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DEVELOPMENT AND PERFORMANCE EVALUATION OF A SINGLE ROW GRAIN CROP PLANTER FOR SMALL-HOLDER FARMERS

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ABSTRACT
The primitive methods used by the small scale farmers for planting grain crops constitute a major problem for enhancing higher productivity and yield of crops as this methods of seed planting results in low seed placement, at irregular depth and irregular plant to plant and row to row spacing. In order to increase the productivity of the peasant farmers a single –row crop planter for small scale farmer was developed and evaluated. The major components of the planter are hopper, the meterins unit, the drive mechanism, furrow opener, seed delivery tube, adjustable handle and furrow covering device. Field test was performed to determine the planting efficiency and field efficiency. The evaluation test showed that the planter has planting efficiency of 68%, 81% and 76% and field efficiency of 71%, 83% and 74% at operating speed of 1.8km/hr, 1.2km/hr and 0.9km/hr respectively. The conclusions drawn from the performance evaluation of the planter revealed that the planter had best performance at operating speed of 1.2km/hr, followed by performance at operating speed of 0.9km/hr and minimum performance at operating speed of 1.8km/hr and above.
Keywords: *Development, performance, single-row, planter.*

INTRODUCTION

Small-scale farmers dominates Nigerian agriculture. They constitute about 70% of the population of farmers in the country with potential to cultivate small farm land because of their primitive methods of farming. Despite been involved in primitive methods of farming, they are still dependable and reliable source of food supply in Nigeria (Angelucci and Cadini, 2013). However, the replacement of the primitive tools used for planting namely: stick, cutlass, hoes, etc with a simple mechanical device is capable of boosting the productivity of farmers as limited effort would be required to accomplish planting within a specified time. Furthermore, it eliminate the problems associated with the primitive method such as reduction in drudgery, time and energy consumption and pains associated with constant bending posture. Generally, design of planters involves metering seeds to desired plant population, placing seed at a designed depth and specified plant to plant and row to row spacing. These functions makes planter have an edge over the primitive methods and make it relevant to increase the production and yield of the small scale farmers. Therefore, there is need to develop a simple planter that would be easy to operate, maintain and purchase by the small scale farmers. The aim of this study is to develop and evaluate a precision seed planter for its performance.

Ani et al (2006) reported various types of planter designed and developed in Nigeria, that Olajide and Manuwa (2014) designed and tested a low-cost grain planter having field capacity of 0.36 ha/hr and efficiency of 71% with a percentage seed damage of 2.58%, spacing of 50.2cm and an average depth of 4.28cm. Ikechukwe et al (2014) designed and fabricated a manually operated single row maize planter and the field test results showed planting capacity of 0.0486ha/hr. Bamigboye and Mofolasayo (2006) developed a manually operated two-row okra planter, and the field efficiency and field capacity were 71.75% and 0.36ha/hr with seed rate of 0.36 kg/hr and seed damage of 3.51%. Adisa and Braide (2012) reported Kaul and Egbo (1985) that planter has a metering mechanism that controls spacing between seeds on the row and spacing between rows.

Ashok et al (2015) mentioned some factors that influence the percent cell fill for a given planter namely: maximum seed size in relation to cell size, the range of seed sizes, the shape of the seeds, the shape of the cells, the exposure time of a cell to seed in the hopper and the linear speed of the cell.

MATERIAL AND METHODS

Design Considerations

The design of manually operated single row precision planter was based on the following considerations.

i) The machine should be of light weight for ease movement
ii) The fabrication materials should be available locally
iii) The ease of fabrication of component parts
iv) The ease of operation by human effort

DESIGN ANALYSIS OF THE PARTS OF PRECISION SINGLE-ROW PLANTER

Determination of the Diameter of the Ground Driving Wheel

The operating speed of the planter is expressed as,

Speed of operation of the planter, $V = \frac{\pi D_W N}{60}$ m/sec…………equ (1)

Ashok et al (201)

Speed of Operation of planter = 0.5m/sec (Kathirvel, 2001)

Average Revolution per minute for a manually operated machine = 32 Rpm

Using equation (1), the diameter of the ground wheel was 300mm

Determination of the Number of Seed Cell on the Metering Devices

The number of seed cells is given as $V = \frac{\pi D_M}{S} \ldots\ldots\ldots\ldots\ldots (2)$

(Ani et al 2016)

Where,

πD = Forward travel of the ground wheel
S = plant spacing
Plant spacing for maize and beans = 300mm, using equation 2, the number of seed cell on metering device is 3 seed cells.

Determination of the Diameter of the Metering Device (DM)
The expression for the circumference of the metering device is given as circumference of the metering device = Number of seed cells x half plant spacing
πD_M = 3 x (half of the plant spacing) ………. Equ (3)
$DM = \frac{3 \, x \, 150}{\pi} = 143mm$
Diameter of metering device (DM) = 143mm.

HOPPER DESIGN
The hopper was designed as trapezoidal shape in order to permit fee flow of seeds into the metering device. The volume of the hopper (V_h) is determined as the volume of the t rapzoidal section given as:
$V_h = \frac{1}{2} (a \, x \, b)h \, x \, t \ldots \ldots \ldots \ldots . eque \ (4)$
Where t = thickness of the hopper = 3mm

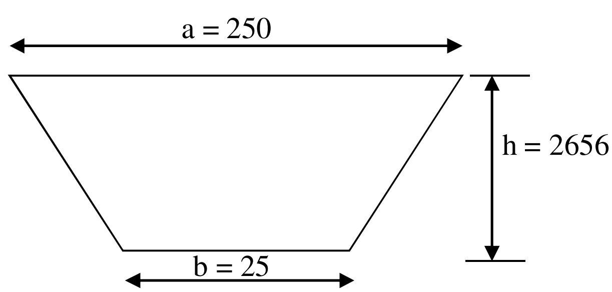


Figure 1: **Sectional View of the Hopper**

The hopper designed capacity is to hold 5kg of either maize or beans

Mass of maize or beans is given by Mg = Vg x Pg -----------equ(5)

Where $Vg = \frac{M_g}{P_g}$

Where,

V_g = Volume of the grain

M_g = Mass of the grain

P_g = Bulk density of the grain

The volume of the hopper (Vh) was computed as 109312.5mm^3 using equ(4). The shaft diameter used as the transmission shaft was obtained as 25mm, based on the bending and shock to which the shaft would be subjected to when in operation.

DESCRIPTION OF THE PRECISION SINGLE ROW PLANTER

The developed manually operated single row precision planter consists of seed hopper of volumetric capacity of 1093125mm^3. It was made of galvanized metal sheet of gauge 3mm and situated upon metering unit to enhance easy flow of seeds into seed cells around metering device. The metering unit consists of metering housing and metering device. The drive mechanism consists of ground driving wheel, hub and the transmission shaft. The ground wheel was fabricated of mild-steel and the friction lug was provided on the ground wheel to aids traction of the wheels.

Main Frame: The mainframe is the skeletal structure of the seed planter on which all other components are mounted. It was made of mild steel angle bar of 40mm x 40mm and 5mm thickness

Pillow Bearing: These were fixed at the two ends of the frame to support the shaft on which the driving wheels are attached. The furrow covering device was fixed to the lower part of the frame.

Furrow Opener: The furrow opener is used for forming narrow slit under heavy soils for placement of seeds at medium soil depths. It was made of mild steel angle bar and is adjustable to keep the opener along vertical axes, such that the different placement depth of the seeds is obtained for different seeds and soil conditions.

Seed Delivery Tube: It deposits the seeds at desired uniform spacing into the opened furrow, was made of galvanized iron hollow pipe and leads the seeds from the metering device to the furrow opener to the opened furrow on the ground.

Adjustable Handle: It consists of two galvanized iron hollow pipe of 1125mm long hinged to the frame at an inclined angle of 45^0 or less with a provision for increasing and decreasing its inclination with respect to the ground that accounts for different height of the operators.

Furrow Covering Devices: It was made of mild steel plate of dimension 25mm x 290mm, and is perpendicular to the direction of travel of the machine to facilitate proper covering of the soil to cover up the seeds dropped into the furrow. The isometric view, orthographic view and exploded view of the planter are shown in the figure 2, figure 3 and figure 4.

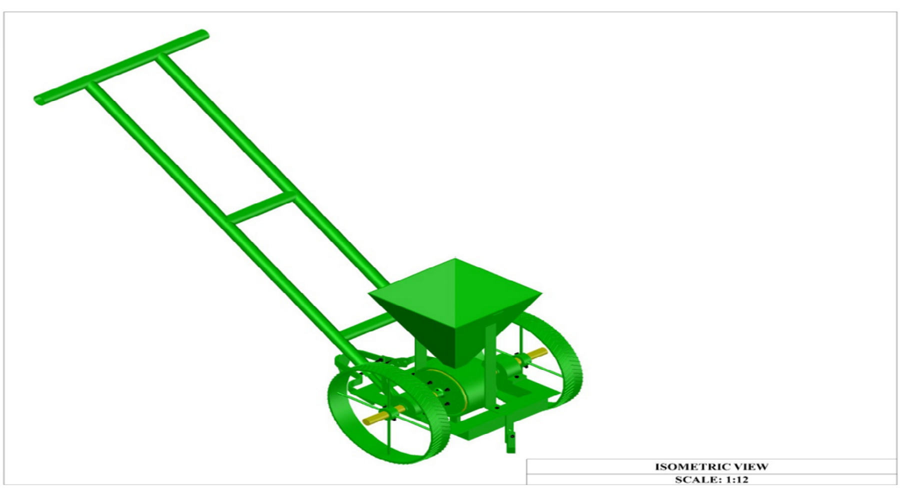


Figure 2: **Isometric View of the Planter**

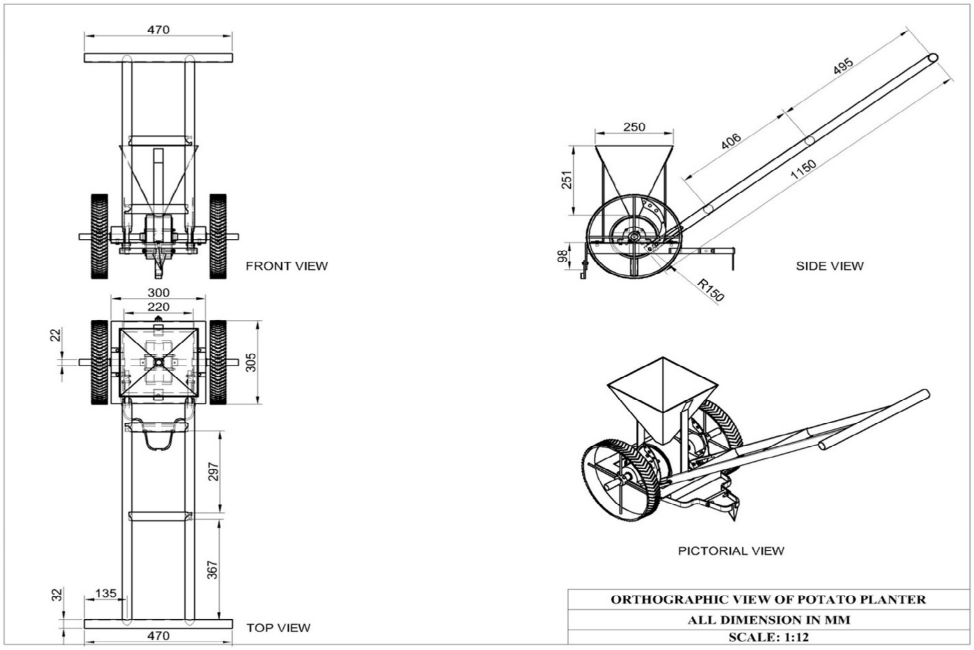
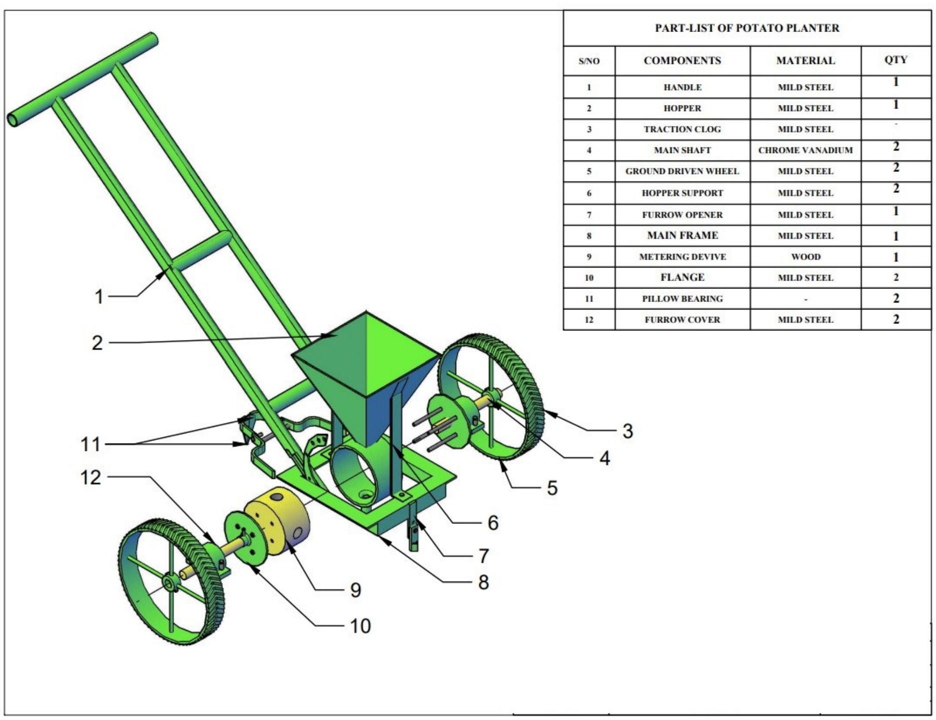


Figure 3: **OrthoGraphic View of the Planter**



PART-LIST OF POTATO PLANTER			
S/NO	COMPONENTS	MATERIAL	QTY
1	HANDLE	MILD STEEL	1
2	HOPPER	MILD STEEL	1
3	TRACTION CLOG	MILD STEEL	-
4	MAIN SHAFT	CHROME VANADIUM	2
5	GROUND DRIVEN WHEEL	MILD STEEL	2
6	HOPPER SUPPORT	MILD STEEL	2
7	FURROW OPENER	MILD STEEL	1
8	MAIN FRAME	MILD STEEL	1
9	METERING DEVIVE	WOOD	1
10	FLANGE	MILD STEEL	2
11	PILLOW BEARING	-	2
12	FURROW COVER	MILD STEEL	2

Figure 4: **Exploded View of the Planter**

Principle of Operation of the Planter

The pushing force applied to the planter through the handles, sets the ground driving wheels into motion. The motion of the ground wheel through the transmission shaft transfers rotary motion to the metering device key to the transmission shaft. As the metering device rotates, enables seed in the hopper to pass through the seed cells and drop to the soil via the delivery tube as the furrow opener opens up the soil. The covering device covers the seed with soil as planter is pushed along

Performance Evaluation of the Precision Seed Planter

The performance evaluation was carried out on an experimental plot of land measured 5mx5m. The plot was further divided into three subplots. The plot was of minimum tillage and the soil type was sandy-loamy and soil moisture content and bulk density were 5.3% and $1.63 g/cm^3$ respectively. The planter hopper was filled with maize seeds and pushed to plant by the operator. The test was carried out using one operator at three selected operating speeds of 1.8km/hr, 1.2km/hr and 0.9km/hr at three replicate. The number of seeds dropped per run was determined by visual observation and time of operation was measured using a stop watch. The performance parameters determined were the planting efficiency (%), and field efficiency (%). The results of the evaluation test is shown on table 1.

Table 1: Result of the Performance Evaluation of Planter

s/no	Run	Speed 1 = 1.8km/hr Seed drop at 5ec/run R₁	R₂	R₃	Total seed dropped	Speed 2 = 1.2km/hr Seed dropped at 15sec/run R₁	R₂	R₃	Total seed	Speed 3 = 0.9km/hr Seed dropped 20sec/run R₁	R₂	R₃	Total seed
1.	5m	27	32	31	**90**	36	39	38	**113**	35	32	34	**101**
2.	5m	31	35	29	**95**	33	32	33	**98**	40	31	39	**110**
3.	5m	24	36	32	**92**	38	42	41	**121**	32	30	37	**99**
Average Seed Dropped					92				110				103

EXPRESSION FOR PERFORMANCE PARAMETERS

Planting efficiency ($\%_p$) $\frac{average\ seed\ drops}{expected\ seed\ drops}\ x\ 100\% ----eq\ (\quad)$

Expected seed dropped = Number of seed dropping parcel x number of seed cell x number of runs

Expected seed dropped = 3 x 3 x 5 x 3 = 135seed

Field efficiency ($\%_F$) = $\frac{T_a}{T_t}\ x\ 100\% ----------eq\ (\quad)$

Where,

T_a = Time taken for actual planting

T_t = Total time taken

Table 2: Actual Time and Total Time Taken to Plant

Operating speed	1.8km/hr	1.2km/hr	0.9km/hr
Actual Time (T_a) (sec)	5	15	20
Total Time (T_t) (sec)	7	18	27

Table 3: Computing Planting Efficiency and Field Efficiency of the Planter

Parameter	Speed 1 1.8km/hr	Speed 2 1.2km/hr	Speed 3 0.9km/hr
Planting Efficiency ($\%_P$)%	68	81	76
Field Efficiency ($\%_F$)%	71	83	74

RESULT AND DISCUSSION

The overall result of the evaluation test of the planter interms of the planting efficiency and field efficiency is presented in table 3. It can be seen from this table that the planter performance increased with increase in the operating speed. The planter had best performance at operating speed of 1.2km/hr followed by the performance at operating speed of 0.9km/hr and minimum performance at operating speed of 1.8km/hr. However, the minimum performance obtained at operating speed of 1.8km/hr showed that at higher speed, the average time taken to complete planting was so small to enable enough seeds to drop from the hopper to the metering device and meters the seeds to the delivery tube, while the better performance at operating speed of 0.9km/hr indicated that the longer time taken to complete planting enabled more seeds to drop from the hopper to the metering device and the best performance at operating speed of 1.2km/hr showed that the time taken to complete planting was adequate for the seeds to drops from the hopper to the metering device and meters to the delivery tube.

CONCLUSION

A single-row crop planter was developed for small scale farmers as a reliable substitute for the primitive methods used by the farmers. The planter developed and fabricated has ability to meters seeds to desired plant population, placing seed at a designed depth and specified plant to plant and row to row spacing. The results of the performance evaluation revealed that the planter had the best performance at moderate operating speed of 1.2km/hr follower by the performance at lower operating speed of 0.9km/hr and above and minimum performance at higher operating speed of 1.8km/hr and above.

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