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Development and Performance Evaluation of a manually operated Cowpea Precision Planter

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ABSTRACT

A manually operated cowpea precision planter was developed and evaluated for performance by laboratory and field investigations. The laboratory test was conducted to investigate the rate of seed discharge, uniformity of intra-row seed spacing and seed damage during operation, while the field test examined the field efficiency, field capacity, planting depth and average seed spacing within the row. An average weight of 4.62g of seeds was discharged during the test, at the planting space varying from 48.4cm to 49.6cm obtained from the field and laboratory test respectively. The planter effectively metred out two seeds per discharge at average planting depth of 2.22cm with minimum seed damage of 2.34% 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 71.71% and average field capacity of 0.260 ha/hr were obtained from the test. With good care/maintenance, the planter would relief the difficulties encountered by the rural farmers in cowpea production.

Keywords: *Cowpea, field efficiency, planting depth, precision planter, rural farmers, and seed rate.*

1. INTRODUCTION

Cowpea is a staple food crop, highly delicious and balanced nutritiously (Oluka and Nwuba, 2001). Nigeria leads in the production of cowpea World Wide (key, 1979). It is a good source of phosphorus, vitamins, calcium, iron, thiamine etc. (Steele, 1972).

Most of our farmers especially in the rural areas and/or small scale farmers use matchet or sticks to sow different seeds. This matchet or sticks is used to open the soil as the farmer drops the required numbers of seed (often times more than the require numbers are dropped) and then covers them up. This method of planting is labour-intensive and can benefit considerably from simple mechanization (Bamiro et al, 1986). According to Bamgboye and Mofolasayo (2006), the traditional 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 machine in agricultural operations in the world today should never be underestimated, be it manually operated or powered (Sam and Okokon, 2013). 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 their planting.

Sowing cowpea by hand increase production cost as extra man-hours is required for thining operation as excessive seed is inevitably sown per hole in addition to drudgeryness and boring nature of the work. It is therefore better to develop a system that will be affordable, maintainable, portable and easy to manage which will traditionally relief them from these difficulties and increase their productivities.

Bamgboye and Mofolasayo (2006) developed a manually operated two-row Okra planter. The field efficiency and field capacity were 71.75% and 0.36 ha/hr while seed rate was 0.36kg/hr with low average seed damage of 3.51%. Gupta and Herwanto (1992) designed and fabricate a direct paddy seeder to match a two-wheel tractor. The machine had a field capacity of about 0.5 ha/hr at a forward speed of 0.81mls, and there was no damage caused by the metering mechanism for soaked seeds; though 3% damage was recorded for pre-germinated seeds. 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 important 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 43.2kg/hr while the field capacity was 0.282 ha/hr. Test revealed minimal seed damage with good performance for wheat and barly. Ladeinde and Verma (1994) compared the performance of three different models of Jab planters with the traditional method of planting. In terms of field capacity and labour requirement, there was not much difference between the traditional planting method and the Jab planters. However, backache and fatigue were substantially reduced while using the planters.

Cowpea cultivation has been limited to manual planting, which is tedious, drudgery and laborious. To relief these plights from the local farmers, there is therefore a need to develop a simple tool or system that will be used to plant cowpea seeds. The objective of this work is to develop and evaluate the performance of a manually operated cowpea precision seed planter that can be affordable and easy to maintain by rural and small scale farmers.

2. MATERIALS AND METHODS

2.1 Description of the cowpea Precision Planter

The developed cowpea precision planter consists of the handles, seed hopper, furrow opener, transport wheels, seed discharge tube, Furrow covering device, and metering disc housing

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

b) **Seed hopper:** the seed was made of mild steel having a frustration cross-section of a pyramid of 50mm square at the bottom, 100mm square at the top and 300mm height. The design capacity of the seep hopper is 1,750,000mm$^{3.}$ The capacity is based on the volume of seeds required to plant a hectare of field.

c) **Furrow opener:** The Furrow opener is a 45mm mild steel (angle bar) with a length of 130mm. The angle bar iron was fabricated to shoe type like structure to facilitate an easy cut through the soil. Nut and both were used to fasten the device to the frame through a hole drilled on the frame.

d) **Transport wheels:** The transport wheels are made of mild steel. The right wheel has a horizontal plate that bears the key that slide the precision metering mechanism which was castellated in such a way that each castellated point pick up two seeds at a time and introduces the seeds into the seed discharged tube that deposits the seed in the soil. The diameter of the wheel is 350mm and 310mm long spokes cut from 20mm diameter iron rod were 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 seed spacing within row to enable the planter discharge three times in one revolution of the wheels.

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

f) **Furrow covering device:** The Furrow covering device is made of rectangular mild steel plate of dimension 80mm x120mm. It was fastened with nut and bolt to the frame through a hole drilled on the frame. The Furrow covering device is perpendicular to the direction of travel of the machine to facilitate proper covering of the soil.

g) **Metering disc:** the metering disc was constructed from mild steel of 110mm internal diameter and 60mm long. Two slots of 75mm were made at the upper and lower portions on the metering housing. Seeds from the hoppers pass through the lower slot to the castellated metering mechanism to the lower hole, into the discharge tool

2.2 Design Considerations

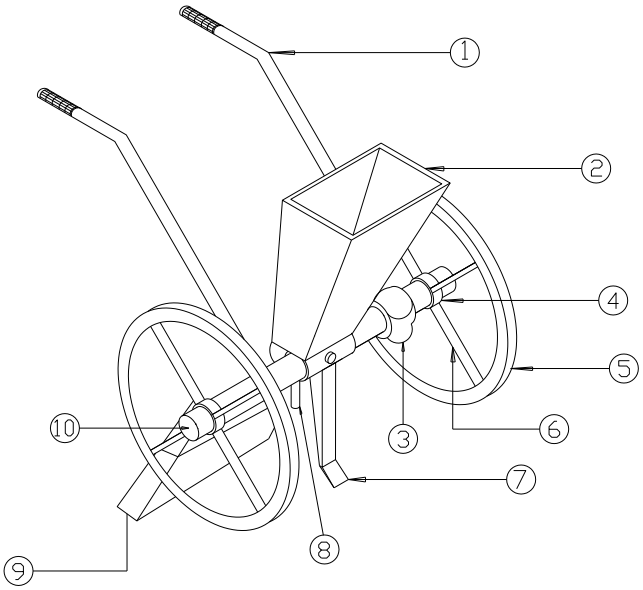
The design of cowpea precision planter is based on the following considerations.

i. The ease of fabrication of component parts.
ii. The safety of the operator
iii. The operation of the machine should be simple for small scale or rural farmers.
iv. The materials available locally were used in the fabrication of the components.
v. Availability and cost of the materials for construction.

2.3 Mode of Operation

The machine consists of a vertical slightly angled plate fixed below a hopper. The edge of the plate is castellated in such a way that each castellated point pick up two seeds at a time. Below the plate is an attachment of the Furrow opening device which opens the Furrow for the seeds.

As the plate rotates below the hopper, the seeds are picked up into the castellation of the notch and carried on until they drop into the seed discharge tube and finally fall into the opened Furrow. The furrow covering device covers the open furrow after the seed deposition, and the process continues



COWPEA PRECISION PLANTER

Figure 1. Cowpea precision planter.

Key to figure 1

1. Handle
2. Seed hopper
3. Metering disc housing
4. Wheel bushing
5. Drive/transport wheel
6. Strokes
7. Furrow opner
8. Seed discharge tube
9. Furrow covering device
10. Axle

2.4 Performance Test

The cowpea seed variety called Ogboriga popularly grown by local farmers was purchased from Eke Izhia market in Ebonyi State, Nigeria. These seeds have average moisture content of 13.68% as measured using the oven dry method of moisture content measurement. The standard code suggested by Mehta et al, (1995) for seed drill as recorded by Bamgboye and Mofolasayo (2006) was adopted in the evaluation of the machine performance. Laboratory and field tests were conducted to determine the performance of the machine.

2.4.1 Laboratory Test

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

Caliberation Test: The hoper of the planter was loaded with 4kg of cowpea seeds. The planter was jacked up to allow for free rotation of the drive or transport 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. The drive (transport) wheels were rotated for 100 times at low speed as would be obtained on the field. A stop watch was used to measure the time taken to complete the

revolutions. The seeds collected in the sac was weighed on a balance and the procedure was repeated ten times.

Test for Uniformity of Seed Spacing: To determine the uniformity of seed spacing, 4kg of seeds were loaded into the hopper. 15m was marked out on the plain ground and the machine run within the length at walking speed, and the time of travel was recorded. A measuring tape was used to measure the distance between successive drop of seeds. This process was repeated five consecutive times and measurement of distance between successive drop of seeds were recorded.

Test for Seed Damage: The planter was jacked up as described in the calibration test; 4kg of seeds were loaded in the hopper. The wheels were rotated 30 times in turns and the time taken to complete the revolution was recorded with the aid of stop watch. The seeds discharged from the seed tube were observed for damage and recorded.

2.4.2 Field Investigation

A field of 100mx50m was used for the performance test of the planter. This land was properly tilled (ploughed and harrowed) to obtain a good soil condition for the crop, and workable condition for the planter. The field efficiency, field capacity, planting depth of seeds and uniformity of seed spacing were determined.

Determination of Field Efficiency: To determine the field efficiency, the planting operation was performed longitudinally with a constant forward speed as determined by noting the distance of travel using measuring tape and corresponding time to complete the distance with the aid of a stop watch while planting the area of the prepared field. The effective operating time and the time spent to fill the seed hopper, remove stumps and other obstructions were recorded (Afzalima et al, (2006). The field efficiency was calculated from equation (1) suggested by kepner et al, (1978).

$$\varepsilon = \frac{100T_e}{T_t} \qquad 1$$

$where\ \varepsilon = Field\ efficiency\ (\%)$

$T_{e=effective\ operating\ time\ (min)}$

$T_t = Total\ time\ (\text{min})$

Effective field capacity: The effective field capacity was determined by measuring the effective width of the machine using a measuring tape and the forward constant speed of planting operation; the effective field capacity was therefore evaluated from equation (2) propounded by kepner et al, (1978)

$$C_{e=\frac{WS}{1000}\varepsilon} \qquad 2$$

$where\ C_{e=effective\ field\ capacity,\ (ha/hr)}$

$w = implement\ effective\ width, m$

$S = forward\ speed, km/hr$

$\varepsilon = fielde\ efficiency\ (\%)$

Planting Depth: The average depth of seed placement was determined by running the planter to and fro over an area of 10 square metre without the furrow covering device and with medium setting of the furrow opener (Bamgboye and Mofolasayo, 2006). During the process, the time taken to travel the length of the field was recorded to determine the average speed of operation in the field. Along each furrow, five hills were randomly sampled and investigated for depth of planting. A measuring tape was used to measure the required depth.

Uniformity of Seed Spacing: After seed germination, ie two (2) weeks after planting, the distances between successive seedlings within the row were determined for the whole area of land planted using a measuring tape. All operational and adjustment problems were detected and ratified during the field operation of the planter.

3. RESULTS AND DISCUSSION

Table 1 reveals the results obtained from the calibration of the precision planter. It is observable from the table that the average weight of seeds discharged from the hopper is 4.62g. This value is within the range obtained for Two-Row Okra planter by Bamgboye and Mofolasayo (2006) and also within the range of $\pm 7\%$ recommended for optimum inter Furrow variation by Mehta et al (1995). The planter was able to effectively metre out average of two seeds per discharge and has an average seed rate of 0.37kg/hr. An adjustment can be affected using adjustable metering device to meter more seeds per discharge.

Table 2 Presents the intra-row plant spacing measured in the laboratory and on the field determined after germination (2 weeks after planting). In the test conducted in the laboratory, the average intra-row seed spacing was 49.6cm while in the field, the spacing obtained was lower with value of 48.4cm. the result of laboratory and field test shows uniformity in the plant spacing and equally gave close intra-row spacing to 45cm as recommended by NIHORT (undated) in Bangboye and Motolasayo (2006). However, the slight discrepancies in the results may be due to seed clogging and other operational factors.

Table 3 shows the total average percentage of seed damage incurred during operation. It is observable from the table that the percentage average damage is 2.34%. The damage is very low as compared to 3.51% obtained for Two-Row Okra planter

(Bangboye and Motolasayo, (2006). The low damage may be due to the speed of rotation of the transport wheels. Low damage of seeds and good spacing will be maintained if the machine is being operated at a uniformly low speed.

Table 4 reveals the field efficiency and field capacity of the planter obtained from the field test. From the result, the field efficiency of the machine is 71.71% which implies good performance and fall within the range of values obtained by Bamiro et al (1986), Afzalinia et al (2006), kepner et al (1978) and Kumar (1986). Moreso, the result of the field capacity according to the table showed average value of 0.260 ha/hr. This value fall within the range of 0.282 ha/hr for manually operated seeding attachment of animal drawn cultivator designed and constructed by Kumer et al. (1986).

Finally, Table 5 presents the planting depth measurement recorded in the determination of the average depth of the furrow opened for the planting of the seeds. The average planting depth of furrow opened is 2.22cm. This is greater than the mean depth of furrows opened at the medium setting of the openers of 9mm and 8mm for two furrows in Two-Row Okra planter developed by Bamgboye and Mofolasayo (2006). But it is within the range of a sowing depth of 25mm recommended by Anderson (2002). However, the Furrow opening device can always be adjusted to suit the planting depth needed.

Table 1: Laboratory Calibration of Cowpea Planter

Replications	**Weight of seeds discharged (g)**	**Time for 100 rev (min)**	**Speed (rpm)**
1	5.68	1.54	30.4
2	4.54	1.50	33.3
3	4.98	1.49	28.8
4	3.66	1.46	30.6
5	4.38	1.53	30.9
6	5.64	1.51	29.7
7	4.59	1.48	32.4
8	3.88	1.50	30.2
9	4.90	1.57	29.8
10	3.98	1.49	33.0
Total Rate	46.23	15.07	307.1
Mean	4.62	1.51	30.71
Seed Rate	0.18kg/hr		

Table 2: Laboratory and field determination of uniformity of seed spacing in row

Replications	**Time (s)**	**Speed (m/s)**	**Laboratory spacing (cm)**	**Field spacing (cm)**
1	30	0.6	51	45
2	30	0.6	48	57
3	30	0.6	50	54
4	30	0.6	49	46
5	30	0.6	50	40
Mean	30	0.6	49.6	48.4

Table 3: Percentage seed damage during operation

Replications	Time for 30 rev (min)	Speed (rpm)	No of seeds discharged	No of seeds damaged	Percentage damage %
1	49	36.7	68	2	2.9
2	45	40.0	75	4	5.3
3	48	27.5	81	0	0
4	46	39.1	63	0	0
5	48	37.5	71	3	4.2
6	48	37.5	77	1	1.2
7	47	38.3	69	2	2.8
8	46	39.1	72	1	1.3
9	48	37.5	77	0	0
10	48	37.5	70	4	5.7
Mean	47.3	3.7.07	72.3	2	2.34%

Table 4 Field Efficiency and Effective Field Capacity of the Planter

Activity	Time for $\frac{1}{10}$ hectare (S)	Time/hectare (min)
Turning at field end	73	12.4
stumping/cods removal	94	20.56
Removal of clogs	65	11.05
Fillings of seed hopper	68	11.18
Setting/adjustment	56	10.3
Actual planting	910	145
Total time	1269	210.49
Field eficiency (%)	71.71	
Effective field capacity (ha/hr)	0.260	

Table 5: Average Planting Depths of the Seeds

Replications	Planting Depth (cm)
1	2.02
2	1.62
3	2.68
4	2.88
5	1.21
6	2.74
7	1.72
8	1.90
9	2.72
10	2.75
Mean	2.22

4. CONCLUSION

The manually operated cowpea precision planter was developed from locally available materials to match the need and relief the difficulties of the rural and/or small scale farmers. It has a field efficiency of 71.71% and operates at a field capacity of 0.260 ha/hr with an average planting depth and spacing of 2.22cm and 49.6cm respectively. The planter metres an average of two seeds per discharge with minimal or no damage of the seeds and can be adjusted to metre more seeds per discharge according to the choice of the famer.

REFERENCES

[1] Afzalinia, S; Shaker, M and Zare, Z. 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

[2] Anderson, C.R (2002). Okra. Home Gardening Series Division of Agriculture, Cooperative Extension service, University of Arkansas.

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

[4] Bamiro, O.A, Nurudeen, A. and Akuru, I.O. 1986. Introductory Technology for schools and colleges. Evans Brothers (Nigeria publishers) limited. PP 227-233.

[5] Gupta, C.P and Herwanto, T. 1992. "Design and development of a direct paddy seeder". Agricultural machination in Asia, Africa and Latin America. Vol.23, No.1,PP 23-27

[6] Kepner, R.A; Bainer, R. and Barger, E.L. 1978. Principles of farm machinery. 3rd Edition. West port. G; AVI publishing company Inc.

[7] Key, D.E. 1979.. "Food Legumes" Tropical product institute, crop and product Digest, No.3.

[8] Kumark,K, Naaresh N.K. and Ojha, T.P. 1986. "Design, construction and Performance of a manually- operated seeding attachment for an animal drawn cultivator". Agricultural Mechanization in Asia, Africa and Lalin America. Vol.17, No.2, pp.35-38.

[9] Ladeinde, M.A. and Verma, S.R 1994. Performance evaluation of hand operated seed planters in light and medium soils in Nigeria". Agricultural mechanization in Asia, Africa and America, vol.27.No3pp.17-19.

[10] Mehta, M.L; Verma, S.R; Misra, S.K; Sharma, V.K 1995. Testing and Evaluation of Agricultural machinery. National Agricultural Technology Information Centre, India. PP 68-79.

[11] National Institute of Horticultural Research, NIHORT (UNDATED) "Guide to the production of Tomato, English, Melon, Okra and paper", Extension Research Liaison and Training, NIHORT, Ibadan.

[12] Molin, J.P. and Dagostine, V. 1996. Development of a rolling punch planter for stony soil conditions" Agricultural mechanization in Asia, Africa and Latin America. Vol.27, No3, pp17-19.

[13] Oluka, S.I and Nwuba, E.I.U 2001. "Physical and Aerodynamic properties of cowpea seeds, Hulls and Stalks". JEAS vol1, No1, Sept. 2001. Pp.35-43

[14] Steele, N.M. 1972. Cowpea in Nigeria. Unpublished Ph.D. Thesis. University of Reading, Reading, U.K.