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***Journal of Scientific and Engineering Research*, 2022, 9(2):7-12**

Research Article

ISSN: 2394-2630
CODEN(USA): JSERBR

Comparison of the Performance Evaluation of Walk Behind and Hand Held Rice Reaper for Harvesting Soyabeans

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Abstract Grain loss occurred during harvesting of soyabeans has resulted to low output. The objective of this research work is to compare a walk behind rice reaper to a hand held rice reaper for harvesting soyabeans. However, Soyabeans TGX1448-2E was harvested at moisture level of 4.85% (wb) using walk behind motorized rice reaper and hand held rice reaper. The total area used for the experiment was 0.056ha. the time of operation, effective field capacity, theoretical field capacity, fuel consumption, field efficiency, cutting efficiency and harvesting loss for walk behind and hand held rice reaper are 3.1567, 14.7880 h/ha; 0.3170, 0.0677 ha/h; 0.3355, 0.0691 ha/h; 7.0238, 7.2619 L/ha; 94.49, 98 %; 94.13, 99.77 %; and 3.7300, 1.6884 % respectively. The results showed that the field and cutting efficiency of hand held rice reaper is higher than walk behind motorized rice reaper. Also, the percentage harvest loss of soyabeans using hand held rice reaper is less than that of walk behind motorized rice reaper. Although, the amount of fuel consumed and the time taking to complete a hectare by hand held rice reaper were higher compared to that of walk behind motorized rice reaper. However, hand held rice reaper performed better compared to walk behind motorized rice reaper.

Keywords Comparison, Rice reaper, Soyabeans, Field capacity, Field efficiency, Harvesting

Introduction

Soyabeans (*Glycine max (L.) Merr.*) is an important legume crop which is a leading source of dietary protein and oil in animal feeds, as well as a staple food for human consumption [1]. It has gr eat economic importance worldwide due to its extensive use for multiple purposes and the exceptional adaptability to a diversity of r egions [2]. Nigeria is the largest producer of soyabeans in Sub Sahara Africa (SSA). This crop is mostly produced in the middle belt where Benue state account for the highest production. Some of the states producing soyabeans in Nigeria include Kwara, kogi, Oyo, Ondo, Osun, Nassarawa, kaduna, Niger, Bauchi, Ogun, and Taraba states. Other states are Adamawa, Jigawa, Lagos, Plateau, Ekiti and the Federal Capital Territory (agronewsng.com. One of the challenges of soyabeans production in Nigeria is harvesting. Nigeria farmers harvest their soyabeans traditionally using hands to uproot the crop. This method is tedious, slow, expensive, and time consuming. According to [3] the traditional method of harvesting soyabeans required about 100-200 man–hours to do the operation on one hectare. Hence, the need to use walk behind and hand held rice reaper to harvest soyabeans as well as compare their performance and choose the most suitable one.

Material and Method

Features and Operation of the Reapers

Walk behind rice reaper is suitable for harvesting and windrowing cereals and oilseed crops such as soyabeans. It consists of petrol engine, power transmission box, pneumatic wheel, cutter bar, crop row dividers, chain, operating controls and sturdy frame. While the hand held rice reaper consist of handle, petrol engine, rotary blade, throttle and guard. The engine for the motorized type transmits power to the cutter bar and conveyor through the transmission mechanism. During forward motion of the motorized reaper, crop row dividers that divide the soyabeans which come in contact with cutter bar and cut at an average height of 0.11m above the ground and conveyed it to the right side of the machine by the conveyor. While the hand held reaper cut the soyabeans as the engine start and the throttle is engaged. The harvested soyabeans were gathered and transported to the threshing unit. See the figures 1 and 2.

Figure 1: Walk behind motorized rice reaper

Figure 2: Hand held rice reaper

Performance Evaluation of the Reapers

Theoretical Field Capacity

Theoretical field capacity means the rate of work that would be achieved if a machine performs its function at its full-rated forward speed for 100% of the time. However, machine cannot operate at its full capacity due to the following factors: turning and idle time, operating at less than full width, cleaning clogged equipment, handling harvested materials etc. Theoretical field capacity can be expressed mathematically as;

$$TFC = \frac{A}{T} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where,

TFC is theoretical field capacity (ha/h),

A is the total area covered (ha),

T is the actual time used during harvesting (h)

Effective Field Capacity

The effective field capacity is the rate at which the machine is able to harvest crop. According to [4] effective field capacity is expressed mathematically as:

$$S = \frac{A}{T_p - T_I} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Where,

S = Effective field capacity (ha/h)

A = Area covered (ha)
T_p = Productive time (h)
T_I = Nonproductive time (h)

Time of Operation

The time of operation is expressed as the inverse of the effective field capacity.
Therefore,

$$OT = \frac{1}{EFC} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

where;
OT is the time of operation (h/ha)
EFC is the field capacity (ha/h)

Fuel Consumption

Fuel consumption is the quantity of fuel required by the machine to harvest a given area of land. In this study refilling method was used to determine the amount of fuel used by the machine. The fuel tank was filled to its capacity on a level ground before the field test, at the end of each trial test the fuel tank was refilled using a calibrated measuring cylinder to determine the quantity of fuel used. This can be mathematically expressed as:

$$FC = \frac{Q}{A_T} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

Where,
FC is the fuel consumption (L/ha)
Q is the amount of fuel consumed during harvesting (L)
A_T is the total area covered during harvesting (ha)

Field Efficiency

Field efficiency is an important criterion to check the field capacity and to make important decisions about the management of the machines, especially at harvest [5]. According to ASAE [6] the efficiency is related to the unused total working width of the machine, with the operator's habits, time and maneuvering characteristics of the area and shape of the blocks. It was calculated using expression of [7].

$$FE = \frac{EFC}{TFC} \times 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

Where,
FE is the efficiency of the machine (%)
EFC is effective field capacity (ha/h)
TFC is theoretical field capacity (ha/h)

Cutting Efficiency

Cutting efficiency of a reaper was determined by considering the number of soyabeans stands at a particular distance before harvest and the number of stands left uncut on the same distance after harvest. This was calculated using the equation of [8].

$$CE = \frac{W_1 - W_2}{W_1} \times 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

Where,
CE is the cutting efficiency (%)
N_1 is the number of stands before cutting
N_2 is the number of stands after cutting

Harvesting Loss

According to [9] the crop losses are influenced by inherent culture factors which related to the harvester. It is necessary to select the best seeds suitable for the required region, plant at the right time, and make use of best agronomic practice to minimize harvesting loss. [10] reported that, despite the high technology available to

harvest soyabeans in Brazil, losses are still experienced leading to reduction in productivity and profits of producers. Harvesting losses which include pre-harvest loss, shattering and uncut stands are determined by the following equation as provided by [11].

$Wg_t = Wg_1 + Wg_2 + Wg_3$ …….. (7)

Where,

Wg_t is the total weight loss (g/m^2)

Wg_1 is pre-harvest loss (g/m^2)

Wg_2 is shattering loss (g/m^2)

Wg_3 is uncut losses (g/m^2)

Therefore;

$H = \frac{Wg_t - Wg_1}{Yg} \times 100$ …….... (8)

where,

H is the harvesting loss (%)

W_{gt} is the total weight loss (g/m^2)

W_{g1} is ths pre-harvesting loss (g/m^2)

Y_g is the harvesting yield (g/m^2)

Results and Discussion

Result

Table 1: Result Obtained for Harvesting Soyabeans Using Walk behind Motorized Rice Reaper

S/N	Area Covered (ha)	Time of Operation (h/ha)	Effective Field Capacity (ha/h)	Theoretical Field Capacity (ha/h)	Fuel Consumption (L/ha)	Field Efficiency (%)	Cutting Efficiency (%)	Harvesting Loss (%)
1	0.056	3.2594	0.3068	0.3235	8.7500	94.82	90.12	5.71
2	0.056	3.1358	0.3189	0.3371	6.0714	94.62	93.98	2.67
3	0.056	3.0750	0.3252	0.3459	6.2500	94.03	97.60	2.82
Average	**0.056**	**3.1567**	**0.3170**	**0.3355**	**7.0238**	**94.49**	**94.13**	**3.73**

Table 2: Result Obtained for Harvesting Soyabeans Using Hand Held Rice Reaper

S/N	Total area Covered (ha)	Time of Operation (h/ha)	Effective Field Capacity (ha/h)	Theoretical Field Capacity (ha/h)	Fuel Consumption (L/ha)	Field Efficiency (%)	Cutting Efficiency (%)	Harvesting Loss (%)
1	0.056	14.7710	0.0677	0.0691	7.5000	97.97	99.63	1.7176
2	0.056	14.7929	0.0678	0.0690	7.1429	98.26	100.00	1.7447
3	0.056	14.7493	0.0676	0.0692	7.1429	97.69	99.67	1.6028
Average	**0.056**	**14.7711**	**0.0677**	**0.0691**	**7.2619**	**98.00**	**99.78**	**1.6884**

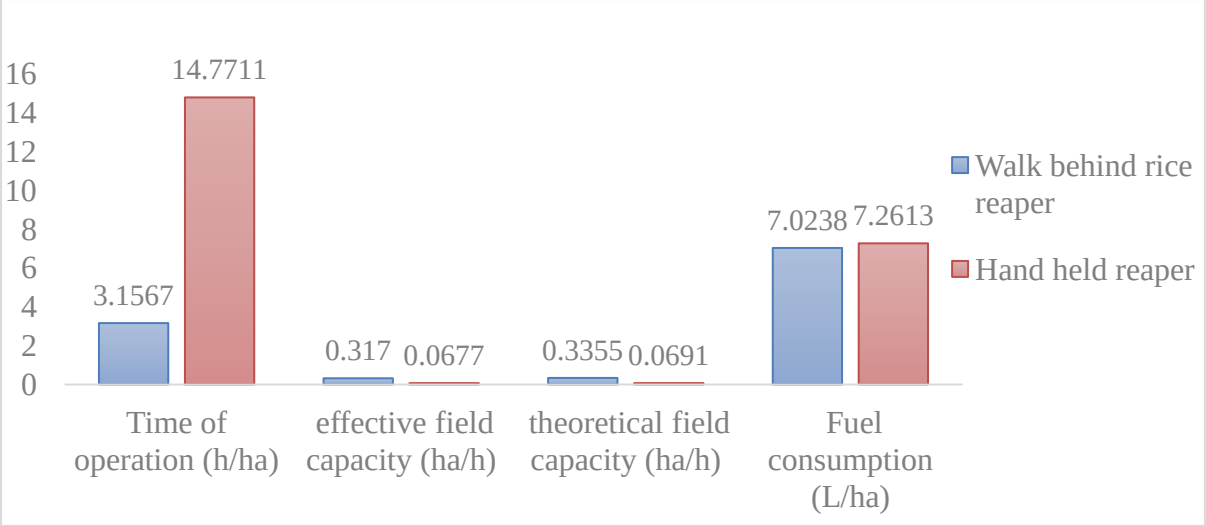

Figure 3a: Comparison of the parameters evaluated for walk behind and hand held rice reaper used for harvesting soyabeans

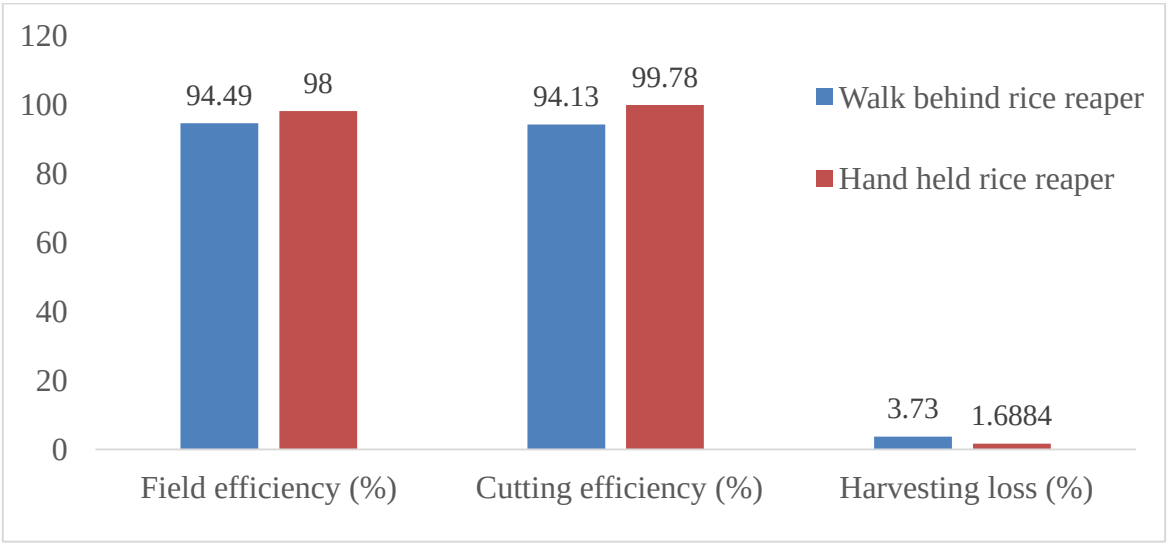

Figure 3b: Comparison of field and cutting efficiency and harvesting loss of walk behind and hand held rice reaper used for harvesting soyabeans

Discussion of the Result

A walk behind and hand held rice reapers were used to harvest on the experimental field of 0.056ha in three replica. The soyabeans stands were cut at an average height of 0.11m above the ground. The results obtained for time of operation, effective field capacity, theoretical field capacity, fuel consumption, field efficiency, cutting efficiency and harvesting loss during the field evaluation of the two reapers were shown in table 1 and 2. The analysis from figure 3a showed that it takes hand held rice reaper a long period of time to finish the operation compare to walk behind rice reaper. This is because the speed of operation is dependent on the speed of the operator but walk behind type is self-propelled. The field efficiency, cutting efficiency for hand held reaper is higher than that of walk behind rice reaper, also the percentage harvesting loss is less compare to that of walk behind rice reaper as shown in figure 3b. Generally, the hand held rice reapers performed better in terms of field and cutting efficiency, percentage harvesting loss compared to walk behind rice reaper though takes a longer time to finish the task. Furthermore, comparing this result to a related study carried out by [8] where field efficiency and cutting efficiency was 92% and 98% respectively. [12] evaluated a rice reaper for harvesting rapeseed. His result showed that the required labour and the cost of harvesting reduced significantly. [13] used self-propelled vertical conveyor reaper (KAMCO Model KR120) to harvest paddy crop. His result showed that

the actual field capacity was 0.29 ha/h, field efficiency was 70% and fuel consumption was 0.8 l/h. however, it can be deduced that both walk behind and hand held rice reaper performed better when compared to related work done by the researchers.

Conclusion

The comparison of the performance evaluation of walk behind and hand held rice reaper on 0.056ha of soyabeans experimental plot was done in three replicates. The result obtained showed that, fuel consumption, time operation field efficiency, cutting efficiency and percentage harvesting loss for walk behind and hand held rice reaper are; 7.0238, 7.2613L/ha; 3.1567, 14.7711 h/ha; 94.49, 98.00%; 94.13, 99.78% and 3.7300, 1.6884% respectively. The two rice reapers were found to be efficient, fuel economical and easy to maintain. However, hand held rice reaper performed better compared to walk behind rice reaper though it takes more time and consumed more fuel to complete its operation. The adequate operating speed of the reaper played an important role during harvesting. If the speed of operation of hand held reaper can be increased and maintained by the operator the better. Therefore, both the walk behind and hand held rice reaper are suitable for adoption to harvest soyabeans.

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