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Development and Performance Evaluation of a Rice Thresher for Rural Farmers in Ganye Adamawa State Nigeria

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ABSTRACT---- ***Threshing of rice is one of the unit operations during rice processing where grain losses are incurred most. In addition, most of the existing rice threshing machines seem to be expensive and sophisticated for the rural farmers in the study area. This machine was conceived, developed with locally available materials to improve rice production and accompanying profitability. The machine was constructed locally, tested and found to be efficient and affordable. The performance evaluation shows that, the mean values of the throughput capacity of the machine at varying engine speed were significantly different ($p \leq 0.05$) and increased with increasing engine speed. The values of throughput capacity are 50.52 kg/hr, 105.94 kg/hr and 193.58 kg/hr corresponding to 780 rpm, 920 rpm and 1014 rpm engine speed respectively. However, the efficiency and percentage losses for the varying engine speeds were not significantly different ($p \leq 0.05$), while the percentage losses tend to decrease (12.20%, 12.00% and 10.47%) with increasing speed, the efficient was almost the same (88.00%) for all the engine speeds. An optimum engine speed of 920 rpm was recommended for optimum performance and reduced wear and tear of the machine components.***

Keywords--- Rice, threshing, efficiency, throughput capacity, percentage losses, engine speed, rural farmers and processing

1. INTRODUCTION

Rice is a universal staple food for human beings. [8]. It is a seed of grass called Oryza sativa, a monocot crop grown for a year [6]. Nigeria is the most populated country in Africa with most of its populace being rice consumers. However, most of the rice consumed in Nigeria prior to the introduction of rice policy by the present government were imported [3]. The diversification of the economy and the ban on importation of rice have improved the rice production, however, the unhygienic processing and high cost of the processing machines seem to hinder the local rice from competing favourably with the imported ones [7]. Rice is also grown and consumed for it nutritious value and digestibility, though it has a low protein content [8]. In addition, rice is preferred to other grains because of its ease and fast processing before final consumption. After threshing, the next is shelling (milling) then cooking, unlike other grains like maize.

Threshers are generally used for separating economic seeds from the chaffs and other foreign particles [10]. Most threshers are classified based on the types of crops being threshed [8]. Threshing seems to be the unit operation where grain losses are incurred most. In addition, most of the rice threshing methods practiced in the rural areas are labourious and time consuming. The methods employed include; beating of heaps of rice with sticks and beating of bunch of rice on either drums or tree trunks. Either methods are labourious and in addition to inefficient winnowing, the final product in most cases contains a good percentage of foreign particles. As a result, where the rice from these operations is not milled with highly sophisticated machines, which are lacking in the rural areas, the final milled rice brings forward the foreign particles it inherited at threshing operation. This makes the local rice to be of low quality and inferior to the imported ones [7]. In addition, this affects the profitability of the rice production. Hence, this work is aimed to develop an efficient Rice Thresher that will be easy in terms of operation and maintenance and affordable by the rural farmers. This will assist the government to realize its food security goals and improve the living standard of the rural farmers.

1.1 Threshing

This is the process of separating the edible parts of cereal from the chaffs, it follows harvesting and is followed by winnowing to separate the grains from the chaffs and less dense foreign materials[2]. Threshing is one of the most important crop processing operations, which makes the crops marketable [5]. [9] stated that, in most cases threshing is done manually in the rural areas. A number of threshers have been in existence but their affordability and sophistication limits their ownership and usage by the rural farmers. Threshing can be either manual, mechanical but manually driven or engine powered [1, 4, 11, 12, 9, 13, 14 and 8].

2. MATERIALS AND METHODS

Ganye Local Government Area is located in the Southern Senatorial Zone of Adamawa State between Latitude 8^0 12ꞌ - 8^0 40ꞌ N and Longitude 11^0 37ꞌ - 12^0 15ꞌ E. It has a population of 240,686 most of whom are farmers. The area has a favourable condition for agricultural activities with rainfall above 1000 mm and temperature ranging between 19 ^{0}C and 32 ^{0}C [15]. Most common crops grown are Rice, Maize, Yams, Cassava, Sugarcane, Beans, Soya beans, etc. Rice production in the area is boosted with the current Federal Government policy of banning the importation of rice and some food items in addition to the high selling price of rice. However, despite all these advantages and improvement in the rice production, processing is now becoming a factor militating against rice production in the area. This is because most of the more especially on farm activities are done manually. This could lead to poor quality of the product, high percentage of losses and poor marketability of the product.

The machine was constructed and evaluated at the Department of Agricultural and Bioenvironmental Engineering Technology, Adamawa State College of Agriculture, Ganye.

2.1 Design Considerations

In designing agricultural machines such as threshers, such factors as physical, mechanical and aerodynamic properties of the crops must be considered. These crop properties will determine factors such as size of drum, peripheral speed of the drum, etc [10].

2.2 Materials used for the Construction

All the materials used for the construction of the machine were sourced locally from Ganye market, but with careful considerations of their Engineering properties. In addition, the construction was done locally in the Department Workshop. These have helped in making the cost of production of the machine low and therefore affordable by the farmers.

The construction was done by cutting the materials according to the required sizes of the various components of the machines. The components were welded and/bolted where necessary with the help appropriate tools and machines.

2.3 Description of the Machine

The machine which, uses a 5.5 Hp gasoline engine has the following components:

Frame: The frame is made up of a mild steel angle iron, the frame the dimension of 130 cm x 62.5 cm x 51.1 cm. The frame is made in such a way that it is very strong to bear the load of the machine, threshing mechanism, the engine and all other accessories.

2.4 Threshing Mechanism

The threshing mechanism is made up of the threshing drum with some beaters mounted on the drum. This combined is mounted on a shaft. The drum is positioned such that there is a clearance of about 4 cm between it and the middle lower part of the concave and around 10 cm clearance bottom and top end of the concave. The concave has some holes (screens) that allows particles about the size of the rice gain to pass.

The threshing mechanism plays multiple roles during the threshing. First, it pulls the rice stalks into the threshing chamber, and then crushes the stalk during which the rice grain is separated from the stalk; the stalk is also crushed to very small and lighter sizes. During the threshing, the grains and all particles smaller than the screens and of density similar with the rice grains pass through screens and to the grain outlet, while those that are larger than the screen size and lighter are blown out through the chaff outlet.

Fan: The fan or blower is made up of mild steel metal sheet. Three blades are arranged at 120^0 to each other on the fan shaft. The fan is driven by the engine with the help of belt and pulley arrangement. The mass of air from the fan is directed towards the bottom of the screen such that all materials less dense than the air mass are blown out through the chaff outlet. The amount of chaff and the distance the chaff is blown away from the chaff outlet varies with the speed of the fan. The speed of the fan is set such that only very small quantity of clean rice is blown together with the chaff. The fan is housed such that air from the fan is directed to the screen.

Grain Outlet: The grain outlet is positioned at angle below the screen such that once the grains fall on it, it will just move out by gravity.

Chaff outlet: The chaff outlet is positioned such that all materials blown by the fan moves out some distance depending upon the speed of the fan away from the machine.

Hopper: The hopper is also made up of mild steel metal sheet with the following dimension…..

Shafts: The shafts were selected such that they can carry the weights of the threshing mechanism and the weight of the fan together with their accompanying external forces.

Mode of Operation: The mode of operation has been described under the threshing mechanism.

2.5 Performance Evaluation

Prior to the actual performance evaluation, the machine was first test run. During this test, the machine was run without any load for about ten (10) minutes. The machine was then loaded with some quantities of rice to see how smooth it can work.
The rice on reaching thee fully ripened stage was harvested manually. It was then allowed to stay on the farm for some days; this is too allow it dry under natural conditions. Though moisture content of the rice was measured, allowing it to dry naturally mimic the natural condition practiced in the study area.
Some measured quantity of the rice was fed into the machine for the threshing. The time taken for threshing, the quantity fed into the machine, the quantity of rice threshed, the quantity of chaff and the quantity of unthreshed rice were recorded. Each operation was replicated three times for a particular speed of the engine.
Three different speeds were used. The speeds were varied by increasing the speed of the engine and measured with a digital tachometer. At each selected speed of the speed of the engine is kept constant until all operation for that speed is completed. The following parameters were then computed:

Throughput capacity (TPC) (kg/hr) = $\frac{M\,(kg)}{t\,(hr)}$ ………………………………………………… 1

Efficiency (%) = $\frac{Qt\,(kg)}{M\,(kg)} \times 100$ ………………………………………………………....2

Percentage Losses (%) = $\frac{(Qu+Qb\,(kg)}{M\,(kg)} \times 100$ ……………………………………………….3

Where
M = Quantity of rice fed into the machine (kg)
Qt = Quantity of threshed rice (kg)
Qu = Quantity of unthreshed rice (kg)
Qb = Quantity rice blown together with the chaff (kg)

2.6 Data Analysis

The data obtained were analyzed using Analysis of Variance appropriate for the design (CRD) at 5% significant level.

3. RESULTS AND DISCUSSIONS

The results of the performance evaluation of the machine is presented in Table 1.

3.1 Throughput Capacity (kg/hr)

The results from table show that there is significant difference between the mean values of the TPC. The result also shows that TPC increases with increase in the speed of the machine. This could be the main reason for significance differences between thee mean values of the TPC, since the quantity is fixed, TPC would vary with varying speed of the engine. TPC would normally vary with either the speed of the engine or the quantity of material being fed to the machine, however, the quantity is kept fixed. The results also show that, TPC is highest (173.58 kg/hr) with the highest speed off 1014 rpm and lowest (50.52 kg/hr) with the lowest engine speed of 780 rpm.

3.2 Efficiency (%) and Percentage Losses (%)

Efficiency and percentage losses are the major performance parameters of the machine. The results show that, the mean values of both parameters do not differ statistically and in magnitude with variation of the speed of the engine. However, the results show that losses tend decrease a bit with increase in speed of the engine 12.20%, 12.00% and 10.47% for corresponding with 780 rpm, 920 rpm and 1014 rpm respectively, while the efficiency remaining almost constant (87.80%, 88.00% and 88.00%) with the varying speed. This conforms to that of [8] whose machine performance parameters were given as 88.96% efficiency and 12.79% percentage losses.

4. CONCLUSION

An efficient and affordable Rice Thresher was successfully developed for the rural farmers in the study area. The optimum speed for the optimum performance of the machine would be 920 rpm. This is because at that speed, the wear and tear of the machine that would be due to high speed could be reduced, while TPC, efficiency and percentage losses would be minimally affected.

Table 1: Mean values of the Performance Parameters

Speed (rpm)	Performance Parameters		
	TPC (kg/hr)	Efficiency ((%)	Percentage Losses (%)
780	50.52	87.80	12.20
920	105.94	88.00	12.00
1014	173.58	88.00	10.47
SIGN	**	NS	NS

Key:
** = Highly significant
NS = Not significant

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