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DEVELOPMENT AND EVALUATION OF A PROTOTYPE MANUAL PRECISION RICE PLANTER FOR SMALLHOLDER FARMERS IN NORTH-EASTERN NIGERIA

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Abstract

The design and construction of a manual precision rice planter was undertaken with the aim of achieving precise planting on the farm. The machine was designed, constructed and tested on the University farm in Yola-Nigeria, using locally available materials. The machine consists of roller-metering device that rotates and receives constant flow of seeds from a bottomless hopper, a furrow opener and covering device. There is a front land wheel from which the seed-metering device is directly driven through chain and sprockets. The frame is made of hollow pipe on which the entire assembly is mounted. The machine performance evaluation was carried out using paddy rice BG 302 variety. The actual field capacity of the machine was found to be 0.067ha/h with field efficiency of 77.9%, and application rate of 21.62 kg/ha. The planter has a mean planting depth of 3.2cm, hill distance of 15.12 cm and 6 seeds per hill. It was concluded that efficient and precision planting could be better achieved with this kind of machine than with rice seed broadcasters.

1. Introduction

Rice production is extending rapidly to areas which are not traditional producers of the crops (Khush and Toenniessen, 1991). It is one of the world's stable food crops and primary food for more than half of the world population. Williams et al. (1989) reported that one of the most difficult and time-consuming operations in rice production is the planting operation. In Nigeria, most farmers use traditional tools such as sticks, hoes and so on for rice planting. This makes rice planting operation tedious and time wasting, leading to low yield. To meet the growing demand for rice, these traditional tools have to be substituted with improved planting equipment.

Rice broadcasters commonly used in Nigeria enable fast rice planting but have been observed to have some limitations that affect their economic utilization on small farms. These limitations, according to Bishop et al. (1993), include: seed position at varying depths, intra and inter row spacing, planting depth, number of seeds per hole, uneven field coverage leading to poor germination rates, seed wastage and difficulty in carrying out subsequent operations like weeding. According to Kepner et al. (1980) rice dibbling and drilling using local tools proved to be successful in terms of germination rates and yield, but the problem regularly encountered is irregular intra and inter-row spacing, planting depth and number of seeds per hole. To achieve efficient rice planting, a prototype manual rice precision planter was developed and tested. The results of the actual field performance evaluation of this planter are reported in this paper.

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2. Materials and method

2.1 Description of the Precision Planter

The main features of the planter are shown in Figure 1, which include a hopper, roller metering device, land wheel, sprockets, chain, furrow opener, covering device, handles and parking stand.

The hopper was constructed from steel metal sheet of 2mm thickness that forms the feeding unit through which rice seeds are fed into the metering device. The metering device was constructed from hard wood. It consists of grooves into which the seeds fall from the bottomless hopper. The furrow opener and the covering device were constructed from hard steel, which has high resistance to wear and corrosion. The flute was made up of smooth and flexible plastic hose, which was attached to the metering mechanism housing.

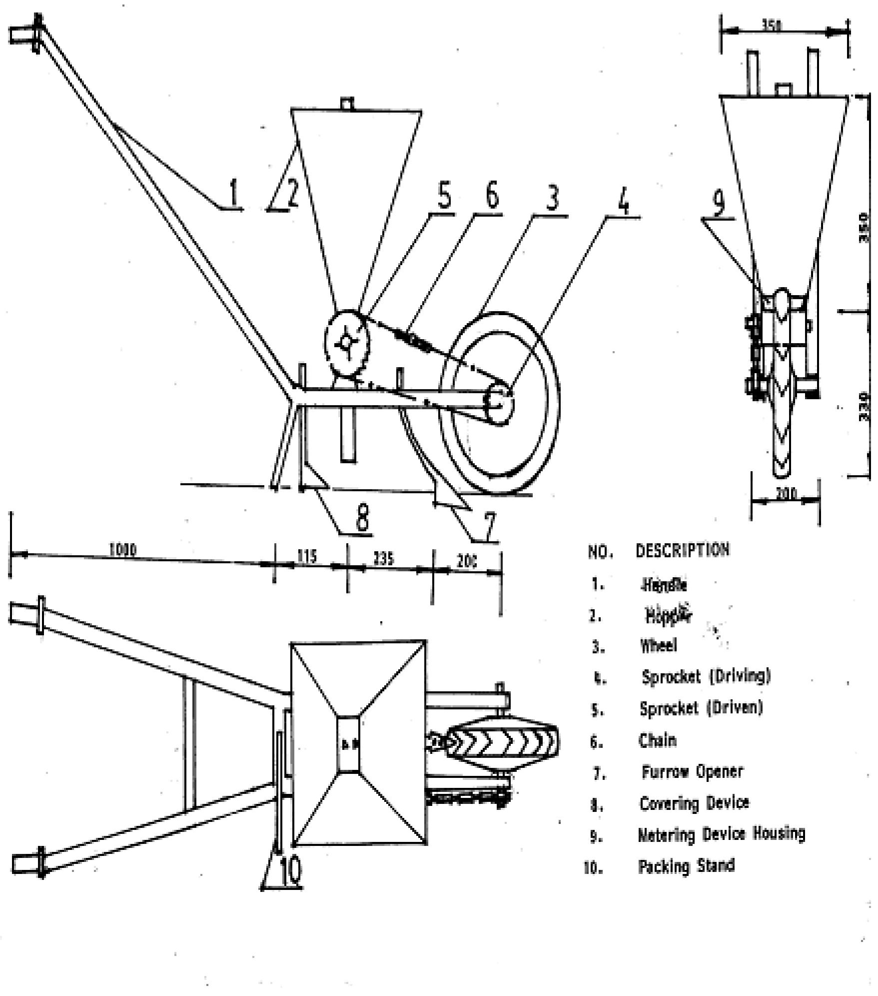

Figure 1: Assembly drawing of the rice planter

2.2 Design considerations and analysis

Agronomic parameters considered

Agronomic factors considered during the design of the rice planter include intercrop spacing between rice plants which was given as 15-16 cm, inter-row spacing of 30cm, 5-8 number of seeds per hole and planting depth of 2-4 cm as reported by Jackquot and Courtesis (1988).

Roller metering device

In the design of roller metering device, groove size and number of grooves are important design parameters. The number of grooves on the roller has a great influence on the distribution of seeds. The proper number of grooves can be obtained by equating the ratio of the open angle of the groove with a desired degree of distribution, Dsc that is defined as a ratio of desired seed distribution to the spacing between stands. That is:

$$n = 3.6Dsc/\theta g \qquad (1)$$

(Chittey and Perkin, 1986)

Where,

n = number of grooves and is calculated as shown in Table 1, θ_g = open angle of groove (^{o}), D_{sc}= desired degree of seed distribution range to the spacing between hills (%).

Degree of seed distribution of 25-30% is sufficient for rice precision planting (Chittey and Perkin, 1986). In roller-type-metering device, the quantity of seeds per hill is given by:

$$Q_h = Q_{sr} ds/10 \qquad (2)$$

(Chittey and Perkin, 1986)

Where,

d = hill length (m), s = row spacing (m). Q_{sr}= sowing rate (kg/ha) and Q_h = quantity of seeds per hill (g)

Design of shaft

The planter consists of two shafts, the traction shaft and the metering shaft, which support the metering wheel. Power is transmitted to the metering shaft from the land wheel by a chain and sprocket drive. The following equation (Mott, 1985), was used to determine the shaft diameter.

$$D^3 = (16 / \pi S_s) \sqrt{} (k_b M_b) 2 + (k_t M_t) 2 \qquad (3)$$

Where: D = shaft diameter (m), S_s = shear stress ($N/mm2$), k_b & k_t = combined shock and fatigue factors applied to the bending and torsional moments respectively, M_t = tortional moment (Nmm), M_b = bending moment (Nmm).

An available steel shaft of diameter 0.022*m* was used for the planter.

The rolling resistance offered by soil on the land wheel as the planter is being operated is as given by Klenin *et al.* (1985)

$$f = \varphi R \qquad (4)$$

Where;

f = rolling resistance (N), φ = coefficient of rolling resistance of the land wheel on the soil. According to Klenin et al. (1985), φR = 0.30. R = total weight of the machine plus seeds = 437.53N

The rolling resistance (f) was calculated to be 131.3N. This is also equal to the force (F) required for pushing the planting machine in Equation 5.

The power required for pushing the planter is given by:

$$P = F \times S \qquad 5)$$

Where

P = power required (W), F = total draft or force required for pushing the planter (N) and S = normal walking speed of a man (*m/s*). From practice, an average man's pace is assumed to be 0.71 *m/s* even though Kaul and Egbo (1992) gave S = 0.60 *m/s* for field sowing operation.

The power required therefore, to push the planter at 0.6 *m/s* speed is 78.8 *W*.

2.3 Performance evaluation

Testing the performance of the planter involved evaluation of the machine capacities and efficiencies. The parameters investigated include capacity (ha/h) and filed efficiency (%). The field test was conducted on a piece of land measuring 25m x 25m on the University farm. The materials used for testing the performance of the planter include locally available paddy rice (BG302), stopwatch, measuring tape, measuring container and weighing balance. Although the ultimate criterion for evaluating a complete planting operation is the stand obtained in the field (Kepner *et al*., 1980). A pre-test was conducted in the laboratory, to remedy some of the design deficiencies observed before testing on the field. The laboratory test was conducted by turning the land wheel of the planter 10 times in suspended position. A wetted textile material was used to collect seeds falling from the flute. This was done in order to determine the regularity of seed spacing. The average distance on the wetted material was determined. Seed spacing, distribution pattern and the standard deviation of the planter were determined using standards and procedures of evaluating planters as reported by Kepner *et al*. (1980) and Kawuyo and Haque (2003).

2.4 Field Data Collection

A piece of harrowed land measuring 25 *m* x 25 *m* was marked out. The planter was operated without furrow opening at a speed of 0.8m/s to drop the seeds on the field. During this test no furrows were opened so as to allow for measuring the distance between stands. The planter was then operated to plant the seeds on the field. The time taken to cover the land was noted using stopwatch. The test was replicated three times using the same procedure. The planter's performance parameters were evaluated using Equations 6 and 7 below:

$$C_a = A/T \quad (6)$$

$$E_f = C_a/T x 100 \quad (7)$$

Where

C_a = Actual field capacity (*ha/h*), E_f = Field efficiency (%), A = Area covered by planter (*ha*) and T = Total time taken to cover the field (*h*).

3. Results and discussion

Table 1 shows the design results while Table 2 shows the field test results in terms of seed spacing, number of seed per hole and the depth of planting. The distance between stands was found to be 15.12cm, number of seeds per hole 6 and average depth of planting of 3.20cm. The mass of the seed planted was 1.35kg on an area of 625m2. The seed rate was 21.62kg/ha. This compares favourably with values (21-22kg/ha) given by Onwueme and Sinha (1999).

Table 1: Design Parameters

Sn	Parameters	Results
1	Number of grooves on the roller, n	5
2	Quantity of seed per hill, Q_h (g)	223 seeds (180 *g*)
3	Diameter of land wheel shaft, D (*mm*)	22
4	Diameter of metering device shaft, D (*mm*)	22
5	Weight of planter plus seeds, R (N)	437.53
6	Rolling resistance offered by soil, f (*N*)	131.3
7	Force required for pushing the planter, F (*N*)	131.3
8	Power required for pushing planter, P (*W*)	78.8

Table 2 Field Test Results

SN	Distance between hill (*cm*)	Number of seeds planted per hole	Depth of planting (*cm*)
1	14.8	7	3.6
2	15.3	5	3.2
3	15.1	5	2.8
4	14.4	6	3.0
5	16.0	8	4.1
6	15.1	6	3.0
7	14.7	6	2.9
8	15.0	7	2.8
9	15.6	6	4.0
10	15.2	5	2.5
Mean *X*	**15.12**	**6.00**	**3.20**
Standard deviation. *δ*	**0.43**	**0.94**	**0.50**

Table 3 Test results in terms of area coverage

S/n	Quantity of grain in the hopper Qs (g)	Area covered, Ac (ha)	Time taken to cover the area, T (min)
1	2350	0.0625	55.88
2	2350	0.0625	56.4
3	2350	0.0625	55.7
Mean	**2350**	**0.0625**	**55.7**

Table 3 shows the test result it terms of area coverage. The result shows that an area of about 625m2 (0.0625ha) was planted in a mean time of 55.7 minutes (0.928h), giving the filed capacity of 0.067ha/h. the machine was found to have a field efficiency of 77.9%. This compares favorably with grain / fertilizer efficiencies of 60% to 78% as recommended by Smith and Wilkes (1990).

4. Conclusions

The development of the precision rice planter was carried out with the aim of achieving efficient and precise rice planting on the farm. The laboratory and filed tests of the planter show that it can be used effectively for planting rice. The tests revealed a seed rate of 21.6kg/ha and stand spacing of 15.12cm. Actual field capacity of 0.067ha/h and field efficiency of 77.9% recorded with the planter compares favorable with the agronomic specifications for planters. The power required for operating the planter is 78.8W, which is within the normal average output of a man (80W). The planter could overcome the limitations of seed broadcasters and manual operation commonly used in Nigeria.

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References

Bishop, D.D.; P. L. Carter; R. S. Chapman and F. W. Bennet (1993). *Crop Science and food production*. McGraw Hill publishers Ltd, London, p8

Chittey E.T. and D.J. Perkin (1986). A method of recording and evaluating Seedling distribution. *Journal For Agricultural Engineering* Vol. 12,133.

Jackquot, M and B. Courtosis (1988). *Upland Rice*. Macmillan Publishers Ltd, Hong Kong.

Kaul R. N and C.O. Egbo (1992). *Introduction to Agricultural Mechanization*. Macmillan Press Ltd. London, P. 79.

Kawuyo, U.A and M.A. Haque (2003). Design and Construction of A Manually Operated Maize Planter. In: Proceedings of the 4th International conference of the Nigerian Institution of Agricultural Engineering Vol 25, (56-60).

Kepner, R.A.; R. Bainer and E.L Barger (1980). *Principle of Farm Machinery*. 3rd edition, AVI publishing.

Khush, C.N and G.H. Toenniessen (1991). Rice Biotechnology. C.A.B. International rice Research Institute Manila, Philippines, P38.

Klenin, N.L.; I.F. Polov and V.A. Sakun (1985). *Agricultural Machines*. Amerind Publishing Company PVI. Ltd New Delhi.

Mott, R.L. (1985). *Machine Elements in Mechanical Design*, Charles E. (ed). Merril Publishing Company. A Bell and Howell Company Columbia Toronto.

Onwueme I.C and T.D Sinha (1999). Field Crop Production in Tropical Africa; Technical Center for Agric and Food Cooperation. ACP-EU. Lome Convention Michael Health Ltd. Raigate Survey.

Smith, H.P and L.H. Wilkes (1990). *Farm Machinery and Equipment*. Sixth edition, TATA McGraw-Hill publishing Company Ltd; New Delhi P440

Williams, C.N.; W. Y. Chew and J. A. Rajaratnan (1986). Trees and Field Crops of the tropics (Macmillan Publishers Ltd, London. Pp6. Company, Inc. Westport, Connecticut P230