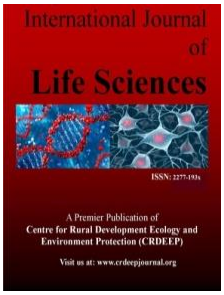
Vol. 10. No.4. 2021.

Contents available at:
http://www.crdeepjournal.org/category/journals/ijls/

International Journal of Life Sciences (ISSN: 2277-193x) CIF: 5.411; SJIF: 6.431
A Peer Reviewed Journal



Full Length Research Paper

Adoption of a Hand Guided Motorized Rice Reaper for Harvesting Soyabeans

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ARTICLE INFORMATION

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Article history:
Received: 05-10-2021
Revised: 26-10-2021
Published: 01-11-2021

Key words:
Adoption, Rice reaper, Soyabeans, Field capacity, Field efficiency, Harvesting

ABSTRACT

Harvesting has been a major challenge for small and medium scale of the Nigeria soyabeans farmers. The loss incurred by farmers during harvesting can be reduced by the use of appropriate technology to minimize grain loss and improve production output. The objective of this study was to adopt a hand guided motorized rice reaper for harvesting soyabeans. However, Soyabeans TGX1448-2E was harvested after 14 weeks of planting at moisture level of 4.85% (wb) using hand guided motorized rice reaper GS130-2CN. The machine was also used to harvest rice for adequate comparison between the two crops. The field parameters evaluated for soyabeans and rice are operating speed (2.400, 2.363km/h); time of operation (3.1567, 2.9225h/ha); effective field capacity (0.3170, 0.3358ha/h); theoretical field capacity (0.3355, 0.3581ha/h); fuel consumption (7.0238, 6.7262 L/ha); rate of fuel consumption (2.2177, 2.2583L/h); field efficiency (94.49, 93.78%); cutting efficiency (94.13, 98.14%) and harvesting loss (3.7300, 2.7720%) respectively. The total area used for the experiment was 0.056ha. The results showed that field efficiency of the machine for both crops are almost the same with difference of 0.71% which could be as a result of physical characteristics of the field where the two crops were planted. There was a significant difference of 0.030 for time of operation and 0.126 for cutting efficiency of the reaper for the two crops. This was due to differences in mechanical properties of stems of the two crops. Soyabeans stem is hard compared to rice stem which is straw. There was no significant difference in operating speed, fuel consumption and harvesting loss for both crops. In general, the reaper was found to be efficient, economical and suitable for harvesting soyabeans.

Introduction

Soyabeans (*Glycine max 'Edamame'*) belong to the legume family which originated from South east Asia and were first domesticated by Chinese farmers around 11000 BC (www.ncsoy.org) [1]. Soyabeans are excellent source of protein and dietary fiber. It has great economic importance worldwide due to its extensive use for multiple purposes and the exceptional adaptability to a diversity of regions [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). The planting period of soybeans in Nigeria is between June - July depending on agro ecological zones. Soyabeans can be harvested between 3 - 4 month after planting depending on the varieties and the time of planting. One of the major challenges facing soyabeans growers in Nigeria is harvesting. Most farmers in Nigeria harvest their soyabeans manually using hands to uproot the crop while few use sickle and knife as a means of harvesting. This method is tedious, slow, expensive, and time consuming. The traditional method of harvesting soyabeans using sickles and scythe is very slow. It required bout 100-200 man–hours to harvest crop in one hectare [3]. Hence, the need to use a mechanical method of harvesting soybean by adopting a hand guided motorized rice reaper GS130-2CN to overcome the aforementioned challenges. The machine was selected because it is easy to operate and maintain, efficient and fuel economical.

Material and method

Features and Operation of the Reaper

A hand guided motorized rice reaper as shown in figure 1 is a motorized type 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. The engine transmits power to the cutter bar and conveyor through the transmission mechanism. The specifications of the machine are shown in table 1. During forward motion of the reaper, crop row dividers divide the soyabeans stands which come in contact with cutter bar and cut the stands at an average height of 0.11m above the ground which then conveyed and windrowed to the right side of the machine along the field by the conveyor. The harvested soyabeans was bundled manually and transported to the threshing unit. See the figure 1, 2, 3 and 4.

Fig 1: GS130-2CN Motorized rice reaper

Fig 2: Rice reaper in operation

Fig 3: Packing of harvested soybean

Fig 4: Harvested soybean ready for threshing

Performance Evaluation of the Reaper

Operating Speed

The operating speed is the distance covered by the machine over a period of time. The operating speed was calculated using equation given by [4].

$$s = \frac{D}{T} \times 3.6 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where,

S is the speed of operation (km/h)

D is distance covered during harvest (m)

T is time taking during harvest (sec)

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;

$$TFC = \frac{A_t}{T} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Where,

TFC is theoretical field capacity (ha/h),

A_t 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 hak2rvest crop. According to [5] the effective field capacity was expressed as:

$$S = \frac{A}{T_p - T_I} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

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,

$$OT = \frac{1}{EFC} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

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:

$$FC = \frac{Q}{A_T} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

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)

Rate of Fuel Consumption
The rate of fuel consumption is the quantity of fuel consumed by the machine over a period of time during field test. This can be mathematically expressed as;

$$FC_R = EFC \times FC \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

Where,
FC_R is the rate of fuel consumption (L/h)
EFC is the effective field capacity (ha/h)
FC is the fuel consumption (L/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 [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 [7]. It was calculated using expression of Hancock *et al.*, [8].

$$FE = \frac{EFC}{TFC} \times 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (7)$$

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 [3].

$$CE = \frac{W_1 - W_2}{W_1} \times 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (8)$$

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

The crop losses are influenced by inherent culture factors which related to the harvester [9]. 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. However, despite the high technology available to harvest soyabeans in Brazil, losses are still experienced leading to reduction in productivity and profits of producers [10]. Harvesting losses which include pre-harvest loss, shattering and uncut stands are determined by the following equation as provided by [11].

$$Wg_t = Wg_1 + Wg_2 + Wg_3 \quad \ldots\ldots\ldots\ldots\ldots (9)$$

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;

$$H = \frac{Wg_t - Wg_1}{Yg} \times 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (10)$$

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

Table 2: Result Obtained for Harvesting Soyabeans Using a GS130-2CN Walk behind Rice Reaper

S/N	Area Covered (ha)	Operating Speed (km/h)	Time of Operation (h/ha)	Effective Field Capacity (ha/h)	Theoretical Field Capacity (ha/h)	Fuel Consumption (L/ha)	Fuel Consumption (L/h)	Field Efficiency (%)	Cutting Efficiency (%)	Harvesting Loss (%)
1	0.056	2.500	3.2594	0.3068	0.3235	8.7500	2.6845	94.82	90.12	5.71
2	0.056	2.350	3.1358	0.3189	0.3371	6.0714	1.9362	94.62	93.98	2.67
3	0.056	2.350	3.0750	0.3252	0.3459	6.2500	2.0325	94.03	97.60	2.82
Average	**0.056**	**2.400**	**3.1567**	**0.3170**	**0.3355**	**7.0238**	**2.2177**	**94.49**	**94.13**	**3.73**

Table 3: Result Obtained for Rice Harvesting Using a GS130-2CN Walk behind Rice reaper

S/N	Total area Covered (ha)	Operating Speed (km/h)	Time of Operation (h/ha)	Effective Field Capacity (ha/h)	Theoretical Field Capacity (ha/h)	Fuel Consumption (L/ha)	Fuel Consumption (L/h)	Field Efficiency (%)	Cutting Efficiency (%)	Harvesting Loss (%)
1	0.056	2.410	2.9762	0.3360	0.3600	7.1428	2.3991	93.33	97.5000	3.0312
2	0.056	2.330	2.9815	0.3354	0.3562	6.7857	2.2759	94.18	98.0500	2.6796
3	0.056	2.350	2.9762	0.3360	0.3581	6.2500	2.1000	93.83	98.8700	2.6051
Average	**0.056**	**2.363**	**2.9225**	**0.3358**	**0.3581**	**6.7262**	**2.2583**	**93.78**	**98.1400**	**2.7720**

Table 4: Statistical Analysis Using Independent Sample Test (T- Test for Equality Means) Equal variances assumed.

S/N	Parameters	t	Df	Sig. (2-tailed)	95% confidence interval of the difference Lower	Upper
1	Operating Speed (km/h)	0.661	4	0.545	-0.1173642	-0.1906975
2	Time of operation (h/ha)	3.293	4	0.030	0.0280621	0.3294713
3	Fuel consumption (L/h)	0.330	4	0.758	-2.2087296	2.8039962
4	Cutting efficiency (%)	-1.931	4	0.126	-10.3371687	1.8571687
5	Harvesting loss (%)	0.963	4	0.390	-1.8094376	3.7321709

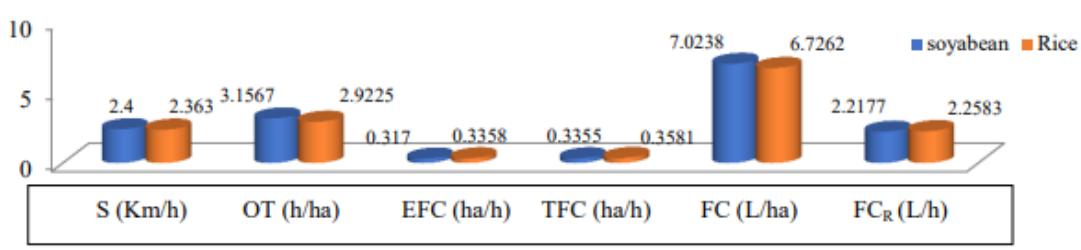

Fig 5a: Comparison of the performance of the reaper used for harvesting soyabeans and rice

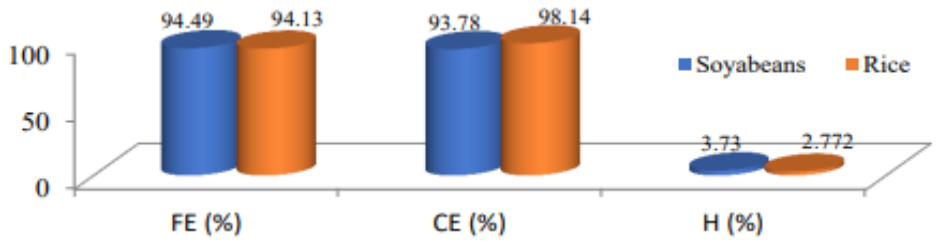

Fig 5b: Comparison of the performance of the reaper used for harvesting soyabeans and rice

Discussion

Hand guided motorized rice reaper GS130-2CN was used to harvest soyabeans. It cut the crop stands at an average height of 0.11m above the ground. The total area covered during the experiment was 0.056ha. The results obtained for parameters evaluation such as operating speed, time of operation, effective field capacity, theoretical field capacity, fuel consumption, rate of fuel consumption, field efficiency, cutting efficiency and harvesting loss during the field evaluation of the machine for both soyabeans and rice were presented in table 2 and 3. Table 4 showed the statistical analysis of the result using independent sample test. The analysis of the result showed that there was no significant difference in operating speed, fuel consumption (L/h) and harvesting loss of the reaper for the two crops. The field efficiency of the machine for soyabeans was slightly higher than rice by 0.71%. This could be as a result of physical properties of the field where the two crops were planted. There was a significant different in time of operation and cutting efficiency of the reaper for harvesting soyabeans and rice. The difference may be due to mechanical properties of the stem of both crops. Soyabeans stem is hard which requires more force and time to cut compare to that of rice straw. Figure 5a and b illustrated the bar chart of the evaluated parameters during the field test of the reaper. Generally, the machine performed satisfactorily when compare to a related study carried out by [3] where time of operation, field efficiency and cutting efficiency was 4h10m, 92% and 98% respectively. A rice was evaluated for harvesting rapeseed and the required labour and the cost of harvesting reduced significantly [12]. Also, a self-propelled vertical conveyor reaper (KAMCO Model KR120) was used to harvest paddy crop and the result showed that the actual field capacity was 0.29 ha/h, field efficiency was 70%, average operating speed was 3.00 km/h and fuel consumption was 0.8 l/h [13]. Therefore, the use of GS130-2CN motorized rice reaper for harvesting soyabeans is efficient, effective and economical.

Conclusion

The performance evaluation of hand guided motorized rice reaper GS130-2CN on soyabeans farm was carried out successfully. The result obtained showed that, fuel consumption and field efficiency are; 2.2177L/h and 94.49% respectively. The reaper was found to be efficient, fuel economical and easy to maintain. The machine was able to cover a reasonable distance at a given period of time. For optimum utilization of the machine a well-prepared land and well calibrated seed drill planter are needed for cultivation of soyabeans in order to have adequate cuttings during harvest. The operating speed of the reaper played an important role during harvest. In this work, the speed of the reaper was between 2.3 to 2.4km/h which was within the range recommended by [3] that speed of the reaper should be between 2-5km/h to avoid clogged of cutter bar of the machine. Therefore, a hand guided motorized rice reaper GS130-2CN is suitable for adoption to harvest soyabeans.

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