance. But there is significant difference ($P \leq 0.05$) on the number of seed per hill, for the second level of interaction for machine type, seed weight and planting speed. Similarly, there is no significant difference ($P \geq 0.05$) on germination count, planting efficiency and plant to plant distance but there is significant difference ($P \leq 0.05$) on the number of seed per hill.

**Table 4: Performance of three-row animal drawn planter as influenced selected in planting maize**

| Treatments | No of seed per hole | Germination count | Planting efficiency | Plant to Plant distance |
|---|---|---|---|---|
| **Machine Type** | | | | |
| Imported | 1.19a | 0.20b | 20.4b | 109.7a |
| Modified | 1.00b | 0.47a | 84.5a | 28.8b |
| SE± | 0.162 | 0.019 | 2.379 | 7.121 |

| | | | | |
|---|---|---|---|---|
| **Interaction** | | | | |
| W*S | NS | NS | NS | NS |

Means followed by same letter(s) in the same column are not different statistically at *P=0.05* using DMRT. NS = Not significant. **= Significant at (P≤0.01)

Generally, at a stable planting speed of 0.8 m/s and varying the seed weight, the number of seed per hill remains constant. Also at constant planting speed of 1.1m/s the number of seed per hill increases and the decreases. But at constant planting speed of 2m/s the number of seed per hill remains constant throughout. Similarly, at constant seed weight of 1.1kg and varying the planting speed the number of seed per hill remains constant throughout, but at constant 2.2kg of seed weight and varying the planting, speed the number of seed per hill increases and then decreases, and lastly at constant 2.9kg and varying the planting speed the number of seed per hill decreases throughout. From these results it could be deducted that the least number of seed per hill was one obtained from all the combination except at 2.9 kg and 0.8m/s where two seeds per hill was recorded.

## CONCLUSION

This study was undertaken to modify an imported three-row animal drawn maize planter that was observed to have poor germination count and excessive seed bruises in order to plant maize and soybean. From the preliminary test carried out, the delivery system, furrow opener, metering device, covering device and soil pressing device were modified. The calibration of both planter was done in the laboratory with the aim to determine seed rate using maize and soybeans as test crops, the values obtained for maize and soybeans was 36.3 kg/ha and 50.9 kg/ha. Field performance of the modified planter in terms of number of seed per hill, germination count, planting efficiency and plant to plant distance were evaluated at three levels of planting speed (2m/s, 1.1m/s and 0.8m/s) and three levels of seed weight (2.9kg, 2.2kg and 1.1kg). The data obtained were subjected to analysis of variance at 1% and 5% levels of significance to determine the effect of the independent variables on the selected performance indices. The performance of the modified planter showed that the germination count, planting efficiency and plant to plant distance when maize and soybean were used as test crops were in the range of 0.46-0.50 and 0.56-0.63, 48.6%-84.4% and 52.9%-62.6%, 27.6 cm-30.0 cm and 37.2 cm-42.7 cm respectively. The comparative performance analysis was carried out between the modified planter and the imported one using maize as test crop, the result shows that the modified planter excels in all the four parameters that were evaluated.

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