Comparative Quality And Performance Analysis Of Manual And Motorised Traditional Portable Rice Threshers

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Abstract
Traditional motorized and manual portable threshers are the two types of threshers common to average farmer in the African continent and about 70% food production is in the hands of these categories of farmers. This paper compares the suitability of these types of threshers for traditional African farmers. The production rates (quantity threshed) and quality (seed loss and mechanical damage) were analyzed for both manual and motorized rice threshers using actual research data. The observed advantages and disadvantages based on production rate, quality, cost and farm sizes are outlined as a guide to farmers. The result of this analysis is also employed to improve the performance of motorized rice thresher.
Key words: rice, threshers, farm machineries, portability

1. Introduction

Threshing is the process of removing grains from the ear heads of crops like rice, sorghums, millet, wheat, beans, guinea corn, etc. The term thresher is a general name for all machines that are involved in the process of detaching grains from the ear head. These traditional farmers do not possess the financial ability and land size to venture into large plantations, hence, modern threshers commonly used in Europe, America and big Asian farms do not fit into their needs.

It remains a fact that today, the bulk of our agricultural production remain in the hands of the traditional farmers. Experience shows that true revolution in agriculture will involve giving the local farmers and the young farmers all the encouragement needed by equipping and training them so that they can depart from the laborious and inefficient traditional methods of crop production and processing. In Nigeria, rice production has remained low both in quantity and quality because of the inefficient production and processing techniques. As a result of these, the locally produced rice cannot compete well with the imported brand. Though it is impossible to have the modern big farms overnight, yet the low per hectare yield and substandard quality of the final products demand that concerted efforts be made to improve on the present approach. In this regard, this paper focuses on the process of threshing rice thereby evolving an approach that will give optimum threshing ability with respect to both quality and quantity of the threshed grain.

Two factors make the locally produced rice uncompetitive, compared with the imported rice. The quality of the rice, sometimes they are broken, this is due to mechanical damage during threshing and milling, broken grain reduces the market value of rice by about half, again the profitability is further reduced due to seed loss and low productivity and uneconomical processing techniques, these aforementioned factors are partly processing problems that require concerted effort, most imported technology do not fit into the traditional setting of the local farmers hence the project focuses on improving the available technology, especially developing portable and cheap thresher, that the traditional farmer can easily move to farm site.

2. Economic Importance of Rice Threshers

In large farms, threshers are components of the combined harvesters, but the combined harvester is an expensive machine and they are meant for big farms. The cost and capacity is beyond the ability of the local farmers, this is one extreme, the other extreme which we must do way with is the use of the traditional methods. It is our desire that our farmers will be out of this last extreme. Rice cropping is common in many parts of Nigeria, indeed rice remains a staple food of the average Nigerian. The annual demand is a little less than two million tones, over half of which is being imported. In 2000, Nigeria was the sixth highest importer of rice accounting for about 3.5% of world imports or 900,000 tones (The Punch, 2006). This leaves considerable room for increased production. The problem of the locally produced rice is not only the low production level but more important is the quality of the produced rice which can not compete well with the imported ones. This is a problem arising from processing techniques. The very first process after harvesting of rice is threshing and usually this is also the first point of contamination with stones or sand. Besides, the harvesting period is a crucial moment for farmers because they combine so many activities at a time, this include, driving away birds and animal, harvesting and threshing immediately to avoid germination and also to save space. Hence an efficient thresher which can easily be transported to site will definitely be a welcome relief. The present government already has in place a policy which aims at encouraging local farmers to produce enough rice for local demand, to this end, rice has been added to the list of commodities whose importation is outlawed. This translates to mean that the paper is in tune with the policy of the Nigerian government.

3. Threshing Technologies

Threshing is the removal of grains from the plant by striking and/or rubbing. The impact and rubbing action severe the grain from the stem. After harvesting, the very next operation is threshing of the harvested rice.

3.1 Traditional Threshing Techniques

Traditional rice farmers carry out threshing in different ways. These methods are however local, inefficient and laborious, besides, they are only suitable for small scale farming, they include; beating on hard or wooden object or screen, sometimes pedal operated threshing drums are employed in fairly big farms, other methods include driving trucks or tractors on the unthreshed rice. Apart from the earlier mentioned disadvantages, these methods suffer much loss due to undetached grain; the loss can range from 1-15%. An attempt to reduce the loss will cost much more man-hour. The production rate for average worker is 30-50kg per man hour.

3. 2 Manual Rice Threshing Machines

Over the decades, rice growing communities have made attempts to produce motorized threshers. Where success is recorded, such threshers become popular among such rice growing communities. The need to develop motorized threshers is born-out of the laborious nature of threshing process. Among such threshers are; India rice threshers which include Olphad and general purpose threshers (Micheal, Orjha, 1987), Japanese type rotary paddy rice threshers, IRRI axial flow thresher, etc.

3. 3 Effect of Operating Condition on Threshing Effectiveness

Threshing effectiveness results from the combination of the following factors; **i.** The peripheral speed of the cylinder. **ii.** The cylinder concave clearance. **iii** The number of rows of concave teeth used with a spike tooth cylinder. **iv** The varieties of rice. The glutinous or starchy varieties are brittle which results in breakage. **v** Moisture content: over dry rice will be brittle hence machine will not operate at optimal speed. Maturity before harvesting immature grain will be brittle and will not detach easily. **vi** The rate at which material is fed into the machine. Table 1 shows the performance test result for sorghum.

Table 1. Performance Test Result of A. B. Minor Thresher for Different Species of Sorghum.

Variety	**L – 1870**	**Short raura**		**L– 1499**	
Moisture Content	8.4	8.1		8.9	
Cylinder Speed (rpm)	700	700	500	700	500
Output Rate (kg/hr)	195	287	371	284	158
Threshing Efficiency (%)	96.5	98.1	94.4	97.7	97.3
Cracked Grain (%)	32.8%	48.6	15.5	28.9	3.5

Source: Choudray, Kaul (1980)

4. Cylinder Speed versus Seed Damage

Table 1 gives a clear picture of the effect of speed of thresher cylinder on seed damage. Though it is obvious that higher cylinder speed will result in better production rate but the gains can be nullified by the loss due to grain damage or breakage. The mechanical damage also increases as the seed moisture content reduces.

Table 2. Cylinder Peripheral Speed and Clearance for Common Cereal Using Spike Teeth Threshers

Cereal	**Peripheral Speed (m/s)**	**Mean Clearance (cm)**
Rice	23 –28	5 – 10
Barley	23 – 28	6 – 13
Oats	25 – 30	5 – 13
Wheat	25 – 30	5 –13
Rye	25 – 30	5 – 13
Sorghum	20 – 30	6 – 13

Source: Kepner Roy, Barger (1982).

5. Methodology

An optimized multi-drive prototype rice threshing machine capable of been powered by a prime mover or manually was designed and constructed. Different pulleys of varying pulley radii were employed to obtain varying cylinder speeds. Very low speeds below two hundred revolutions per minutes were obtained through the manual attachments. The developed prototype has spike tooth gap of 70mm, an optimal motor speed of 500rpm from a 4 h. p. 1000rpm motor. The motor was selected such that speed ratio was within tolerable limit. Mild steel was used as the major material for machine frame and concaves.

The machine average capacity is 250kg/hr of threshed rice; and there were attachment provision for manual threshing such as foot pedal wheel or handle for arm pedal.

The indigenous rice threshing machines used for comparison were previously developed at Rufus Giwa Polytechnic, Owo. The manual attachments to the prototype made it possible to compare the performance characteristics of the manual threshing machines. Several readings were taken for each data and the average was taken and recorded.

6. Performance Parameters for Threshing Cylinders

The processed data were used to plot performance curve. The performance parameters sought are Production Rate (P. R.), Seed Loss (S. L.), and Mechanical Damage (M. D.). The results obtained were analyzed, using mathematical equations and performance characteristic curves.

Seed Loss (S. L.)

This can be divided into the quantity loss as a percentage of seed not detached from ear head to the total seed at the completion of threshing operation. It is known as threshing effectiveness. Seed Loss (S. L.) decreases with increase in cylinder speed.

$$\text{S. L.} \ \alpha \ \frac{1}{\omega_c}$$

$$\% \ \text{S. L.} = \frac{K_1}{\omega_c}$$

K_1 depends also on spike tooth or finger interval gap. ω_c is the speed [rev/min]. High seed loss may also result from seed scattering.

Mechanical Damage [M. D.] This is also known as quality loss , this is the percentage of seed damage in form of breakage which occurs during milling and threshing, breakages reduce drastically the market value of the grain. The damage may not be noticed until the rice is milled. The easy method of obtain the percentage of mechanical damage is by germination test method, the damaged seed will not germinate. Mechanical damages are caused by impact forces. Since the impact is proportional to the square of the cylinder peripheral speed;

$$\% \ \text{M. D.} \ \alpha \ \omega_c$$

$$\text{M. D.} = k_2 \ \omega_c$$

k_2 depends also on dryness of seed, spike tooth or finger gap and dryness of seed.

Production Rate [P. R.]

Production rate depends on the efficiency and speed of rotation of the cylinder. Thresher mechanism must ensure low seed loss to avoid recycling to recover unthreshed grain, where this becomes unavoidable, the production rate becomes too low. Principally poor production rate is directly link to the speed of rotation of the cylinder.

$$\text{P. R.} \ \alpha \ \omega_c$$

$$\text{P. R.} = K_3 \ \omega_c$$

K_3 also depends on dryness of rice ear head and rice variety.

7. Manual Rice Thresher

Manual threshers used in this research work are of two types; the hand powered type and the pedal type (Figure 1). The interesting characteristics of manual threshers are their ability to generate and sustain required torque for a reasonable length of time and they do not suffer appreciable mechanical damage. The foot pedal is able to deliver a velocity ratio of as high as 1: 10 reaching an average speed of between 150 – 200 rev/min. Speed delivered equals pedal speed x velocity ratio.

The manual threshers were developed with the aim of having a thresher that will not run on petrol engine or electric motor but rely solely on human power, the various manual threshers share similar characteristics judging by their advantages and disadvantages.

The manual thresher here excludes using mortal and pestle and driving vehicles/tractors over piles of rice ear-heads.

Figure 1: Hand Powered Manual Thresher
Source: Department of Mechanical Engineering, Rufus Giwa Polytechnic, Owo

8. Prototype Rice Thresher Developed

The prototype machine developed is a multi-drive machine, it can be powered manually by hand and by foot pedal, again it can be powered by a prime mover of 4hp or 3kw.

It provides an unbiased basis of comparing the performance of thresher based on speed (100 – 700 rev/min). The pulley for the cylinder shaft was varied to deliver different speed to the shaft. Figure 2 shows picture of the prototype rice thresher.

Figure 2: Prototype Multi-drive Rice Thresher
Source: Authors' Field Work.

9. Test Results

The speed, production rate (kg/hr), seed loss and mechanical damage were taken for both manual and prototype machines.

Table 3. Test Data for Speed Range of 100 - 700rev/min.

Speed (rpm)	**Production Rate (Kg/hr)**	**Average Seed Loss (%)**	**Mechanical Damage (%)**
120	28	13	0
150	50	10	0
180	80	6	0
300	205	3	0
400	255	2	0
500	340	1	0
600	390	0	1
700	430	0	1.5

Source: Author's Field Work Computation (2010)

Table 4. Summary of Various Thresher Performance Data

Type of Thresher	**Speed (rpm)**	**Production Rate (Kg/hr)**	**Average Seed Loss (%)**	**Mechanical Damage (%)**
Hand Powered	100-150	20-30	13	0
Foot Pedal (treadle)	140-180	40-50	10	0
Prototype Hand Powered	120-180	40-80	6	0
Prototype Foot Pedal	180-220	0-100	5	0
Prototype Motor Power	400-750	200-400	0.5	1.5

Source: Author's field work computation (2010)

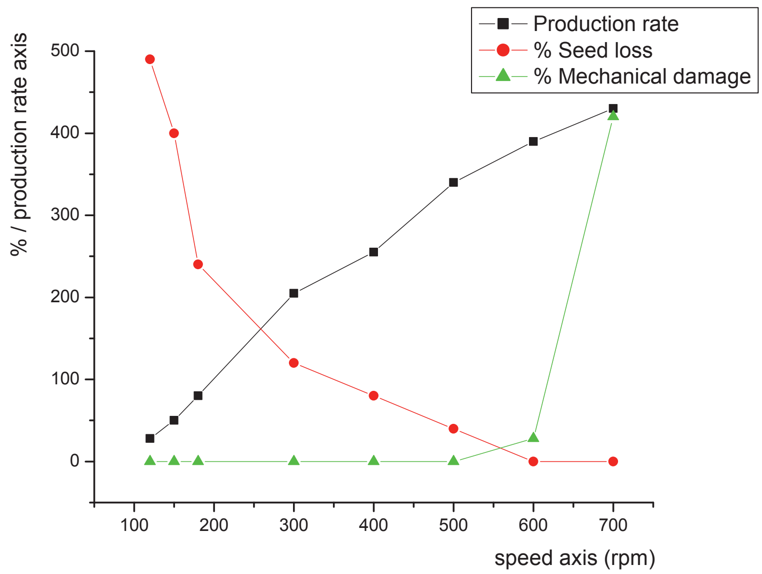

Figure 3. The Three Parameters Interpolated
B- Curve of production rate (kg/hr)
C- Curve of percentage seed loss
D- Curve of Percentage Mechanical Damage

10. Discussion of Results

Steady progress was achieved over the time duration of the study work, the research and development effort was born out of a desire, to have a mobile and affordable rice thresher. The first step was targeted at improving on the lighter manual threshers at Rufus Giwa Polytechnic, Owo. The relatively low production rate and quality of threshed rice prompted the need for a motorized thresher. As seen in Tables 3 and 4.

10.1 Production Rate: The hand powered thresher has a low speed of 150 rpm maximum with a maximum production rate of 35kg/hr. At this rate it will take about a week to thresh 1.5 tons of rice, however, a motorized thresher will thresh one ton in less than 3 hours. Applying the approach, the foot pedal will thresh one ton in less than four days. The general curve of production rate shows that production rate is directly proportional to the speed of the cylinder w_c that means increasing the speed will enhance the production rate. For the motorized thresher, the production rate at 300 rpm is about half the production rate at 600 rpm as table 3.

10.2 Percentage Seed Loss: It is clear from the data that at lower speeds the seed loss due to undetached rice is very high, this is a major disadvantage of the manual thresher, the manual thresher both hand or pedal powered run at below 200rpm. The percentage seed loss is between 6 – 13%, this is the reason why motorized thresher is preferred. At above 400 rpm, the seed loss is negligible. To avoid seed loss it is preferred that the machine operates at above 400 rpm.

10.3 Percentage Mechanical Damage:

Mechanical damage is due to impact force, the impact is negligible at lower speed, and this is where manual thresher has an advantage. At speeds above 600 rpm mechanical damage sets in, this lowers the market value of rice and germination rate. Besides, at higher speed, the machines wear increases.

11. Conclusion and Recommendation

Looking at the graph, it is observed that between 450 and 550 rpm there are negligible seed loss and no mechanical damage. This speed range has production rate of between 300 – 350 kg/hr.

This is a little higher than the average for existing mobile threshers. Based on this, a cylinder speed of 500 rpm is recommended for this particular thresher. However, the recommended speed may vary slightly for different machines, due to the spike tooth design, materials and gap for the same machine size.

The benefits of mobile threshers are immense. Transportation of bundles of ear-head is eliminated, only threshed grains are transported while the risk of contamination with stone is reduced.

In summary, the optimized parameter results in time saving, reduction in percentage seed loss and percentage mechanical damage. The cost of operation is also reduced and the quality of produced rice is enhanced. The prototype shows these features and it is believed that the above mentioned advantages will benefit the traditional rice farmers if the result is made available to them by the appropriate government agencies.

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