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Performance Evaluation of a Tractor Mounted Precision Soya Beans Planter

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***Abstract* - The performance of an existing tractor mounted soya bean planter was evaluated at different levels of machine forward speeds (1.67 km/hr, 2.00 km/hr and 3.60 km/hr) and a planting depth of 5 cm. It was observed that the both the theoretical and effective field capacities increased with increase in the forward speed of the planter and it was observed that both the field efficiency and the metering efficiency decrease with increase in forward speed. The theoretical field capacity at 1.67 km/hr, 2.0 km/hr and 3.6 km/hr were 0.130 ha/hr, 0.158 ha/hr and 0.250 ha/hr respectively; effective field capacity at 1.67 km/hr, 2.0 km/hr and 3.6 km/hr were 0.103 ha/hr, 0.115 ha/hr and 0.150 ha/hr respectively; field efficiency at 1.67 km/hr, 2.0 km/hr and 3.6 km/hr were 79.23%, 72.78 % and 60 % respectively and metering efficiency at 1.67 km/hr, 2.0 km/hr and 3.6 km/hr were 95.67 %, 93.33 % and 93 % respectively. The laboratory test for germination viability was 94 %. Results of the field test show a mean germination rate after the tenth (10th) day of planting as 84 %, 88.26 % and 78.4 % for the speeds of 1.67 km/hr, 2.0 km/hr and 3.6 km/hr respectively. The lowest percentage recorded for the 3.6 km/hr may be due to the more damage of seeds during metering.**

Key Words: Performance, Soya Beans, Tractor Mounted, Precision, Planter.

INTRODUCTION

Soya bean (*Glycine max*) is among the major industrial and food crops grown in every continent. The crop can be successfully grown in many states in Nigeria using low agricultural input. Soya bean cultivation in Nigeria has expanded as a result of its nutritive and economic importance and diverse domestic usage. It is also a prime source of vegetable oil in the international market. Soya bean has an average protein content of 40% and is more protein-rich than any of the common vegetable or animal food sources found in Nigeria. Soya bean seeds also contain about 20% oil on a dry matter basis, and this is 85% unsaturated and cholesterol-free [1].

The rapid growth in the poultry sector in the past five years has also increased demand for soya bean meal in Nigeria. It is believed that soya bean production will increase as more farmers become aware of the potential of the crop, not only for cash/food but also for soil fertility improvement and *Striga* control [1]. The market for soya bean in Nigeria is growing very fast with opportunities for improving the income of farmers.

Because of the seasonality of rain fed farming, soya bean planting is often late resulting in considerable losses in crop yield. A need exists for improved soya bean planting tools that allow farmers to plant in a timely manner in order to increase yield and reduce drudgery. Early planting is one of the most basic requirements for good crop production [2]. Early planting benefits from the higher soil fertility present at the beginning of the rainy season. As the season progresses, nutrients leach below the root zone and are therefore no longer available for uptake. Early planting also benefit from more days of sunshine.

Uses of Soya Beans

Direct human consumption of soya beans is significant in Nigeria, especially among rural low-income groups that cannot really afford animal protein sources such as meat, fish and eggs [3].

Soybean seeds contain 40 % protein and 20 % oil. Industrial and domestic processing give rise to numerous products consumed by both animals and man [4]. Examples are:

Soybean meal: used as a protein supplement in poultry feeds, hog and cattle feed.

Soybean Oil: An edible oil, which is also used to produce paints, vanish, soap, lubricant, sealant and pharmaceuticals.

Lecithin: Used in oil and chocolate industries.

Soybean curd: Soymilk, soy moimoi, dadawa, ogi etc. are produced from soybean curd.

Industrial Uses of Soya Beans

Leading infant food manufacturers in the country use soya beans because of its high nutritional value. Soya beans are also processed into flour and soya bean oil. Soya bean oil is used in paints, varnishes, ink, cosmetics, and soap making industries. Other uses include making a variety of popular products, such as salad and cooking oils, shortenings, and margarine [5].

MATERIALS AND METHODS

Description of the Precision Planter

Plate 1 is the Photograph of the Precision Planter and Table 1 is the specifications of the planter. The planter consists of the wheels made up with polymer material, frame made of mild steel rectangular iron sections, the furrow openers, feed hoppers having metering plates for feeding and metering seeds, hoses for connecting hoppers with pipes mounted on furrow openers and hitch assembly mounted on the frame. During operation, the seeds are fed by the operator manually in the feed hoppers, which flow to the bottom of the furrow openers. The metering plate which has a number of holes rotates in the bottom of a container having two holes. As the plate rotates, when the bottom holes of container and meter plate hole coincide seeds will flow through the pipe to the soil. The metering plate gets rotary motion through the bevel gear assembly and the bevel gears get the motion by rear wheels with the help chain and sprocket assembly. The machine is a double row-seeding device suitable for sowing soya beans. Planting is accomplished by pulling the device using a tractor in a pre-established furrow.

Plate 1: The Photograph of the Precision Planter

Table 1: Specifications of the Soybeans Planter

Parameter	Specification
Length x Width x Height	1250 x 800 x890 mm
Weight of planter	165 kg
Volume of hopper	0.02486 m^3
Number of planting units	2
Inter-row spacing	300 mm
Intra-row spacing	700 mm
Land wheel (pneumatic) diameter	320 mm
Length of chain	1400 mm
No. of teeth of driver sprocket	36
No. of teeth of driven sprocket	12
Power source (Tractor)	75 hp
Theoretical field capacity	0.179 ha/hr
Effective field capacity	0.123 ha/hr
Field Efficiency	70.67 %
Metering Efficiency (1.67 km/hr)	96 %

Determination of Machine Parameter

A four-wheel-drive Mersey Ferguson MF 375E tractor with Gross weight of 2,200 kg, Overall width of 1,651 mm, Overall length of 3,542 mm and Ground distance of 338 mm was used to perform the experiments. The machine parameter determined was the tractor speed.

Determination of Tractor Speed

Four treatments of the tractor speeds chosen were 1.67, 2.00, and 3.60 km/hr corresponding to S_1, S_2, and S_3 respectively. Before the actual experiments starts, the various revolutions per minute of the engine read off from the speedometer that corresponds to the chosen tractor forward speeds were determined.

Plot Design and Layout

The experimental plot is 20 m long and 15 m wide. The field experiments were laid out as 3 x 1 row-column designs replicated three times. Seeds were planted on flat surface at 70 × 30 cm spacing placed at about 5 cm depth, with 3 seeds per hole.

Experimental Procedure

The planter was tested on a flat field ploughed and harrowed at different forward speeds. A land measuring 20 m x 15 m (L X W) was used for the tests. One factor, machine speed was considered for this study and was evaluated at three levels, namely 1.67 km/hr, 2.00 km/hr and 3.60 km/hr. The soya bean planter was tested at a constant operation depth of 5 cm with three different speeds on a prepared flat field. At each speed, the number of seeds planted was measured.

At various speed of planting, which was determined by recording the time taken to plant a length of 20 m per each run, number of seeds dropped in uncovered seed furrow was counted. Expected number of seeds to be dropped per each run was 120 seeds. This was to determine seed filling efficiency of the planting metering system. The performance indices were evaluated as follows:

Theoretical field capacity

This is the rate of possible field coverage possible if the planter works all the time at the recommended speed and utilizes its entire width of operation (it takes into account all the number of times used for loading, planting, turning and resting among others). Theoretical field capacity was calculated using the equation;

$$T_{fc} = T_L + T_P + T_t + T_r \quad [6] \qquad (1)$$

Where,

T_{fc} = Theoritical field capacity ($\frac{ha}{hr}$)

T_L = Is time taken for loading (hr)

T_P = Is time taken for planting (hr)

T_t = Time taken for turning (hr)

T_r = Time taken for resting (hr)

Effective field capacity

This is the actual rate of coverage by the planter. It represents the time taken to carry out the actual planting only.

$$Ef_c = T_p \quad [6] \qquad (2)$$

Where;

E_{Fc} = effective field capacity ($\frac{ha}{hr}$)

T_p = actual time taken for planting

Field efficiency

This is the ratio of effective field capacity to theoretical field capacity.

$$F_e = \frac{E_{fc}}{T_{fc}} \times 100 \quad [6] \qquad (3)$$

Where,

F_e = Field efficiency

T_{fc} = Theoretical field capacity

E_{fc} = Effective field capacity

Metering efficiency

The metering efficiency of the machine was determined using the equation;

$$M_e = \frac{No\ of\ seeds\ metered}{No\ of\ seeds\ expected\ to\ be\ metered} \times 100 \qquad (4)$$

RESULTS AND DISCUSSIONS

Results

Table 2 show the capacity performance of the planter and Table 3 is the cumulative values of the field seeds germination counts.

Table 2: Capacity Performance of the planter

Speed (km/hr)	Theoretical Field Capacity (ha/hr)	Effective Field Capacity (ha/hr)	Field Efficiency (%)	Metering Efficiency (%)
1.67	0.130	0.103	79.23	95.67
2.00	0.158	0.115	72.78	93.33
3.60	0.250	0.150	60.00	93.00

Table 3: Cumulative Values of field seeds germination counts

Sample Days	Forward speed (km/hr)					
	1.67		2.00		3.60	
	No. of seeds	% Germination	No. of seeds	% Germination	No. of seeds	% Germination
6	102	68.0	110	73.3	98	65.3
7	120	80.0	127	84.7	106	70.7
8	130	86.7	138	92.0	122	81.3
9	135	90.0	141	94.0	130	86.7
10	143	95.3	146	97.3	132	88.0
Total	630	420	662	441.3	588	392
Mean	126	84	134.4	88.26	117.6	78.4

DISCUSSIONS

Capacitive Performance and Efficiencies of the Developed Planter

From Table 2, it was observed that the both the theoretical field capacity and effective field capacity increased with increase in the forward speed of the planter. It was also observed that both the field efficiency and the metering efficiency have negative association with the forward speed. Both the field efficiency and the metering efficiency decrease with increase in forward speed. The theoretical field capacity at 1.67 km/hr, 2.0 km/hr and 3.6 km/hr were 0.130 ha/hr, 0.158 ha/hr and 0.250 ha/hr respectively; effective field capacity at 1.67 km/hr, 2.0 km/hr and 3.6 km/hr were 0.103 ha/hr, 0.115 ha/hr and 0.150 ha/hr respectively; field efficiency at 1.67 km/hr, 2.0 km/hr and 3.6 km/hr were 79.23%, 72.78 % and 60 % respectively and metering efficiency at 1.67 km/hr, 2.0 km/hr and 3.6 km/hr were 95.67 %, 93.33 % and 93 % respectively. From the results it was observed that the theoretical field capacity and effective field capacity were high at the higher speed of 3.6 km/hr. However, the lowest field efficiency of 60% was recorded at the highest speed of 3.6 km/hr.

Percentage Germination

Soya beans TX 1483-30 were used for performance evaluation of the developed planter. The laboratory test for germination viability was 94 %. Results of the field tests as presented in Table 3 shows a mean germination rate after tenth (10^{th}) day of planting as 84 %, 88.26 % and 78.4 % for the speeds of 1.67 km/hr, 2.0 km/hr and 3.6 km/hr respectively. The lowest percentage recorded for the 3.6 km/hr may be due to the more damage of seeds during metering.

CONCLUSION AND RECOMMENDATIONS

CONCLUSION

The planter had good performance on flat land. The furrow opener and the metering mechanism had impressive performances. Results of the performance evaluation of the machine showed that operation speed had negative association with theoretical and effective field capacities. It was also observed that both the forward speed had negative association with field efficiency and the metering efficiency.

RECOMMENDATIONS

i. The precision planter should be operated at a speed of 1.67 km/hr and at a depth of 5 cm, inter-row spacing of 30 cm and intra-row spacing of 70 cm for optimum performance.

ii. The gears should be independent i.e. not be run by a single shaft as a skid in rotation do affect the rate of spacings (Inter and Intra-rows).

iii. The diameter of the land wheel should be increased to ensure that the wheel does not come out of transport position during planting.

iv. The planter is best used on flat land.

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