Performance Evaluation of a Hand Pushed Vegetable Seed Broadcaster

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Abstract
The performance of a hand pushed vegetable seed broadcaster was evaluated by conducting both laboratory and field tests. The laboratory tests include seed discharge rate, air discharge velocity and operational or working speed. The field tests include theoretical field capacity, effective field capacity and field efficiency. The average seed discharge rate and operational/working speed obtained were 6.669 g/s and 0.66 m/s respectively. The air discharge velocity obtained range from 7.2-12.2 m/s. The average theoretical field capacity, effective field capacity and field efficiency were 0.18 ha/hr, 0.17 ha/hr and 94% respectively. The machine was able to plant Amaranthus seed at an average seeding rate of 2.70 kg/ha.

Keywords: Vegetable seed, broadcaster, field tests, laboratory tests, field capacity.

1.0 INTRODUCTION

Vegetables play a very important role in human nutrition as they supply dietary fibre and essential vitamins, minerals and trace elements. They can be eaten raw or cooked and are mostly low in fat and carbohydrates. To improve the health of their citizens, many governments encourage their citizens to consume a lot of fruit and vegetables, five or more portions a day often being recommended. It has been estimated that about 790 million people are chronically undernourished in the developing regions of the world (FAO, 1992) and consumption of vegetables can reverse this deficiency.

Methods of planting vegetables include seed drilling and broadcasting. Seed drilling involves sowing seeds by metering out the individual seeds, positioning them in the soil, and covering them in the soil to a certain average depth. Seed drilling sows the seeds at equal distances and proper depth, ensuring that the seed get covered with soil and are saved from being eaten by birds. Broadcasting involves random scattering of the seed over the soil. However, in developing countries like Nigeria both drilling and broadcasting of vegetable seeds are mostly done manually due to high cost of imported seed drill and broadcasters. There is therefore the need for local productions of these machines to make them affordable for farmers.

Several researchers have developed different locally produced planters for different crops such as cowpea (Aderinlewo *et al.*, 2016), maize (Adisa and Braide, 2012), okra (Bambgoye and Mofolasayo, 2006), maize (Ukatu, 2001), maize (Soyoye *et al.*, 2016), maize (Ani *et al.*, 2016), maize (Ikechuckwu et al, 2014), cowpea (Nwachukwu, 2000), maize (Gambari, et al, 2017), Soybean (Gbabo *et al*, 2017), cowpea, maize and soybean (Adekaye and Akande, 2015). Most of these locally produced planters were for grain crops like maize, cowpea and soybean, much appears not to have been done for vegetable crops.

The objective of this work was therefore to evaluate the performance of a locally developed hand pushed broadcaster for leafy vegetables.

2.0 MATERIALS AND METHOD

2. 1 Description of the planter

The planter (Figure 1) was designed and fabricated at the department of Agricultural and Bio-resources Engineering (Afose, 2017), Federal University of Agriculture, Abeokuta. The planter uses

air supplied by a centrifugal blower to plant vegetable seeds by broadcasting. It consists of the following components:

(i) Seed box or hopper. The hopper is made from mild steel. It is trapezoidal in shape with square top and base. The length of the top is 200 mm and that of the base is 45 mm. It is fitted at the base with a gate for regulating the discharge of the seed into the air duct.

(ii) A centrifugal blower of diameter and a discharge duct of (0.2 x 0.2) m^2

(iii) An air duct that receives the seeds from the hopper and subsequently broadcast it on the soil.

(iv) A petrol engine with rated output of 2.2 kW at 3000 rpm and has a maximum torques of 7.5 Nm at 2500 rpm. Power from the engine is transmitted to blower by a v- belt.

(v) A handle for pushing the planter.

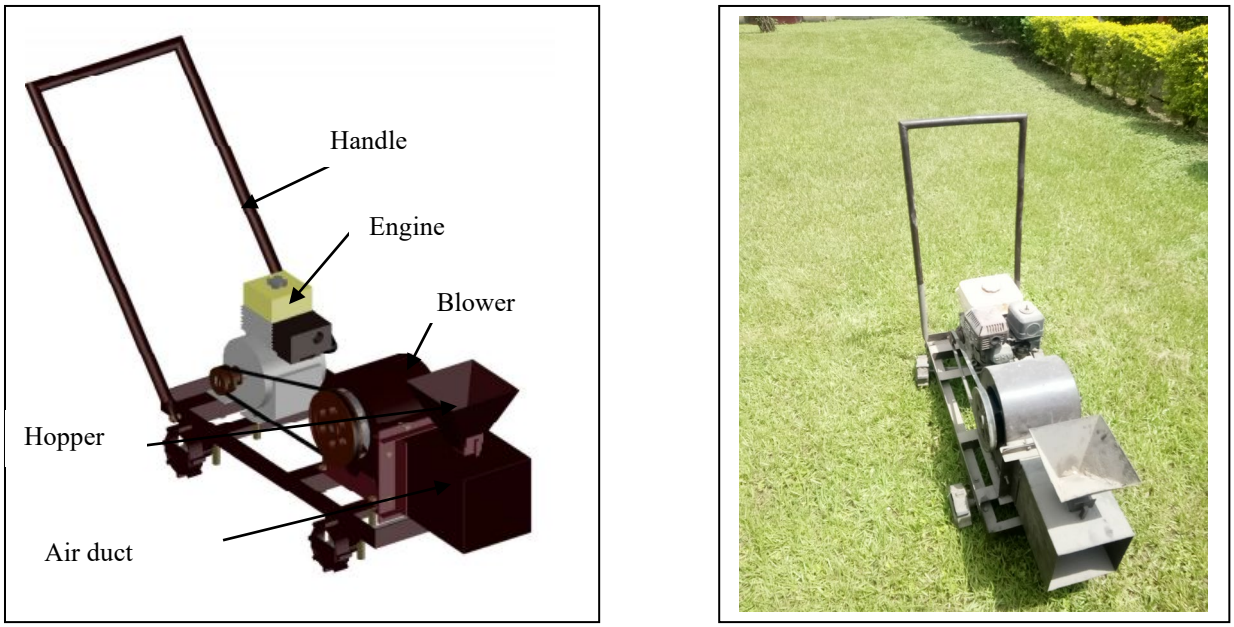

Figure 1. The hand pushed Pneumatic Planter: (a) Computer aided design model (b) The fabricated broadcaster

2.2 Test and evaluation of the planter

2.2.1 Laboratory tests

(a) Air Speed. The planter was calibrated in the laboratory to determine the air speeds obtainable at different speeds of the engine. This was done by varying the speed of the engine through its choke and measuring the corresponding air velocity at the air duct. The speed of the engine was measured with a digital Tachometer DT-2234A (Circuit Specialists, China) while that of the air was measured with a digital Anemometer LM-81AM (Ram Meter, Inc, USA).

(b) Seed discharge rate. The rate of discharge of the seeds from the planter into the air stream was determined in the laboratory using amaranthus seeds as test seed. Amaranthus seeds of mass 100 g were placed in the hopper. The machine was operated for 10s in a stationary position and the seeds discharged were collected in a bag. The mass of seeds collected was then measured using a digital beam balance. The procedure was replicated five times.

(c) Determination of the operational speed (working speed) of the machine. The machine was pushed over a distance of 10 m in the laboratory and the time taken to cover the distance was

recorded with a stopwatch. The speed of operation which is distance divided by time was then determined. This was replicated five times and the average speed was calculated.

2.2.2 Field Test

Three plots of land each of size 3 m X 1.5 m on a loamy soil were used for the test. Amaranthus seeds mixed with saw dust in ratio 1:4 (to achieve adequate spacing) were planted on each plot using the machine. The average terminal velocity of Amaranth seed is 4.25 m/s (Kram and Szot, 1999). The terminal velocity of saw dust particles range from 0.4 to 2 m/s (Bulginis *et al*, 2001). The field capacity (both theoretical and effective) which is the rate of field coverage by the machine and field efficiency which is a measure of the performance of the machine were then calculated using the following relationships (Eqns. 1-3), as described by Adisa *et al*, 2013:

Theoretical field capacity = $\frac{sw}{10}\ ha/hr$ (1)

Effective field capacity = $\frac{acre\ or\ hectare\ covered}{Time\ used\ in\ hour}$ (2)

Field efficiency = $\frac{Effective\ field\ capacity}{Theorectical\ field\ capacity}$ (3)

Where,

S = speed (km/hr)

W = working width (m)

3.0 RESULTS AND DISCUSSIONS

The different air speed the machine can deliver at different speed of the engine is presented in Table 1. The blower speeds ranged from 646.2 to 1829.1 rpm, the engine speeds ranged from 2161.5 to 3101.1 rpm and the corresponding air velocity ranged from 7.2 to 12.2 m/s. This implies that the machine can be used to broadcast any vegetable seed whose terminal velocity is below 12.2 m/s. Since the average terminal velocity of amaranthus seed is 4.25 m/s, the lowest speed of 7.2 m/s was used for the tests.

Table 1: Air speeds at various speeds of the engine and blower

S/N	Blower (rpm)	Engine (rpm)	Air speed (m/s)
1	646.2	2161.5	7.2
2	650.8	2307.3	8.4
3	972.3	2439.8	9.6
4	1474.3	2615.6	10.2
5	1829.1	3101.1	12.2

The results of laboratory test of mass of amaranthus seeds discharged when the machine was operated for 10 s at air speed of 7.2 m/s is presented in Table 2. The average mass discharged is 66.69 g in 10 s which is equivalent to 6.669 g/s (Table 3). This is adequate for planting seeds like amaranths seed. The average operational/working speed obtained is 0.66 m/s, as shown in Table 4.

Table 2: Mass of seed discharged at the lowest speed

S/N	Distance (m)	Time (s)	Operational speed (m/s)
1	10	15.6	0.64
2	10	15.1	0.66
3	10	14.8	0.68
4	10	15.4	0.65
5	10	15.3	0.65
Average			0.66

Table 3: Operational/working speed

S/N	Distance (m)	Time (s)	Operational speed (m/s)
1	10	15.6	0.64
2	10	15.1	0.66
3	10	14.8	0.68
4	10	15.4	0.65
5	10	15.3	0.65
Average			0.66

Table 4: Field test of the broadcaster

	Plots			
	I	**II**	**III**	**Average**
Area of plot(m^2)	(5.6 x 1.5)	(5.6 x 1.5)	(5.6 x 1.5)	(5.6 x 1.5)
Machine working width (width of broadcast)(m)	0.75	0.75	0.75	0.75
Machine rated speed (km/hr)	2.40	2.40	2.40	2.40
Machine working speed(Km/hr)	2.30	2.26	2.24	2.26
Time (hr)	4.85 x 10^{-3}	4.95 x 10^{-3}	4.99 x 10^{-3}	3.96 x 10^{-3}
Theoretical field capacity (ha/hr)	0.18	0.18	0.18	0.18
Effective field capacity (ha/hr)	0.17	0.17	0.17	0.17
Field efficiency (%)	0.94	0.94	0.94	0.94
Seeding rate (Kg/ha)	2.60	2.8	2.7	2.70

The average field capacity, effective field capacity and field efficiency obtained for the three plots are 18, 17 and 94%, respectively (Table 4). These show that the planter was efficient for the planting operation in terms of the work rate for small farm holding.

4.0 CONCLUSION

The locally developed vegetable seed broadcaster was tested in the laboratory and on the field for planting Amaranthus seed. It was observed that the machine can broadcast an average of 6.669 g of amaranthus seed per second, which is appropriate for planting amaranthus seed when mixed with saw dust in the right proportion. The average field capacity, effective field capacity and field efficiency of the machine were 0.18 ha/hr, 0.17 ha/hr and 94%, respectively. The cost of production

of the machine is ₦ 55,100 which shows that it can be affordable by peasant farmers. It is recommended that the machine is motorized to make it suitable for large scale farming.

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