DEVELOPMENT AND PERFORMANCE EVALUATION OF A FOUR-ROW HAND PUSHED SEED PLANTER

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ABSTRACT

A four row planter hand pushed was developed and tested. The performance test was conducted to investigate the rate of seed discharge, uniformity of intra-row spacing, seed damage during operation, field efficiency, field capacity, planting depth and average intra-row spacing distance. An average weight of 4.32 g of seeds was discharged during the test which occurred at an average planting distance of 45 cm. The planter effectively metred out three seeds per hole at an average planting depth of 2.61 cm with minimum seed damage of 1.98% during operation. The planter could be maneuvered or adjusted to metre more seeds at more or less planting depths depending on the choice of the farmer. The field efficiency of 88.55% and average effective and theoretical field capacities of 0.85 ha/h and 0.96 were obtained from field test. The planter can be produced at a cost of ₦57,600.00k.With proper maintenance, the planter would overcome the difficulties encountered by the rural farmers in sowing seeds.

KEYWORDS: *Field efficiency, planting depth, combine planter, rural farmers, and seed.*

1. INTRODUCTION

Farmers in rural areas use matchet, finger or stick to sow different seeds (Oduma et al., 2014[a]). The matchet, finger or sticks are used to open the soil for dropping the required number of seeds and in most times more than the required number of seeds are dropped in a hole. This method of planting is labour-intensive which according to Bamiro et al. (1986), can benefit considerably from simple mechanization. According to Bamgboye and Mofolasayo (2006), this primitive planting method is tedious, causing fatigue and backache due to the longer hours required for careful hand metering of seeds if crowding or bunching is to be avoided. The importance of the use of machine in agricultural operations in the world today should by no means be underestimated, be it manually operated or powered. One of the major problems confronting the peasant farmers in Nigeria is in the area of planting seeds because of the limited manual power they can put up and most of them cannot afford the money to procure or hire sophisticated machinery that can be used for planting.

According to Oduma *et al.* (2014b), sowing seeds by hand increase production cost because extra man-hours is required for thinning operation and excessive seed is inevitably sown per hole in addition to drudgeries and boring nature of the work. Therefore, it is better to develop a device that will be affordable, maintainable, portable, profitable and easy to manage which will economically save the rural or small scale farmers from these difficulties and increase their productivity in the farm.

Molin and D' Agostin (1996) developed a rolling planter for stony conditions, using 12 spades radially arranged with cam activated doors and a plate seed meter. Performance evaluation showed better improvement in the planting operation with reduction in human effort, more accurate stands and high field capacity. Kumar *et al.* (1986) developed a manually operated seeding attachment for animal drawn cultivator. The seed rate was 43.2 kg/h while the field capacity was 0.282 ha/h. Test results revealed minimal seed damage with good performance for wheat and barly. Oduma et al. (2014[b]) developed a single row cowpea precision planter which has a field efficiency of 71.71% and operates at a field capacity of 0.260 ha/h with an average planting depth and spacing of 2.22 cm and 49.6 cm, respectively. The planter metres an average of two seeds per hole with minimal or no presence of damage seeds.

This research work was initiated to overcome the difficulties involved in seed planting especially in the rural areas where farmers do not have sufficient money to procure sophisticated machines for seed sowing thereby limiting them to manual planting which is tedious and labour-intensive. To help the local farmers overcome this problem, there is need to develop a simple planter that will be used to sow seeds. The objective of this research is to develop and evaluate the performance of a hand pushed seed planter.

2. MATERIALS AND METHODS

2.1 Description of the Planter

The developed planter consists of the handles, four seed hoppers, four furrow openers, land wheels, seed discharge tubes, four furrow coverers and metering disc housing.

I. **Handles:** The handles consist of two mild steel pipes of 20mm external diameter, each 1300 mm long fastened to the frame at both ends of the pipes.

II. **Seed hopper:** The seed hopper was made of mild steel having a cross-section of a pyramid with top and base areas of 90 $mm^2$and 45 mm^2, respectively. It has a height of 300 mm. The design capacity of the seep hopper is 27,000 mm^3. The capacity is based on the volume of seeds required to plant a hectare of field. It was fabricated following the expression

$$V = \frac{LWH}{3} \quad (1)$$

Where:

V = volume of hopper, cm^3

L = length, cm

W = width, cm

III. **Furrow opener:** The furrow opener is made of 45 mm mild steel (angle bar iron) having a length of 140 mm. The angle bar iron was fabricated to take the form of a shoe shape that will aid the easy opening of the soil. The bars were welded to the frame.

IV. **Land wheels:** The land wheels were made of mild steel. The wheels have horizontal plates that bear the keys that slide the metering mechanism which were fabricated in scalloped form in such a way that each scalloped point picks up two seeds at a time and introduces the seeds into the seed discharge tube that deposits the seed in the soil (Oduma, et al. 2014a). The diameter of the wheel is 400 mm which has a 380 mm long spokes cut from 20 mm diameter iron rod welded to the wheels and the periphery of bushing which suspends the axle. The circumference of the wheel is designed such that it is thrice the required intra-row spacing distance to enable the planter discharge two times in one revolution of the wheel. Mathematically expressed as

$$s = \frac{2\pi r}{3} = \frac{c}{3} \quad (1)$$

Where:

s = intra-row spacing, cm

r = radius of the land wheel, cm

c = circumference of the land wheel, cm

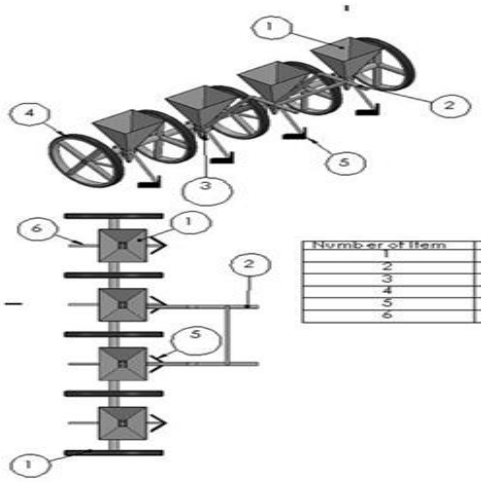
V. **Furrow coverer:** The furrow coverer is made of 80 mm by 120 mm rectangular mild steel plate. It was fastened with nut and bolt to the frame through a hole drilled on the frame. The furrow coverer is perpendicular to the direction of travel of the planter to aid the proper covering of the soil.

VI. **Seed tube:** The seed tube is made of mild steel hollow pipe of 90 mm diameter and 60 mm long. Two holes of 75 mm diameter each were made at the lower and upper parts of the metering housing. Seeds picked from the hoppers pass through the upper hole at the slide of the scalloped metering mechanism to the lower hole into the discharge tube which deposits the seeds into the opened furrow.

2.2 Design Considerations

The planter was designed based on the following design considerations:

i. The ease of fabrication of the planter's component parts.
ii. Safety of the operator.
iii. Easy to use by the operator.
iv. Locally sourced materials were used for the fabrication of the planter's component parts.
v. Ensuring availability of the materials for construction.



Key

1. Seed hopper
2. Handle
3. Seed tube
4. Wheel
5. Furrow covering device
6. Furrow opener

Figure 1. Orthographic view of a four row seed planter

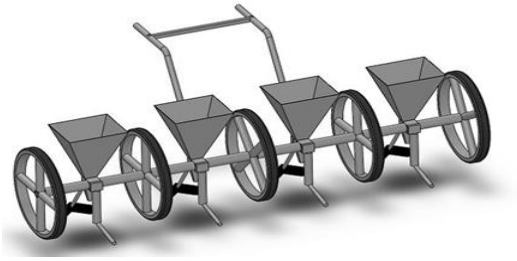


Figure 2.Isometric view of the planter

2.3 PERFORMANCE TEST

Bambara nut that is locally grown were obtained from local farmers. The seeds were stored at an average moisture content of 12.5% w.b. The method adopted by Bamgboye and Mofolasayo (2006) and Oduma *et al.* (2014b) was used for the planter's evaluation. Laboratory and field tests were carried out to evaluate the performance of the planter.

2.3.1 Laboratory Test

The planter was calibrated in the laboratory to assess the rate of discharge, uniformity of seed spacing and seed damage during operation.

I. **Calibration Test:** Each hopper of the planter was loaded with 5kg of bambara nut seeds. The planter was lifted up using a lift jack to allow for free rotation of the wheels. A mark was made on the wheels to indicate the reference points to count the number of revolutions when turned, and a sac was placed on the seed discharge tube to collect the seeds discharged (Bamgboye and Mofolasayo, 2006). The wheels were rotated for 10 times at low speed. A stop watch was used to measure the time taken to complete the revolutions. The seeds collected in the sac were weighed on a balance and the procedure was repeated five times.

II. **Sowing Depth:** The depth of seed placement was determined by running the planter longitudinally to and fro over an area of 10 m^2 without the furrow covering device and with medium setting of the furrow opener (Bamgboye and Mofolasayo, 2006). A metre rule was used to measure the planting depth.

III. **Test for Uniformity of Seed Spacing:** For uniformity of seed spacing test, 5kg of seeds were loaded in the seed hopper. 10m was marked out on the plain ground and the machine run within the length at man-walking speed, and the time to complete the distance was recorded. A measuring tape was used to measure the distance between successive drops of seeds. The process was repeated five consecutive times and measurement of distance between successive drops of seeds were recorded.

IV. **Test for Seed Damage:** The planter was jacked up as described in the calibration test; 5kg of seeds were loaded in the seed hopper. The wheels were rotated 15 times in turns and the time taken to complete the revolution was recorded with the aid of a stop watch. The seeds discharged from the seed tube were observed for damage.

2.4.2 Field Test

A properly tilled and well pulverized field measuring 100 m x 100 m (1ha) was used for the performance evaluation of the

planter. The field efficiency, field capacity, planting depth of seeds and uniformity of seed spacing were determined.

I. **Determination of Field Efficiency:** To determine the field efficiency, the sowing operation was performed longitudinally with a constant forward speed, determined by noting the distance of travel using measuring tape and corresponding time to complete the distance with the aid of a stop watch. The effective operating time, time spent to fill the seed hopper, remove stumps and other obstructions were recorded according to Afzalinia *et al.* (2006). The field efficiency was calculated using the expression given by Kepner et al. (1982) as:

$$\varepsilon = \frac{100Te}{Tt} \quad (3)$$

where,

ε = field efficiency of machine, %
Te = effective working time, h.
Tt = total working time, h.

II. **Effective field capacity:** The effective field capacity was evaluated by measuring the effective width of the planter using a measuring tape and the walking speed of the planter. The effective field capacity was therefore evaluated from equation (2) propounded by ASAE (1999)

$$C_{eff} = \frac{SWE}{10} \quad (4)$$

where,

C_{eff} = effective field capacity, ha/h
W = effective working width of machine, m
S = working speed, km/h
E = field efficiency of machine, %

III. **Theoretical field capacity:** Theoretical field capacity was determined using the relationship given by ASAE, 1999 as:

$$Cth = \frac{SW}{10} \quad (5)$$

where,

Cth = theoretical field capacity, ha/h
W = effective working width of machine, m
S = working speed, km/h

IV. **Material capacity:** Material capacity was determined from the expression given by Hunt (2013) as:

$$M = \frac{SWey}{c} \quad (4)$$

where,

M = material efficiency, t/h
S = working speed, km/h
w = machine working width, m
e = field efficiency, %
y = yield, kg/m^2
c = constant = 10

3. RESULTS AND DISCUSSION

3.1 Results

Table 1.Planter Calibration

No. of trials	Weight of seeds discharged (g)	Time for 10 revs (min)	Speed (rpm)
1.	3.87	1.33	20.4
2.	3.44	1.30	23.3
3.	3.78	1.39	18.8
4.	4.59	1.26	20.6
5.	3.55	1.31	20.9
Mean	**3.85**	**1.32**	**20.8**

Table 2. Uniformity of Seed Spacing

Replications	Time (s)	Speed (km/h)	Laboratory spacing (cm)	Field spacing (cm)
1.	20	0.8	46	42
2.	20	0.8	51	45
3.	20	0.8	47	44
4.	20	0.8	43	43
5.	20	0.8	45	43
Mean	**20**	**0.8**	**46.4**	**43.4**

Table 3. Percentage of Damaged Seed in operation

No. of trials	Speed km/h	No. of seeds discharged	No. of seeds damaged	Damage (%)
1.	0.8	60	0	0
2.	0.8	65	2	3.3
3.	0.8	71	0	0
4.	0.8	61	2	3.3
5.	0.8	61	2	3.3
Mean	**0.8**	**63.6**	**1.2**	**1.98**

Table 4. Results of Field Test

No. of trials	Speed km/h	Working Width, cm	Planting depth, cm	Operation time			Field efficienc, %	Effective field capacity, ha/h	Theoretical field capacity, ha/h	Material capacity t/hr
				Effective time, h	Idle time, h	Total time, h				
1.	0.8	120	2.52	2.05	0.3	2.35	87.23	0.84	0.96	0.00434
2.	0.8	120	2.60	1.98	0.21	2.19	90.41	0.87	0.96	0.0045
3.	0.8	120	2.45	2.00	0.42	2.42	82.64	0.79	0.96	0.0041
4.	0.8	120	3.00	2.11	0.18	2.29	92.14	0.89	0.96	0.0046
5.	0.8	120	2.50	1.87	0.20	2.07	90.34	0.87	0.96	0.0045
Mean	**0.8**	**120**	**2.61**	**2.00**	**0.26**	**2.26**	**88.55**	**0.85**	**0.96**	**0.0044**

Table 5. Bill of Engineering Measurement and Evaluation (BEME)

S/N	Materials	Quantity	Unit cost (₦)	Total cost (₦)
1.	Hopper	4	300	1200
2.	Metering disc	4	400	1600
3.	Stroke	12	250	3000
4.	Discharge tube	4	400	1600
5.	Furrow opener	4	250	2000
6.	Furrow cover	4	250	2000
7.	wheel	4	2000	8000
8.	Handle/ iron bar	4	550	2200
9.	Axle	1	1200	1200
10.	Bushing	8	150	1200
11.	Support Frame	1	1500	1500
12.	Nuts/bolts	16	50	800
13.	Paint	1bkt	1500	1500
14.	Electrode	15 sticks	150	2250
15.	Labour		6000	6000
16.	Transportation		2000	2000
17.	Miscellaneous		2000	2000
Total				**₦57,600:00k**

3.2 Discussion

Table 1 shows the results of the calibration of the planter. The average weight of seeds discharged from each hopper is 3.85 g. This is slightly lower than the value obtained forTwo-Row Okra planter by Bamgboye and Mofolasayo (2006) and also less than the value obtained by Oduma et al (2014a) for cowpea precision planter. The planter meters average of three seeds per hole.

Table 2 reveals the planting distance obtained during laboratory and field tests of the planter. The average planting distance obtained during laboratory and field tests were 46.5cm and 43.4cm, respectively. The variation in the laboratory and field spacing may be attributed to soil condition and other in-field factors that affect machine performance such as clods, stumps, topography etc.

Table 3 shows that an average of 1.98% of the seeds were damaged during sowing. The number of damaged seeds is less than the damages recorded by Oduma et al. (2014b).

Table 4 presents the performance of the planter. Results revealed that the planter worked at full width of 120cm at an average sowing depth of 2.61cm. For the five replications of its sowing operation at constant speed of 0.8 km/h; the planter recorded field efficiencies ranging between 82.64 and 92.14%, effective field capacities ranging between 0.79 and 0.84 ha/h, theoretical capacity of 0.96 ha/h and material capacities ranging between 0.0044 and 46.07 t/hr

The bill of engineering measurement and evaluation (BEME) as shown in Table 5 reveals that the planter can be obtained at acost of Fifty Seven Thousand, Six Hundred Naira (₦57,600.00). An average farmer in the rural area can affor the cost of the machine.

REFERENCES

Afzalinia, S., M. Shaker and Z. Zare. (2006). Performance Evaluation of common Grain Drills in Iran. Canadian Bio-system Engineering/Le genie des bio systems au Canada 48:2.39-2.43.

ASAE. (1999). Agro-processing Engineering. American Society of Agricultural Engineers. CIGR Hand of Agricultural Engineering. St Joseph, Michigan. Vol.III.

Bamgboye, A. I and A. S. Mofolasayo. (2006). "Performance Evaluation of a Two-Row Okra Planter". Agricultural Engineering International: the CIGR Ejamal. Manuscript PM 06002. Vol.VIII. July.

Bamiro, O. A., A. Nurudeen and I. O. Akuru. (1986). Introductory Technology for Schools and Colleges. Evans Brothers (Nigeria publishers) limited. PP 227-233.

Hunt, D. (2013). Farm Power and Machinery Management. Tenth edition. Scientific International Congress on Agricultural Engineering, Dubli. Vol.3, pp.1703-1709.

Kepner, R. A., R. Bainer and E. L. Barger. (1982). Principles of farm machinery. 3rd Edition. West port. G. AVI publishing company Inc.

Kumar, K, N. K. Naareshand T. P.Ojha. (1986). "Design, Construction and Performance of a Manually-operated Seedingattachment for an Animal Drawn Cultivator". J. AMA, 17(2):35-38.

Molin, J. P. and V. D' Agostine. (1996). Development of a Rolling Punch Planter for stony Soil conditions" AMA, 27(3):17-19.

Oduma, O., J. C. Edeh and O.O. Onu. (2014a).Performance Evaluation of a Locally Developed Three-row Maize Planter. International Journal of Agricultural Science and Bioresources Engineering Research, Vol. 3(4):67-76.

Oduma, O., J. C. Ede and J.E Igwe.(2014b).Development and Performance Evaluation of a Manually Operated Cowpea Precision Planter.International Journal of Engineering and Technology, Vol. 4(12):693-699.