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KUMASI-GHANA

COLLEGE OF NATURAL RESOURCE MANAGEMENT AND AGRICULTURE

FACULTY OF AGRICULTURE

DEPARTMENT OF AGRICULTURAL AND BIOSYSTEMS ENGINEERING

PERFORMANCE EVALUATION OF BOTH THE HAND AND FOOT OPERATED RICE THRESHERS

A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR A B.Sc. (HONS) AGRICULTURE DEGREE

BY

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MAY, 2017

DECLARATION

I hereby declare that this project was entirely my own work and that any additional sources of information have been duly cited.

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DEDICATION

This dissertation is dedicated to my father, STANLEY DUAH, my prayerful mother, PAULINA BOAKYE, my uncle JAMES BOAKYE, my siblings and all those who made it possible for me to pursue this first degree program.

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Above all, to the Great Almighty, the author of knowledge and wisdom, for his countless love.

ABSTRACT

The manual hand and foot operated rice threshers are machines designed for the removal of rice grains from its straw. In evaluating these threshers suitable for small scale farming and to replace the outmoded traditional methods which is labour intensive and requires more energy. The speed of the threshing drum, rate of threshing, capacity of thresher, efficiency of the thresher, threshing losses and the drudgery involved were the factors considered. The prototype of the hand operated thresher was manufactured at Fomena and that of the foot operated thresher at RTP Konongo. The study was made to transform the prototype into a marketable product. The evaluation tests were carried out at "Nabewam" in the Ejisu Juabeng District of the Ashanti Region of Ghana. The materials used included plastic sampling bags, a weighing scale, a digital tachometer and a pressure monitor. The average speed of the foot operated thresher after the test trials was recorded to be 153.3 rpm which is relatively higher than the hand operated thresher which was also recorded to be 134.6 rpm. The efficiency of the foot operated thresher after the trials was calculated to be 81.8% which was also higher than that of the hand operated thresher which was 66.5%. The heart rate per kg in using the foot operated thresher was 11.6 beats/kg whereas the hand operated rice thresher recorded a heart rate per kg of 24.3 beats/kg. The threshing rate of the foot operated thresher was recorded to be 22.52 kg/hr whereas the hand operated thresher recorded 12.45 kg/hr. The foot operated rice thresher had a capacity of 68.84 kg/hr whereas the hand operated rice thresher had a capacity of 43.25 kg/hr. The test suggested that a foot stand should be provided for at the base of the Fomena hand operated thresher to make it firm on the ground during threshing and also the length of the threshing drum of both threshers should be increased enough to increase the threshing capacity.

ABBREVIATIONS

FAO	Food and Agriculture of the United Nations
IRRI	International Rice Research Institute
Kg	Kilogramme
rpm	Revolutions per minute
bpm	Beats per minute
USDA	United States Department of Agriculture
Kg/hr	Kilogramme per hour
kg/min	Kilogramme per minute

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Rice is the seed of the grass species *Oryza sativa* (Asian rice) or *Oryza glaberrima* (African rice). Rice is a cereal grain and is the most widely consumed staple food of a large part of the world's human population, especially in Asia. Although its parent species are native to Asia and certain parts of Africa, centuries of trade and exportation have made it commonplace in many cultures worldwide (Wikipedia, 2016). Rice being a monocot, is normally grown as an annual plant although in tropical areas it can survive as a perennial and can produce ratoon crop for up to 30 years (IRRI 2009). It is the agricultural commodity with the third-highest worldwide production after sugarcane and maize as recorded by FAOSTAT data (2012). Rice is the most important grain with regard to human nutrition and calorie intake providing more than one-fifth of the calories consumed worldwide by humans (Bruce 1998). Rice cultivation is well-suited to countries and regions with low labour costs and high rainfall, as it is labour-intensive to cultivate and requires ample water. However, rice can be grown practically anywhere, even on a steep hill or mountain area with the use of water-controlling terrace systems. The soil used in growing rice should have a good water holding capacity. Silt clay, silt clay loam and clay are some of the soil textures that are suitable for rice production. The pH of the soil should be 6 or 7, but rice can also do well in a pH ranging from 4 to 8. The life cycle of rice is 190 days and its harvesting season lasts for about 30 days in mid-September to October. To decrease moisture content of harvested paddy, the crop is left in the field and then bundled and threshed (Alizadeh and Bagheri, 2009).

Africa consumes a total of 11.6 million tonnes of milled rice per year (FAO, 1996), of which 3.3 million tonnes (33.6%) is imported. As many as 21 of the 39 rice producing countries in Africa import between 50 and 99 percent of their rice requirements. Rice production rose

30% on average in sub-Saharan Africa (SSA) in two years at the end of 2012, according to analysis by Africa Rice Center (AfricaRice). The inability to reach self-sufficiency in rice production in Africa is as a result of several major constraints in the rice industry which include its inferior quality as compared to the imported ones and impurities all as a result of the threshing methods adopted and therefore require urgent redress to stem the trend of over-reliance on imports and to satisfy the increasing demand for rice in areas where the potential of local production resources is exploited at very low levels.

Ghana experienced a rapid dietary shift to rice, particularly in the urban centers, during the early post-independence period (starting 1957). Ghana is the largest commercial market for US rice in West Africa (WikiLeaks August 26, 2011). In 2014, Ghanaians consumed a total of 754,698 metric tons of rice and imports made up 52% of the figure. In January 2015 the United States Department of Agriculture (USDA) projected that between October 2014 and September 2015, Ghana would import 600,000 metric tons of rice to augment the country's need. Ghana however is able to produce only 30% of the rice it needs, and therefore has to import the 70% shortfall (USDA). Ghana's per capita rice consumption is currently estimated at about 58.0 kg with a current demand of milled rice for consumption estimated at over one million metric tons with about 40% only produced in Ghana.

The grain moisture content ideal for harvesting rice is between 20 and 25%. When harvest is completed threshing is done immediately to avoid rewetting and to reduce grain breakage. Threshing is the process of separating the grain from the straw. The common method for manual threshing in most parts of Ghana is hand beating against an object, treading, or by holding the crop against a rotating drum with spikes or rasp bar. Also trampling where the crop is spread over a mat or canvass and workers trample with their own feet or use of animals. This process of threshing has been observed to be very laborious, time consuming and above all reducing the quality of the rice and rendering it inferior as compared to the imported ones. There is a high rate of grain loss and breakage during the hand beating method of threshing rendering it inefficient. A power-driven machine for the separation of grain from straw is the thresher. Threshers were first invented by Scottish mechanical engineer, Andrew Meikle for agricultural use. It was devised for the separation of grain from stalks and husks. Mechanical threshers could be manually operated or motorized (Chukwu, 2008). The locally evaluated manual rice threshers were the hand and foot operated ones which were considered as a result of the high cost of the mechanically operated threshers to local farmers. The evaluation was aimed at knowing the threshing speed, losses and drudgery in the process of threshing. In considering the evaluation of the hand and foot operated threshers suitable for small-scale rice farms information on the threshing rates, threshing losses, output quality, and how to improve upon the machine for ease of use will also be provided. The hand and foot operated rice threshing machines were tested with the aim of assessing the threshing performance and mostly gathering feedback from local rice farmers to evaluate the efficiencies of the hand and foot operated rice threshers to determine which will be suitable for local rice farmers.

1.2 Problem statement

Due to drudgery in properly threshing a very large amount of the locally produced rice, Ghana is unable to meet her full demand of rice in the country and therefore able to produce only 30% of its demands for rice while 70% is imported with an estimated amount of $500m annually. Hence, this project will evaluate the efficiencies of the hand and foot operated threshers to suit local rice varieties, improve the quality of locally produced rice and reduce drudgery.

1.3 Justification

The performance evaluation of the hand and foot operated rice threshers will provide information that will be potentially used to produce cost effective and affordable threshers for poor local farmers, suitable for rice varieties in Ghana.

1.4 Main objectives

The main objective of this project is to evaluate the performance of both the hand and foot operated threshers.

1.5 Specific objectives

The specific objectives of this study are;

i. To determine the threshing efficiencies and capacity of both the hand and foot operated manual rice threshers.

ii. To measure the speed of the threshing drum and the threshing rate with both the hand and the foot operated threshers.

iii. To measure the drudgery involved with operating both the hand and foot operated rice threshers.

CHAPTER TWO

LITERATURE REVIEW

2.1 Threshing Operation

Threshing operation is basically the separation of grains or seeds from the husks and straw. These operations may be carried out in the field or on the farm, by hand or with the help of animals or machines. Depending on the influence of agronomic, economic and social factors, threshing operation is done in two different ways. It is however achieved either by hand, with the help of animals or machines. Manual hand threshing which is the most common one involves the hand beating against an object, treading, or by holding the crop against a rotating drum with spikes or rasp bars. This method is normally used for threshing rice that has low moisture content. Also the pedal or treadle thresher consists of threshing drum, base, transmission unit and a foot crank. When pedaled, the threshing drum rotates and rice can be threshed when panicles are applied against the threshing drum. Trampling is the use of bare feet or animals to thresh the crop and with this the crop is spread over a mat or canvass and workers trample with their own feet or use their animals. Animal treading or trampling is also normally carried out at a designated location near the field or in the village. In some regions, animals have been replaced by tractors. After animal treading, the straw is separated from the grains and cleaning of the grain is done by winnowing, with or without the aid of an electric fan. Losses are high from broken and damaged grains in the trampling method of threshing. The moisture content, variety of crop and the level of maturity are the major constrains in adopting this type of threshing. Due to the high labor requirement of manual threshing, mechanical threshers of different types and sizes are increasingly being used. A mechanical thresher works with a drum as axial. The crop turns around the axial and so the teeth of the cylindrical drum make the grains separate from the straw by beating it. The primary aim of threshing machines is to reduce the labor required for the threshing process. Farmers indicated that the overall threshing rate is more important than the rate per person, as paddy must be threshed as soon after harvesting as possible. Once threshing rate is accurately determined, this may be used for an economic analysis of the threshing method (Selco foundation, 2013). IRRI defines threshing losses as scattering loss, threshing loss and grain breakage (2009). While these losses may be significant for industrial scale machines, it was found that detailed measurement of these factors was not practical or particularly informative when testing small-scale machines. The farmers themselves are a good judge of threshing quality and therefore can be asked to evaluate the output and threshing loss instead of using quantitative measurements (Selco foundation, 2013). Threshing force; which is the force that separates a grain from the panicle has a great importance in evaluating losses over design, application of harvesting and threshing machines (Alizadah, 2011).

2.2 Manual Threshing

This is the method of threshing considered as labor intensive, time consuming and only suitable for small scale farming due to its insufficiency. They include; beating on hard or wooden object or screen, sometimes pedal operated threshing drums are employed in fairly big farms (Olumuyiwa *et al.*, 2014). Threshing of rice, can also be done by striking sheaves spread out on a threshing-floor with a flail or a stick. The threshing-floors on which the sheaves are spread must have a hard, clean surface. The pedal-operated thresher consists of a rotating drum with wire loops which strip the grains from the panicles when fed by hand. It can be operated by women and can be used in hilly or terraced areas because of its portability. By using one of these methods of hand-threshing, a worker can obtain 15 to 40 kg of product per hour (Ola *et al*., 2009). Women play a significant and crucial role in agricultural operations; including different crop production activities, postharvest activities etc. (Kwatra *et al.,* 2010).

2.3 Threshing with Hand driven machines

Machines driven by a manual device or a pedal are often used to improve yields and working conditions during threshing. By means of the handle or pedal, a big drum fitted with metal rings or teeth is made to rotate. The rice is threshed by hand-holding the sheaves and pressing the panicles against the rotating drum. The hand-held sheaves must all be of the same length with the panicles all laid in the same direction, and the grains must be very ripe and dry. The machine must be continuously and regularly fed, but without introducing excessive quantities of product (Khan and Salim, 2005). 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 (Olanrewaju *et al*., 2014). According to Adewumi *et al,* the results of the performance analysis showed that threshing efficiency increased with an increase in cylinder speed and threshing efficiencies was found to be in the range of 54.5% to 100% (2007). The use of these threshing machines may require two or three workers. Depending on the type of machine, the skill of the workers and organization of the work, yields can be estimated at a maximum of 100 kg/h. (Adewumi *et al*., 2007)

2.4 Threshing with animals or vehicles

If draught animals are available and there are large quantities of rice, threshing can be done by driving the animals in the form of harnessing; in that case, to threshing devices over a layer of sheaves about 30 cm thick. This operation, which is also called “treading out”, can equally well be accomplished with vehicles. This method of threshing rice is adopted in some Asian countries, using a tractor for power instead of draught animals. Paddy is obtained by running the tractor twice over sheaves of rice that are spread in layers on a circular threshing-floor 15-18 m in diameter. The sheaves must be turned over between the two passages of the tractor. If operations are alternated between two contiguous threshing-floors, yields of about 640 kg/h can be obtained.

2.5 Threshing with motorized equipment

Although they are gradually being replaced by combine-harvesters, motorized threshing-machines still have an important place in the postharvest production process, especially for their convertibility. By the simple replacement of a few accessories and the appropriate changes in settings, these machines can treat different kinds of grain (e.g. rice, maize, sorghum, beans, sunflowers, wheat, soybeans, etc.). Yields depend on the type of machine, the nature and maturity of the grain, the skill of the workers and organization of the work, and they can vary from 100 to 5000 kg/h

2.6 General features of threshers

Most, if not all powered paddy threshers are equipped with one of the following types of cylinder and concave arrangement: (a) rasp bar with concave (b) spike tooth and concave (c) wire loop with concave (d) wire loop without concave. Tests by the International Rice Research Institute, IRRI indicated that the spike tooth cylinders performed well both with the hold-on and the throw-in methods of feeding and its threshing quality is less affected by changes in cylinder speed. In the axial-flow thresher, the harvested crop is fed at one end of the cylinder/concave and conveyed by rotary action on the spiral ribs to the other end while being threshed and separated at the concave. Paddles at the exit end throw out the straw and the grain is collected at the bottom of the concave after passing through a screen cleaner. Several versions of the original IRRI design of the axial-flow thresher have been developed in most countries to suit the local requirements of capacity and crop conditions. Thus, there are small-sized portable ones and tractor PTO-powered and engine-powered ones. Many custom operators in Asia use the axial flow threshers to satisfy the threshing and grain cleaning requirements of rice farmers

2.7 Mechanics of grain threshing

The process of mechanical threshing involves the interaction of machine and crop parameters for the separation of the seed from the pod. Threshing is carried out between a stationary concave and a rotating cylinder. Different configurations of threshing devices have been used. The two types generally employed in present day stationary threshers and combines are rasp bar cylinders and spike tooth cylinders. The latter are used almost exclusively in pea threshers. Also, rubber covered flat bars have been employed on cylinders and concaves for threshing small seed legumes such as crimson clover, giving less damage and less unthreshed loss than the conventional spikes. High-speed motion pictures have shown that the main threshing effect in peas or cereals results from the impact of the cylinder bars at high speeds with the pods. The primary function of the concave appears to be that of holding and presenting the material to the cylinder bar for repeated impaction. A spike tooth has been shown to have a more positive feeding action than a rasp bar cylinder does not plug easily, and requires less power. However, rasp bar cylinders are readily adaptable to a wide variety of crop conditions; are easy to adjust and maintain, and relatively single and durable. Various parameters are in use for evaluating the performance of threshers and determining and retaining the quality of the through-put. The parameters include; threshing effectiveness, grain damage, sieve effectiveness, cleaning efficiency and seed loss. Studies have shown that threshing effectiveness is related to the peripheral speed of the cylinder, the cylinder-concave clearance, the number of rows of spikes, the type of crop, the conditions of the crop (in terms of the moisture content and stage of maturity), and the rate at which material is fed into the cylinder. Cylinder speed is the most important machine operating parameter that affects seed damage. Increasing the speed substantially increases seed damage. Reducing the cylinder concave clearance tends to increase seed damage but the effects are generally rather small in comparison with the effect of increasing cylinder speed. Susceptibility to damage varies greatly among crops. Threshing trials conducted on soya bean and cowpea pods in a rasp bar cylinder thresher showed that visible grain damage was greater in cowpea for the same cylinder speed and concave clearance, and this affected seed germination. The seeds of some dicotyledonous plants such as beans may be damaged excessively at low cylinder speeds, whereas those of non di-cotyledons can withstand very high cylinder speeds without appreciable damage. It has been asserted in literature that mechanically damaged grains do not keep well in storage and are prone to fungal and bacterial infections when stored. The field emergence of such damaged seeds is generally poor.

2.8 Drudgery

High work stress has repeatedly been associated with increased risk for cardiovascular disease. This association could derive in part from detrimental effects on blood pressure (BP) by recurrent autonomic nervous system reactivity to work-related stressors. Evidence for such work-stress effects comes from ambulatory BP studies, which show increased blood pressure levels in subjects with high work stress. Work stress in these studies was usually defined as job strain according to the model of Karasek and coworkers (Tanja *et al*., 1999). The commonly performed agricultural activities in India were weeding, cutting/uprooting, transplanting, mannuring and threshing.

Drudgery is generally conceived as physical and mental strain, agony, monotony and hardship experienced by human beings while all of the women in this regard are alarming as they continue to be constrained by illiteracy, malnutrition and unemployment. Many believe that the involvement of women in agricultural tasks and large is a source of heavy burden of drudgery on them observation of heart rate is a simple and a reliable method of analyzing the workload on the person. The physiological cost of work is expressed in terms of increased heart rate and oxygen consumption (Karnataka, 2006). The average working heart rate (HR work) of the subjects when the paddy threshing was done manually by beating ranged between 143 to 166 beats/min. with a mean HR value of 154.5 beats/min. The corresponding HR values with the use of manual paddy thresher ranged between 120-125 beats/min. with a mean value of 122.5 beats/min (Kwatra *et al.,* 2010).

2.9 Moisture content

According to Darko (2016), moisture content is the quantity of free water in a specified material. Moisture content is expressed as either as decimal ratio or as a percentage by weight in one of two ways: Wet Basis and Dry Basis.

2.9.1 Wet basis (wb)

The moisture content wet basis is defined as the ratio of the weight of water to the total weight of dry matter and water. This is mostly used in agriculture.

2.9.2 Dry basis (db)

The moisture content dry basis is defined as a ratio of the weight of water to the dry-matter weight. This method is normally used in scientific laboratory work.

Table 2.1: Moisture content calculations

MOISTURE CONTENT CALCULATIONS	
Definitions m_i = initial moisture content m_f = final moisture content MC_{wb} = moisture content (wb) MC_{db} = moisture content (db)	**Formulas** $MC_{wb} = \frac{m_i - m_f}{m_i} \times 100\%$ $MC_{db} = \frac{m_i - m_f}{m_f} \times 100\%$
From moisture content (db) to (wb) $MC_{wb} = \frac{100 \times MC_{db}}{100 + MC_{db}}$	**From moisture content (wb) to (db)** $MC_{db} = \frac{100 \times MC_{wb}}{100 - MC_{wb}}$

According to Yakah (2012), *mancho, mansah and jasmine* rice yielded an efficiency of 98.5%, 94.5% and 91.2% at a moisture content (wb) of 18%, 22.5% and 23.1% respectively. The amount of water in the rice grain is represented by the moisture content of the grain. In post-harvest handling, grain moisture content is generally stated on a wet weight basis (M_{wb}). Moisture content of grain can be measured by using a drying oven, or by using a commercial moisturemeter (Selco Foundation, 2015).

CHAPTER THREE

MATERIALS AND METHODS

3.1 EXPIREMENTAL SITE

The study was conducted at Nabewam in the Ejisu Juaben district in the Ashanti region of Ghana. The coordinates of Nabewam are 6º 37ˈ60ˈˈN and 1º 16ˈ0ˈˈW.

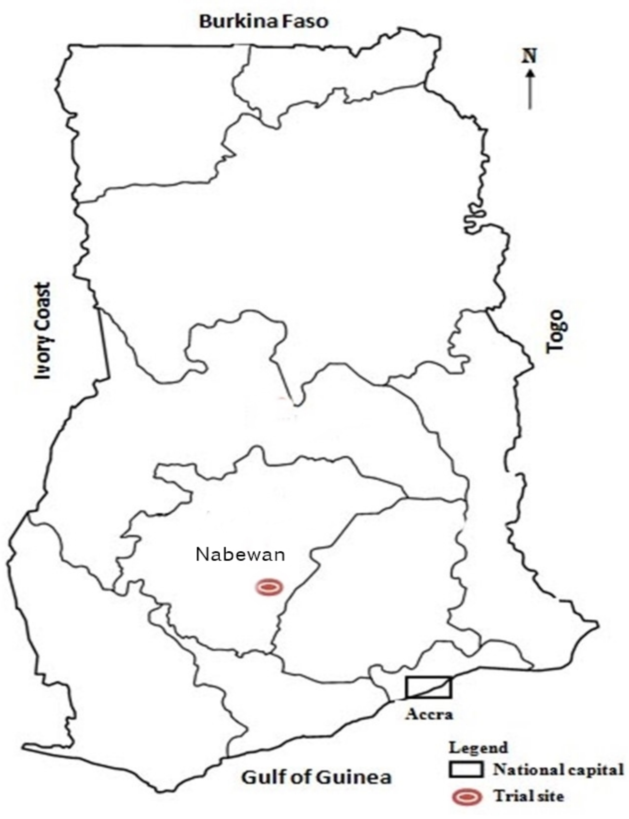


Fig3.1 Map of Nabewam

3.2 SOURCES OF RICE SAMPLES

The rice grains that were used for the evaluation were obtained from a rice farm at Nabewam in the Ashanti Region of Ghana and were from the 2016 growing season.

3.3 MATERIALS

- Hand operated rice thresher
- Foot operated rice thresher
- A pressure monitor
- A weighing scale
- A digital tachometer
- A bucket
- Unthreshed rice
- Plastic sampling bags

3.3.1 MATERIALS AND THEIR USES

MATERIALS	USES
Hand operated rice thresher(Fomena)	Powered by the hand
Foot operated rice thresher(Konongo)	Powered by the foot
Pressure monitor	For measuring pressure
A weighing scale	For measuring the weight of rice
A digital tachometer	For measuring the speed of the threshing drum
Unthreshed rice	The rice sample for the evaluation test
A bucket	For the collection of the threshed paddy.
Plastic sampling bags	For containing and keeping rice samples

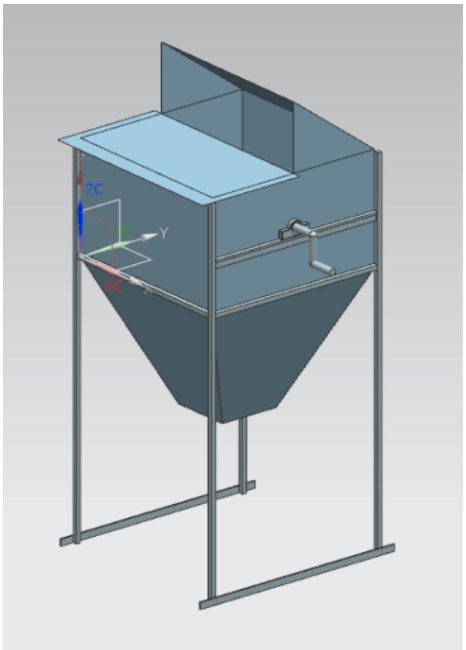
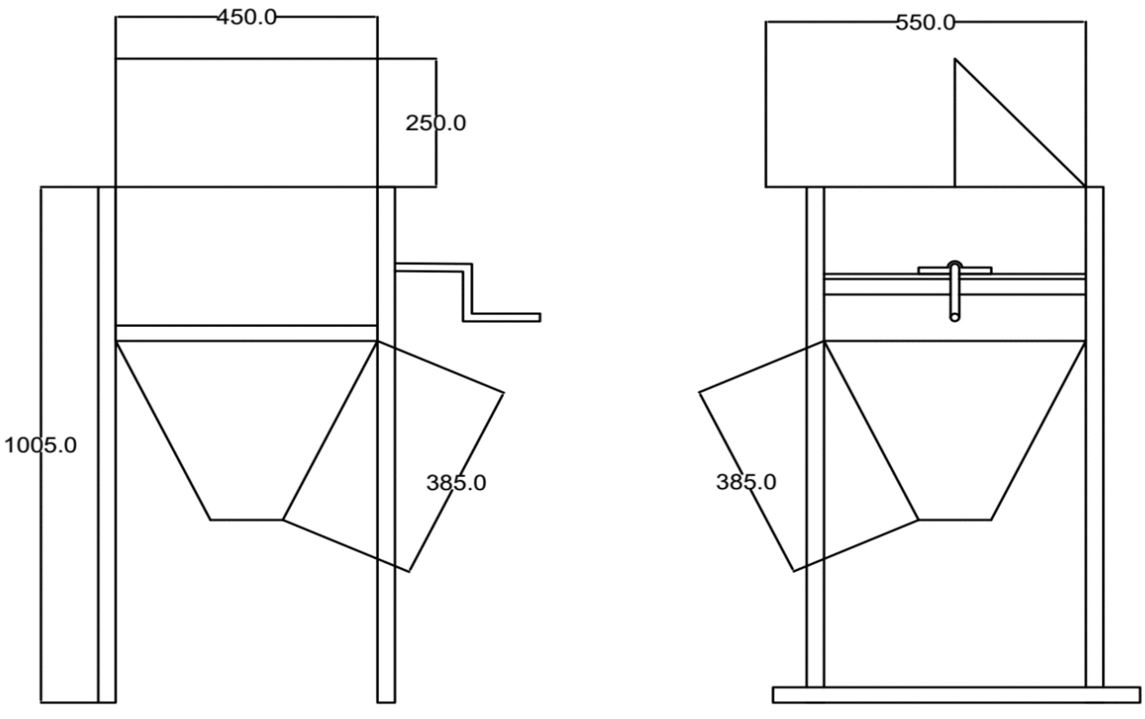


Fig3.2 The hand operated rice thresher in 3D



FRONT VIEW **SIDE VIEW**

Fig3.3 The hand operated rice thresher in 2D

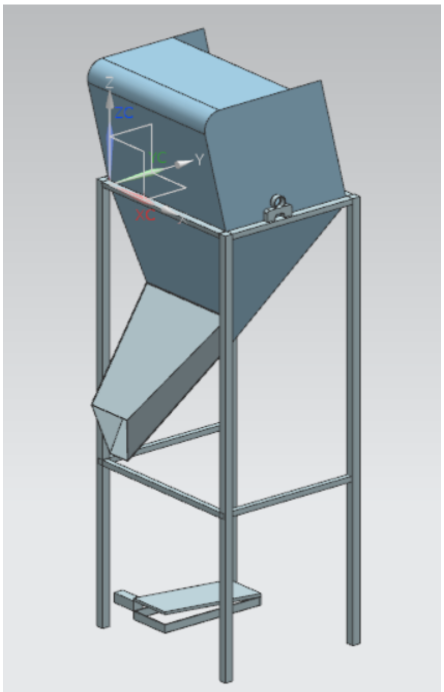
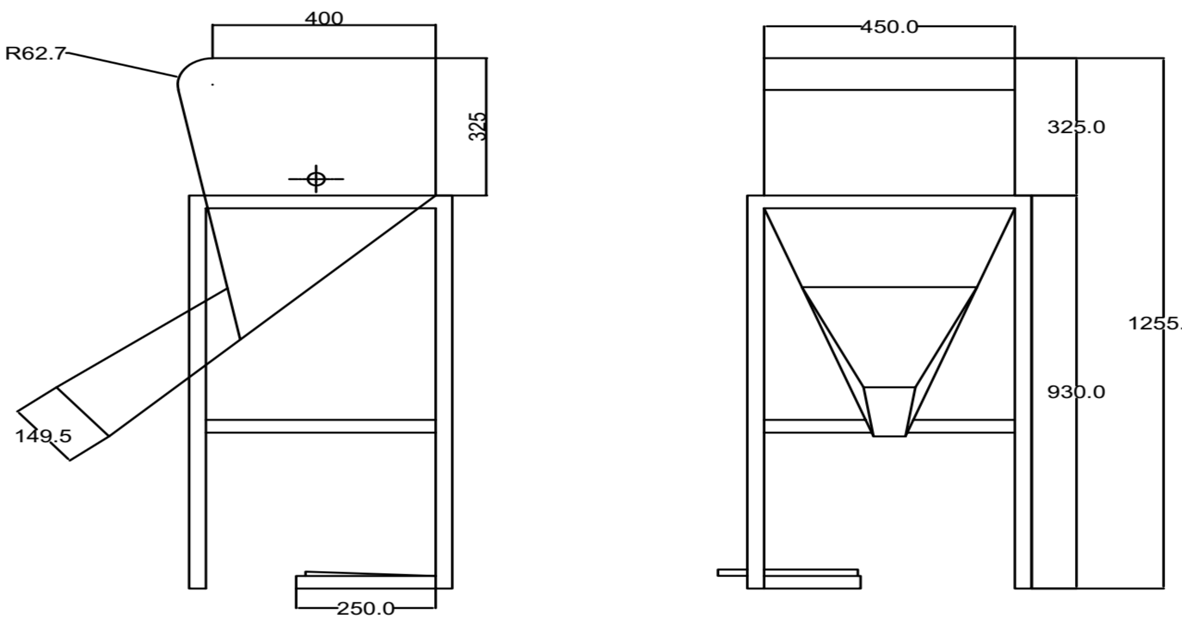


Fig3.4 The foot operated rice thresher in 3D



SIDE VIEW **FRONT VIEW**

Fig3.5 The foot operated rice thresher in 2D

3.4 THRESHING PROCESS

The hand operated rice thresher was developed at Fomena in the Ashanti region whilst that of the foot operated thresher was developed at the RTF center in Konongo also in the Ashanti region. To thresh the rice with the hand operated thresher requires two persons, the stalk of the rice was placed on the rim of the thresher by one individual and the handle was cranked by another person for threshing. With that of the foot operated thresher, the operator kept applying force on the foot pedal with the rice stalk on the rim of the thresher to cause the threshing process to be carried out. Rice stalks were also turned in the process of threshing to ensure contact of the rice on the stalk with the wire loops of the thresher so as to thresh thoroughly.

3.5 DETERMINATION OF LOSS PERCENTAGE

The following equations were used to calculate the percentage loss of the hand and foot operated rice threshers.

$$\text{Scattering losses percentage} = \frac{\text{Scattered grains(kg)}}{\text{Total seed(kg)}} \times 100\%$$

$$\text{Un-stripped grain percentage} = \frac{\text{Un}-\text{stripped grains(kg)}}{\text{Total seed(kg)}} \times 100\%$$

Hence, total loss %= Scattering losses percentage + Un-stripped grain percentage

3.6 DETERMINATION OF THRESHING RATE

This can be defined as the material threshed per unit time in kilogram per hour (kg/h). The Formula used is given by;

$$\text{Threshing rate} = \frac{\text{Threshed seed(kg)}}{\text{time taken(hr)}}$$

3.7 DETERMINATION OF EFFICIENCY

The efficiencies of the hand and foot operated rice threshers according to Tamiru and Teka (2015) were determined using the equation below:

$$\text{Threshing efficiency} = \frac{\text{Threshed seed(kg)}}{\text{Total seed(kg)}} \times 100$$

3.8 CAPACITY OF THRESHER

The capacities of the hand and foot operated rice threshers were determined by the equation below:

$$\text{Threshing capacity} = \frac{\text{Total grain input(kg)}}{\text{Total time(hr)}}$$

3.9 DRUDGERY DETERMINATION

The drudgery in using the hand and foot operated rice threshers according to Mohanty *et al.* (2008) were determined by the equation below;

ΔHRKG= [ΔHR/C].60

Where,

HR = Pulse

ΔHRKG= Increase pulse/kg of grain threshed, beat/kg

ΔHR= (Mean working pulse - Resting pulse), beats/min

C= Capacity of the thresher, kg/h

3.10 MOISTURE CONTENT (MC)

3.10.1 DETERMINATION OF MOISTURE CONTENT

1. The oven was set at 130°C as specified;
2. 10 grams each of three paddy samples were placed in the oven;

3. The samples were removed after 16 hours, and the final weight of each sample were obtained;
4. The values of each sample were then computed and moisture content were calculated using the formula below:

   MC = (10 - Final weight of dried sample in grams)×100/(10);
5. The average moisture content were then obtained of the three samples.

3.10.2 CALCULATION

$$MC_{wb} = \frac{m_i - m_f}{m_i} \times 100\%$$

Where;

MC_{wb} = Moisture content wet basis [%]

m_i = Initial weight [g]

m_f = Final weight [g]

3.11 TRADITIONAL THRESHING

Before threshing rice traditionally by beating it against a wooden structure called the "BAMBAM" box, the initial body pressure readings of the farmer were taken using the pressure monitor. The pressure readings included the farmer's systolic pressure, diastolic pressure and pulse. The farmer threshed an amount of 10kg of rice for 10 trials. In this process, the initial and final pressure of the farmer were recorded. Rest periods of 3 minutes were also taken so as to prevent a situation where there would be stresses from previous trials affecting subsequent readings. After threshing with the "BAMBAM" box, the amount of paddy threshed was collected and weighed as well as the scattered grains so as to be able to determine the losses and output of that method of threshing.

3.12 HAND AND FOOT OPERATED THRESHERS

Before these processes of threshing were also carried out, the initial pressure readings of the farmer was taken and 10kg each of harvested rice was weighed and threshed for 10 trials using the hand and foot operated rice threshers. The speed of the threshing drum was taken with the aid of a tachometer at each trial. Rest time of 3 minutes were taken after each trial and the total time used in threshing were also recorded using a stop watch, which aided in determining the threshing rate for the processes.

3.13 DATA ANALYSIS

The data that were collected were analyzed using Microsoft Excel.

CHAPTER FOUR

RESULTS AND DISCUSSION

The threshing process were carried out at the irrigation development authority (IDA) Nabewam in the Ejisu Juaben district in the Ashanti region of Ghana. The threshers were tested separately and each undergone 10 trials on a leveled surface. During the threshing process the threshing speed at each trial, threshing efficiency, threshing rate, capacity, losses, as well as the drudgery involved in using both the hand and the foot operated rice threshers were measured and compared. The moisture content of the rice was 23.3%.

4.1 Threshing speed

The threshing speed of both the hand and the foot operated rice threshers for 10 trials were recorded using a digital tachometer and compared.

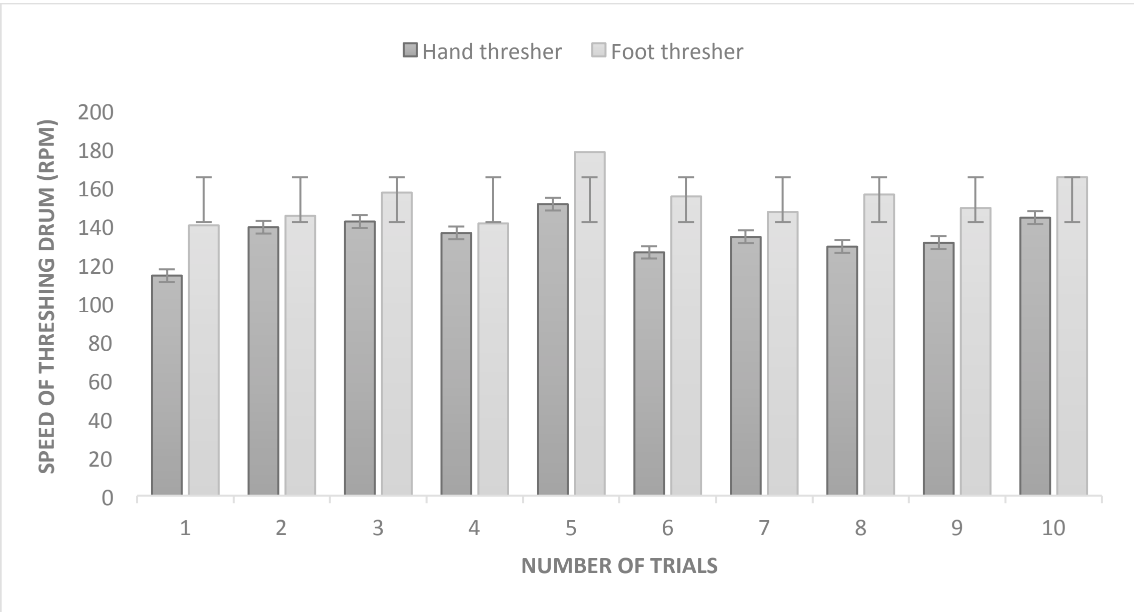


Figure 4.1 Comparison of the speeds of the hand and foot operation of thresher

The speed of the Fomena hand operated rice thresher ranged from 114 rpm to 151 rpm with an average speed of 134.6 rpm after the 10 test trials whereas the Konongo foot operated rice thresher had its speed ranged from 140 rpm to 178 rpm with average speed of 153.3 rpm also after the 10 test trials. This indicates that the Konongo foot operated rice thresher had a higher speed than that of the Fomena hand operated rice thresher. The muscle strength of individuals however affects the speed of the threshing drum in the sense that a farmer with strong muscles would be able to thresh at a higher speed and a reduced time whilst a farmer with weak muscles would thresh the same amount of rice but with increased time as a result of the decrease speed of the threshing drum.

4.2 Threshing efficiency

The efficiencies of the Fomena hand and Konongo foot operated threshers were calculated and compared.

Table 4.1 Efficiencies of the Fomena hand and Konongo foot operated rice threshers

Thresher	Mass of threshed rice (kg)	Efficiency (%)
Hand operated rice thresher	2.6	66.5
Foot operated rice thresher	3.2	81.8

The threshing efficiency of the Fomena hand operated manual rice thresher was calculated to be 66.5% whereas the Konongo foot operated manual rice thresher was also calculated to be 81.8% after the 10 trials. This shows that the Konongo foot operated manual rice thresher was much effective in threshing rice grains than the Fomena hand operated thresher. The moisture content of the rice before threshing and the speed of the rotating rim play important roles in the determination of the efficiency of the thresher. Thus, readings fell within the range recorded by Adewumi *et al*. (2007).

4.3 Threshing rate

The threshing rates of both the Fomena hand and Konongo foot operated manual rice threshers were calculated and compared.

Table 4.2 Threshing rates of the Fomena hand Konongo foot operated rice threshers

Thresher	Mass of threshed rice (kg)	Total time (min)	Threshing rate (kg/hr)
Hand operated rice thresher	2.6	12.53	12.45
Foot operated rice thresher	3.2	9.59	22.52

This is the measure of the output of the thresher with respect to time (hr). The threshing rate of the Fomena hand operated manual rice thresher from the field evaluation results above was determined to be 12.45 kg/hr whereas the threshing rate of the Konongo foot operated thresher was also determined to be 22.52 kg/hr. This indicates that the Fomena hand operated rice thresher is able to thresh 12.45 kg of rice straw per hour whilst the Konongo foot operated thresher is able to thresh 22.52 kg of rice straw also per hour. Hence, the Konongo foot operated manual rice thresher has a higher threshing rate thus ability to thresh more rice straw than the Fomena hand operated rice thresher with respect to time.

4.4 Threshing losses

The threshing losses for the hand and foot operated manual rice threshers were weighed and the results were compared. 10kg of rice straw contained 3.91kg of rice grains. The scattered paddy recorded in using the Fomena hand operated rice thresher was 7.7% whilst the Konongo foot operated rice thresher had no rice scattered after the threshing process indicating that the hand operated rice thresher gave more room for scattering losses to occur, thus making the foot operated rice thresher preferred if scattering losses are to be kept at it's lowest possible level. The unstripped grains recorded however, were as a result of its moisture content which varried from the threshed grains and as well as the moisture content of the the straw.

4.5 Effect of moisture content on threshing

The moisture content of the rice was 23.3 % and had an efficiency 81.8 % with the Konongo foot operated thresher. 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. This means that moisture content below 23.3 % will increase the efficiency of the thresher and reduce the amount of unstripped grains on the straw after threshing.

4.6 Drudgery determination

The drudgery involved in using both the Fomena hand and Konongo foot operated rice threshers were measured with the pressure monitor (sphygmomanometer). This gives the systolic, diastolic and pulse readings of a person at a particular state. The systolic pressure refers to the amount of pressure in the arteries during contraction of the heart muscle whereas the diastolic pressure refers to the blood pressure when the heart muscle is between beats. The normal systolic pressure of a person is between 90-120 mmHg with diastolic pressure also between 60-80 mmHg. Numbers greater than the ideal range indicates that the heart is working too hard to pump blood to the rest of the body. The pulse is the rate at which the heart beats and is usually called the heart rate, which is the number of times the heart beats each minute (bpm). High work stress however, causes an increase in the ideal range of numbers and eventually blood pressure. The initial body pressure of a 32 years old farmer before the test trials was recorded to be systolic 95mmHg, diastolic 61mmHg and pulse 59bpm. The trend in the increase in the systolic and diastolic pressures are as follows:

Figure 4.2 Comparison of the systolic pressures

During the experiment, the systolic pressure readings in using the Fomena hand operated rice thresher ranged from 102 mmHg to 123 mmHg after the 10 trials whereas the systolic pressure readings in using the Konongo foot operated thresher ranged from 81mmHg to 112 mmHg. Hence, the figure (fig. 4.2) indicates that the Fomena hand operated rice thresher imposes more stress on the farmer as compared to the Konongo foot operated rice thresher.

Figure 4.3 Comparison of the diastolic pressures

The diastolic pressure after each trial with the Fomena hand operated rice thresher recorded a range of 74 mmHg to 85 mmHg whereas the diastolic pressure readings in using the

Konongo foot operated rice thresher recorded a range of 69 mmHg to 79 mmHg. The figure above (figure 4.3) also indicates that in using the Fomena hand operated rice thresher the diastolic pressure increased as compared to the Konongo foot operated rice thresher. Therefore the Fomena hand operated rice thresher imposes more stress on the farmer than the Konongo foot operated rice thresher.

Table 4.3 Comparison of the (pulse) heart rate per kg of the Fomena hand and Konongo foot operation of thresher

Thresher	Pulse (bpm)	Mean pulse (bpm)	Capacity (kg/hr)	Heart rate/kg (beats/kg)
Hand operated(Fomena)	71-86	78.6	48.37	24.3
Foot operated(Konongo)	69-81	72.4	68.84	11.6

The table above however shows the trend in the rise of heart rate per kg of threshed rice using the formula for drudgery as stated by mohanty *el al* (2008). The heart rate was therefore obtained by the change in pulse that is, the pulse of the operator at rest and the average pulse after the test trials over the capacity of the thresher multiplied by 60. Hence, the heart rate per kg in using the hand operated thresher was calculated to be 24.3 beats/kg, whereas the foot operated rice thresher recorded a heart rate per kg of 11.6 beats/kg. This indicated that, to thresh 1kg of rice using the hand operated thresher, heart rate increases by 24 beats and thus, more drudgery inflicting than the foot operated rice thresher, which causes 11.6 beats increase in heart rate to thresh 1kg of rice. The heart rate of the operator at rest was recorded to be 59 beats/min.

Table 4.4 Summary data showing measured variables

Parameters measured	Hand	Foot
Amount of harvested rice used (kg)	10	10
Average Speed of threshing drum (rpm)	134.6	153.3
Efficiency of thresher (%)	66.5	81.8
Threshing rate (kg/hr)	12.45	22.52
Total threshing time(min)	12.5	9.59
Threshed grain (kg)	2.6	3.2
Systolic pressure (mmHg)	102-123	81-112
Diastolic pressure (mmHg)	74-85	69-79
Pulse (bpm)	71-86	69-81
Mean pulse (bpm)	78.6	72.4
Capacity (kg/hr.)	48.37	68.84
Heart rate/kg (beats/kg)	24.3	11.6

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

After successfully evaluating the Fomena hand and Konongo foot operated manual rice threshers upon the specific objectives of this project work, the following were observed and the due recommendation given.

1. The threshing efficiency of the Konongo foot operated rice thresher was 81.8 % after the test trials as compared to the Fomena hand operated rice thresher which had 66.5 %. Also, the foot operated rice thresher had a capacity of 68.84 kg/hr., whereas the hand operated rice thresher had a capacity of 43.25 kg/hr.

2. Secondly, the average speed of the Konongo foot operated rice thresher was 153.3 rpm whereas the hand operated rice thresher (Fomena) recorded an average speed of 134.6 rpm. The average threshing rate of the Konongo foot operated rice thresher was 22.52 kg/hr. whilst the Fomena hand operated rice thresher recorded 12.45 kg/hr.

3. The heart rate per kg in using the Konongo foot operated thresher was recorded as 11.6 beats/kg, whereas the Fomena hand operated rice thresher recorded a heart rate per kg of 24.3 beats/kg.

5.2 Recommendations

Upon the outcome of the field evaluation of both the Fomena hand and the Konongo foot operated manual rice threshers, the following recommendations were made:

1. A foot stand should be provided for at the base of the Fomena hand operated thresher to make it firm on the ground during threshing.

2. The length of the threshing drum of both threshers should be increased enough to increase the threshing capacity.
3. There should be a roller handle on the Fomena hand operated thresher to reduce the pressure in the palm during threshing.
4. The edges of the rim of the hand thresher should be smoothened so as to prevent injury during operation.

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APPENDICES

Appendix 1: Tables of recorded data

Table 1 Readings of the hand and foot thresher speeds

Trials	Hand operated thresher Speed(rpm)	Foot operated thresher Speed(rpm)
1	114	140
2	139	145
3	142	157
4	136	141
5	151	178
6	126	155
7	134	147
8	129	156
9	131	149
10	144	165
Mean	134.6	153.3

Table 2 Readings of the systolic pressure in using the hand and foot threshers

Trials	Input(kg)	Hand operated thresher Final systolic pressure(mmHg)	Foot operated thresher Final systolic pressure(mmHg)
1	1	103	97
2	1	119	81
3	1	122	112
4	1	107	89
5	1	120	102
6	1	102	91
7	1	113	104
8	1	123	88
9	1	111	98
10	1	116	94

Table 3 Readings of the diastolic pressure in using the hand and foot threshers

Trials	Input(kg)	Hand operated thresher Final diastolic pressure(mmHg)	Foot operated thresher Final diastolic pressure(mmHg)
1	1	82	69
2	1	85	72
3	1	76	74
4	1	77	75
5	1	78	67
6	1	75	71
7	1	74	74
8	1	76	69
9	1	82	79
10	1	80	77

Table 4 Readings of the pulse in using the hand and foot threshers

Trials	Input(kg)	Hand operated thresher Final pulse(bpm)	Foot operated thresher Final pulse(bpm)
1	1	75	81
2	1	73	69
3	1	76	70
4	1	80	72
5	1	71	69
6	1	84	76
7	1	79	71
8	1	86	70
9	1	79	74
10	1	83	72

Table 5 Readings of the systolic, diastolic and pulse of using the traditional method of threshing

Trials	Final Systolic pressure (mmHg)	Final Diastolic pressure (mmHg)	Final Pulse (beat per min)
1	124	78	75
2	132	73	72
3	127	63	78
4	125	74	82
5	127	64	77
6	131	68	77
7	122	65	79
8	124	74	79
9	137	81	73
10	131	66	76

Table 6 Readings of the rate of threshing of the hand and foot operated rice threshers

Trials	Input(kg)	Time taken(minutes) (Hand operated thresher)	Time taken(minutes) (Foot operated thresher)
1	1	1.41	1.35
2	1	1.56	1.21
3	1	1.18	1.04
4	1	1.24	1.07
5	1	1.22	0.59
6	1	1.14	0.56
7	1	1.08	1.02
8	1	1.27	0.59
9	1	1.17	1.04
10	1	1.26	1.12
Total time	10	**12.53**	**9.59**
Average	1	**1.253**	**0.959**

Table 7 Readings of the capacity of the hand and foot operated rice threshers

Trial	Input (kg)	Hand operated rice thresher		Foot operated rice thresher	
		Time (minutes)	Threshing capacity (kg/hr)	Time (minutes)	Threshing capacity (kg/hr)
1	1	1.41	42.55319149	1.35	44.44444444
2	1	1.56	38.46153846	1.21	49.58677686
3	1	1.18	50.84745763	1.04	57.69230769
4	1	1.24	48.38709677	1.07	56.07476636
5	1	1.22	49.18032787	0.59	101.6949153
6	1	1.14	52.63157895	0.56	107.1428571
7	1	1.08	55.55555556	1.02	58.82352941
8	1	1.27	47.24409449	0.59	101.6949153
9	1	1.17	51.28205128	1.04	57.69230769
10	1	1.26	47.61904762	1.12	53.57142857
Average	1	1.253	48.37619401	0.959	68.84182487

Appendix 2: Images from the field

Fig 1. A hand operated rice thresher (Fomena)

Fig 2. A foot operated rice thresher (Konongo)

Fig 3 Threshing of rice traditionally