Performance Assessment of a Mechanical Mini-Rice Thresher in Maiduguri, Borno State, Nigeria

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Abstract

The thresher is a requisite machine in the production of rice business at present. For a newly constructed rice thresher, evaluating its parameters such as efficiency, capacity, optimum speed of thresher and fuel consumption is essential. In a country where imported rice stands at 70% of what we consume; it is very prudent to increase our local production by motorizing the threshing process. Rice quality is affected by moisture content at harvest and the cylinder speed of the thresher during threshing. The effect of cylinder speed hence the optimum speed of the machine will be working as it is investigated. L50 rice variety was used. A recognized method of calculating efficiency, moisture content, and capacity was adopted. Higher moisture 26.2% (wb) yielded an efficiency of 85.3% while the supplementary tests with moisture content of 16.67% (wb) and 23.37% yielded efficiencies of 90.61% and 89.18%. This result was attained when threshing was done at 890 rpm for both cases. The capacity of the thresher at 800 rpm was 26.01 kg/hr whereas 0.35 l of petrol was used in threshing a unit mass of paddy. The optimum speed of the thresher was 890 rpm. In conclusion, higher efficiency was attained when threshing was done at lower moisture content and higher speed. The efficiency on the other hand would increase if threshing losses are minimized as much as possible. Threshing above the optimum speed would increase the losses hence minimizing the efficiency of the thresher.

Keywords: *Rice Thresher, Evaluation, threshing efficiency, energy and consumption*

INTRODUCTION

Background of the Study

According to Agidi *et al*. (2013), threshing is the process of loosening the edible part of a cereal grain (or other crops) from the scaly edible chaff that surrounds it. It is the step-in grain reparation after which after harvesting and before winnowing, which separates the loosened chaff from the grain. Threshing can be done by beating the grain using a flail on a threshing floor. The threshing floor consists of two main types namely; specially flattened outdoor surface and inside building with a smooth floor of earth (Mohammad and Alireza, 2013). Threshing is one of the most important crop processing operations to separate the grains from the ear heads or the plants and to prepare them for market (Ezzatollah *et al*., 2009).

Threshing is a practical procedure in rice and some cereals production. The thresher was developed for threshing, extrication, and cleaning cereals. The major components of the machine include threshing, separation, and cleaning units (Ghasemi *et al*., 2005). The thrashing machine or in modern spelling, threshing was first invented by a Scottish mechanical engineer by the name Andrew Meikle for agricultural purposes (Correa *et al.*, 2006). It was devised (c.1786) for the separation of grain from stalks and husks. For some thousands of years ago, grains were separated by hand with flails, which made it very tedious and time-consuming. The threshing machine can be put into two main categories with types. The motorized and manual rice threshers. An example is the ASI type for the motorized and the TCC/IDDS manual rice thresher (ARC, 2006).

Rice is from the family, Gramineae, Genus; Oryza and species: Sativa L. and Glaberrima. It was taken to West Africa in the early 19th century (Jirgi et al., 2009). The African rice (*Oryza glaberrima*) is believed to have originated in the Central Delta of the Niger River where it may have been grown since 1,500 BC (Chukwu, 2008). Rice crop production originated from China and was spread to countries such as Sri Lanka and India. Rice is also an agricultural commodity with the third-highest worldwide production after sugarcane and maize (FAOSTAT, 2012). Rice is a staple food for the majority of the world's population. More than 40% of rice consumption in West Africa is imported, which represents 2.75 million tons per year (Barris *et al*., 2013). Worldwide there are more than forty thousand different varieties of rice species *Oryza sativa, doongara, jarrah, keema, reizip* are a few species (IRRI, 2015). It is projected that rice sustains the livelihood of 100 million people and its production has employed more than 20 million farmers in Africa (WARDA, 2005). Rice consumption has been increasing over the years with population growth, hence rice continues to be part of the main diet in most homes due to its relative handiness in preparation and appetizing recipes. Therefore, this study was carried out to evaluate the performance of a motorized mini rice thresher, with the following objectives; To determine the capacity and threshing efficiency of a motorized mini rice thresher, to determine the optimal speed and effect of moisture content on thresher, To determine the energy consumption per unit weight of threshed rice.

Statement of the Problem

Recently, the Federal Government of Nigeria stopped the rice importation and its border to "protect local producers against massive imports of rice". However, local farmers involved in rice production in Nigeria still use local means of threshing. Thus, using wood logs as an implement to aid in the threshing. Aside from being labour intensive, the post-harvest losses are huge.

Studies have shown that threshing losses were higher (6.14%) when threshing was done using the box (a big locally made wooden box) than when the bag beating method (2.45%) was used (Ramatoulaye, 2010). Some small, medium, and large threshers have been in existence for quite a long time, but due to low or poor performance in comparison with the traditional methods, they have not been adopted to a significant extent. Some are hand-held threshers and pedal-operated ones (Chabrol *et al.*, 2005).

Significance of the Study

The most proficient mode of threshing is the use of a motorized rice thresher. To determine the optimal speed, moisture content for threshing, the capacity of the thresher, efficiency, and energy consumption, there is the need to carry out field evaluation of the motorized mini-rice thresher. The comparative evaluation of a mini rice thresher is of great importance. It could serve as a source of reliable information for rice farmers to compare the advantages of using a thresher to local methods of threshing. It would also enable growers to know the predetermined parameters of the thresher.

Scope and Limitation of the Study

The scope of this project covers the evaluation of a motorized mini rice thresher with paddy rice to determine the threshing efficiency, optimal speed, and effect of moisture content on thresher and energy consumption per unit weight of threshed rice.

MATERIALS AND METHOD

Materials

The following materials /instruments were used in the field evaluation; A motorized rice thresher, Paddy rice (L50), Plastic bucket, Oven, A pair of calipers, Measuring tape, Digital tachometer, electronic balance, Plastic trays, Stop watch.

Machine Description and Working Principles

The motorized mini rice thresher has a dimension of 102.3 cm × 63.5 cm × 39.7 cm. The threshing unit consists of a rotating cylinder. The cylinder drum is 8.9 cm in diameter and 48.3 cm in length. There is only one type of threshing element in the cylinder. The threshing drum has loops that are perpendicular to the axis of the cylinder. The threshing is set in motion by the started motor. The threshed paddy is collected through a chamber with a size of 29.8 cm × 10 cm beneath the threshing drum. The thresher is specifically designed for rice. Threshing occurs by a combination of impact and rubbing action as the harvested rice heads pass over the rotating cylinder. The thresher requires only one person to operate it.


Plate 3.1 Motorised Mini-rice Thresher


Plate 3.2: Inlet view of the Motorised Mini-rice Thresher

Performance Evaluation of the Mini-rice Thresher

Two major tests were run: preliminary and actual tests. The preliminary test was run to determine how the thresher functioned by determining the feed rate and threshing speed to optimize performance. The observation and values obtained from the preliminary test were used as a guide for the actual test.


Plate 3.3 Performance test of Mini-rice Thresher

Plate 3.4 Performance test of Mini-rice Thresher

Mini-rice Thresher efficiency

This is the ratio of mass collected at the outlet to the mass inputted into the thresher. The threshing efficiency in percentage (η) is given as;

$$\eta\ (\%) = \frac{output\ of\ thresher}{input\ of\ thresher} \times\ 100 \qquad 1$$

Mini-rice Thresher Capacity

This can be defined as the material output per unit time in kilogram per hour (kg/h), given by;

$$C_{th} = \frac{Mth+Msc}{t} \qquad 2$$

Where; M_{th} = mass of threshed paddy rice collected in the outlet in kg

M_{sc} = mass of scattered paddy in kg.

C_{th} = capacity of thresher in kg/h

t = time taken to threshed in hours.

Moisture content (MC)

The procedures for measuring MC with the oven-drying method are

1. Pre-heat the oven to 130°C
2. Weigh three paddy samples of 10 grams each and place them inside the oven
3. Remove the samples after approximately 16 hours, and obtain the final weight of each sample
4. Compute the MC for each sample, MC = (10 - Final weight of dried sample in grams) *100/(10) and compute the average MC of three samples.

The moisture content wet basis (MC_{wb}) in percentage is given by;

$$MC_{wb} = \frac{M_i - M_f}{M_i} \times 100 \qquad 3$$

Where, M_i = Initial weight (g)

M_f = Final weight (g)]

RESULTS AND DISCUSSION

Results

This chapter presents the results and discussion of analyzed data from the field evaluation and laboratory work. The results are presented in tables and graphs. The local rice used (L50) was cultivated in Nigeria at Koshebe in the Zabarmari District in Borno state of Nigeria. The rice was harvested from a parcel of farmland with a size 18.9 m × 49.1 m. The moisture content of the rice harvested varied from 16.67 – 26.2% (wet base).

Effect of Moisture Content on Rice Threshing

Moisture content is the quantity of free water present in a sample. The moisture content of the rice harvested directly affects the efficiency of the thresher. The rice yielded an efficiency of 98.1%, 94.2%, and 90.9% at the moisture content (wb) of 17.5%, 22.0%, and 17.0% respectively. This clearly shows that at higher moisture content the efficiency decreases.

Table 4.1 Effect of Moisture Content on the Thresher Efficiency

Efficiency (%)	MCwb (%)
98.1	17.5
94.2	22
90.9	17

The field evaluation carried out shows an increase in harvested moisture content and decreased threshing efficiency. The preliminary test with a moisture content of 26.2% (wb) yielded an efficiency of 85.3% while the supplementary tests with a moisture content of 16.67% (wb) and 23.37% yielded efficiencies of 90.61% and 89.18% respectively.

Capacity of Mini-rice Thresher

Capacity refers to the output of the thresher with respect to time in hours. Its SI unit is kg/hr. Capacity is affected by the speed of threshing. The higher the speed the less time it takes to thresh, hence the greater the capacity. The capacity of a particular thresher would always be given at a particular speed.

Table 4.1 Mini-rice Thresher Capacity Determination

Trial	QRT(kg)	T(min)	Speed (rpm)
1	6	7.58	800
2	6	7.50	850
3	6	4.30	870
4	6	4.20	880
5	6	4.10	890
Average	6	0.2307	2145

QRT- Quantity of rice threshed and T- Time taken to threshed

$$\text{Capacity} = \frac{6}{0.2307} = 26.01 kg/hr$$

From the field evaluation results in Table 4.1, the average mini-rice thresher capacity was determined to be 26.01 kg/hr. Meaning in every hour it would thresh 26.01 kg of rice straw on the average. It was also noticed that for every 6 kg of paddy threshed, the time taken lies between 4.10 min to 7.50 min due to the speed used in threshing. For a speed of 800 rpm, the time taken was 7.58 min and its capacity stood at 47.49 kg/hr. However, at a higher speed of 890 rpm, the time taken was 4.10 min and its capacity stood at 87.80 kg/hr.

Fuel Consumption of the thresher

Fuel consumed by the thresher is directly proportional to the mass of paddy threshed as shown in Figure 4.1.

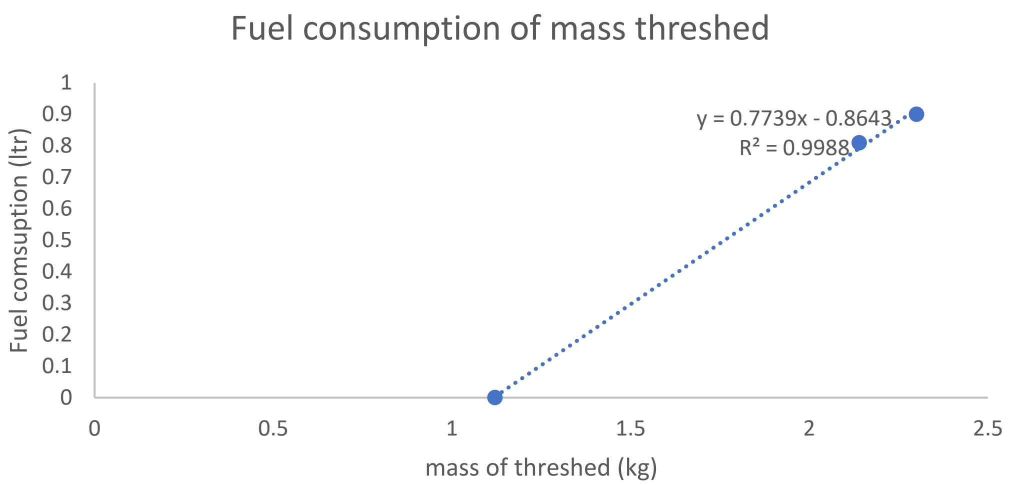

Figure 4.1 Fuel Consumption per Mass Threshed

A perfect relationship exists between the consumption of fuel and mass threshed. The higher the consumption of fuel, the higher the mass threshed. It was however realized that the thresher was fuel efficient. Table 4.2 represents three specified mass threshed and their fuel consumption.

Table 4.2 Fuel consumption per Mass Threshed

Mass threshed (kg)	fuel consumption (I)
1.12	0. 35
2.14	0.81
2.30	0.90

The engine attached to the thresher is a gasoline engine thus it uses petrol as its source of fuel. From Figure 4.2 above, it could be construed that the engine is fuel efficient. Consumption of 0.35 l was used in threshing 1.2 kg of paddy rice. To threshed 2.14 kg of rice, the consumption stood at 0.81 l. Lastly, 0.9 l of petrol fuel was utilized by the engine in threshing 2.30 kg of paddy rice.

Optimum Speed Mini-rice Thresher

The speed of a particular thresher can be drawn into three categories, the maximum speed, the optimum speed, and the minimum speed. Lower efficiency is recorded if threshing is done at the minimum speed. However, many losses are recorded if threshing is done at maximum speed. Therefore, it is very prudent to regulate the optimum speed for threshing in which case reduced losses are recorded and higher efficiency is also realized.

The best determinant in a range is the optimum speed of the thresher. The most appropriate range is (985 – 1002) rpm. With this speed range, an average optimum speed can be calculated as 980 rpm. Within the above-stated range, an average of 390 g of paddy was threshed. The average losses recorded within this same range stand at 36 g which is relatively low as compared with the two higher speeds. The average of these two higher speeds stands at (1011 -1398 rpm) 1200 rpm and the average losses recorded is 52 g while the total mass threshed stands at 1.059 kg. It is very clear that at maximum speed, many losses are recorded.

Efficiency of Mini-rice Thresher

The efficiency of the thresher is the ratio of the output to the input of the sample thresher. The efficiency of every thresher can never be equal to 100% as a result of losses recorded during threshing. As much as possible losses should be minimized since they cannot be avoided in the rice threshing process.

Table 4.3: Efficiency Mini-rice Thresher

C S (rpm)	MR (g)	ML (g)	E (%)
860	360	32	91.5
965	385	36	90.9
985	450	37	91.5
1002	460	50	89.2
1011	465	52	89.3
1398	555	66	89.4

CS – Cylinder speed, MR – Mass of rice, ML – mass losses and E - efficiency

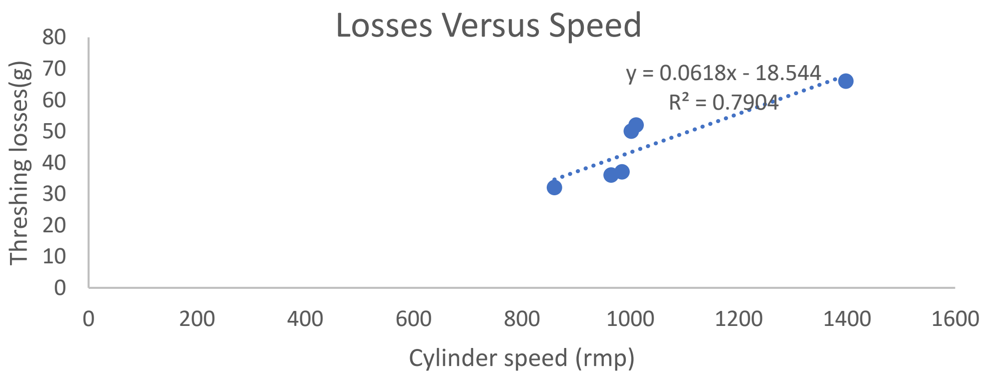

Figure 4.3: Effects of Threshing Losses and Speed

The efficiency of the machine is directly affected by the threshing speed of the cylinder drum. From Table 4.3 above the more advanced the speed gets, the lesser the efficiency. This is normally the case because, at maximum speed, threshing losses are very high. It can be distinguished that at a speed of 1010 rpm, the efficiency estimated was 89.1%. On the contrary, at a much lower speed of 980 rpm, the efficiency is 91.0% with very less losses as compared to the speed at 1010 rpm. In conclusion, the efficiency of the mini rice thresher was 91.0% at a speed of 980 rpm.

CONCLUSION AND RECOMMENDATIONS

Conclusion

These are the conclusions drawn after successfully undertaking the field evaluation of the motorized mini-rice thresher. They were based on the specific objectives of the work. Most importantly, higher moisture content leads to lower threshing efficiency whereas lower moisture content results in higher threshing. Then, the optimum speed for threshing was determined to be 980 rpm. Increasing the cylinder speed above the optimum speed increases the threshing losses. The capacity of the thresher was determined to be 61.27 kg/hr when threshing at a speed of 870 rpm. Furthermore, the efficiency of the thresher was determined as 91.7% when threshing at the optimum speed of 980 rpm. Finally, fuel consumption per unit of mass threshed (1 kg) is 0.37 l on the average. A total of 5.54 kg of paddy was threshed to determine the fuel consumption of the thresher. The thresher required 2.07 l of fuel to thresh 5.54 kg of paddy.

Recommendations

Following the results from the field evaluation: the capacity, fuel consumption, optimum speed, efficiency, and laboratory analysis of the moisture content, these recommendations were made:

1. Since the paddy rice should be harvested at a lower moisture content, a moisture-meter can be used to quickly determine the moisture content before harvesting the rice. This will ensure higher efficiency during threshing.
2. It is also recommended that an external plate be welded tangential to the inlet in order to control losses hence increasing the efficiency of the thresher.
3. The thresher should have two wheels so that it is easily transportable.

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