Comparative Analysis and Performance Evaluation of Engine Operated Portable Wheat Threshers

By

Gete Basa Biru

Thesis

Submitted to the Program of Mechanical Systems and Vehicle Engineering

School of Mechanical, Chemical and Material Engineering

A Thesis Submitted in Partial Fulfillment of the Requirements for Award of the Degree of Masters of Science in Agricultural Machinery Engineering

Office of Graduate Studies

ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY

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Approval of Board of Examiners

We, the undersigned, members of the Board of Examiners of the final open defense by Gete Basa Biru have read and evaluated his/her thesis entitled "Comparative Analysis and Performance Evaluation of Engine Operated Portable Wheat Thresher'' and examined the candidate. This is, therefore, to certify that the thesis has been accepted in partial fulfillment of the requirement of the Degree of Masters of Science in Agricultural Machinery Engineering.

Advisor	Signature	Date
Chairperson	Signature	Date
Internal Examiner	Signature	Date
External Examiner	Signature	Date

CANDIDATE'S DECLARATION

I hereby declare that the work which is being presented in this thesis entitled "Comparative Analysis and Performance Evaluation of Engine Operated Portable Wheat Thresher" in partial fulfillment of the requirements for the award of the Degree of Masters of Science in Agricultural Machinery Engineering is an authentic record of my own work carried out from September to August, 2018 under the supervision of Dr.-Ing simie Tolla Department of Mechanical Systems and Vehicle Engineering, Adama Science and Technology University, Ethiopia.

I confidently declare that this thesis has not been submitted to any other institutions anywhere for the award of any academic degree, diploma, or certificate. All sources or materials used for this thesis have been duly acknowledged.

Name: Gete Basa signature________________ Date_________________

ADVISORS DECLARATION

This is to certify that the above declaration made by the candidate is correct to the best of my knowledge and belief. This thesis has been submitted for examination with my approval.

Advisor: Simie Tolla (Associate prof.) signature______________ Date____________

ACKNOWLEDGEMENTS

First of all, I would like to thank GOD for being with me in all aspects and blessed me to reach this position.

I would like to extend my heartfelt thanks to my advisor Simie Tolla (Associate prof.) for his valuable advice, insight and guidance starting from proposal development to the completion of the research work. I am again thankful to Mr.Meseret Abebe, for his willingness to advise me as well as his valuable guidance and support starting from proposal development to the completion of the research work.

I would like also to express my sincere gratitude to Melkassa Agricultural Engineering Research Center for giving me chance to conduct my research. I would like to thank the whole staff members of Melkassa Agricultural Engineering Research Center and sincerely appreciate their heartfelt support, brotherhood cooperation and encouragements. I am grateful to Wariso Heyi, work shop technician, MAERC, for his technical assistance, commitments and high cooperation during the testing of wheat thresher machine.

I also remain thankful to all the enumerators who assisted me in data collection with patience, commitment and dedication. Their cooperation was not on the basis of their own benefit but is really their own commitment to help me.

DEDICATION

This thesis is dedicated to my lovely mother, who sacrificed much to bring me up to this level and to all my friends and their families for the devotion they made to make my life successful.

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ACRONYMS

AIRIC	Agricultural Implements Research and Improvement Center
ANOVA	Analysis of Variance
ASAE	American Standard of Agricultural Engineering
ATA	Agricultural Transformation Agency
df	Degree of Freedom
ETB	Ethiopian Birr
IRRI	International Rice Research Institute
LSD	Least Significant Difference
MAERC	Melkassa Agricultural Engineering Research Centre
MARC	Melkassa Agricultural Research Centre
MC	Moisture content
METEC	Metal and Engineering Corporation
MS	Mean Square
NARP	National Agricultural Research Project
OABTTA	Office of Agriculture, Biotechnology and Textile Trade Affairs
PAES	Philippine Agricultural Engineering Standards
SADC	Swiss Agency for Development and Cooperation
SS	Sum of Squares

ABSTRACT

Small scale farmers use portable wheat thresher machine developed by different Agricultural Research Centers for threshing wheat crop. But appropriate evaluation of these machines which plays a fundamental role in aiming to reduce agricultural production costs, improve the quality of products and machine reliability in determining the comparative performance of machines are not done well. The aim of this study was to conduct comparative analysis of engine operated portable wheat thresher. The machine was evaluated for wheat crop at three levels of cylinder speeds and three levels of feed rates keeping the concave clearance constant. The test results indicated a maximum of 95.5% threshing efficiency and a minimum of 0.128% *grain damaged and the average output capacity of machine was* $123 kg.hr^{-1}$ *of seed for Melkassa made thresher (thresher I). For Chinese thresher (thresher II) the test results indicated a maximum of* 98% *threshing efficiency and a minimum of* 0.093% *grain damaged and the average output capacity of machine was* $240.234 kg.hr^{-1}$ *of seed. Considering the technical performance measuring parameters Chinese thresher (thresher II) is preferred.*

Key words: thresher, performance, threshing efficiency, damaged/breakage

CHAPTER ONE: INTRODUCTION

1.1. Background and Justification

Agriculture is the mainstay of Ethiopia's economy that provides all the necessary dietary foods, raw materials for food industries and quality products for export market. The country's agricultural potential for food production is known to be immense and over 90% of its export earnings come from this sector. Available sources indicate that a total of 11.6 million tons of cereals, 1.3 million ton of pulses and 0.5 million ton of oil crops were estimated produced annually (CSA, 2007).

Cereals usage ranges from being used as raw materials in industries for production of malt, beverages, beer, etc. being consumed directly as food. Its processing could be done through traditional method (manual) or modern method. Threshing can be done either mechanically or manually.

Inappropriate threshing conditions in a manual threshing process reduces the grain output with respect to excessive and high energy input. In a mechanical threshing process the effect of the inappropriate operating conditions does not only affect the effective recovery of the grains from the other plant materials but it also leads to high grain loss. Grains losses are measured in terms of the damage to the grain kernel and loss to the mechanical elements. Threshing operation is the removal of grains from the plant residues.

Ethiopian government has designed and implemented several economic development plans, notably the sustainable development and poverty reduction plan. According to the plan, the Ethiopian government aims to double agricultural production in the future by increasing the capacity and extensive use of labour, increasing agricultural land utilization linking specialization with diversification, strengthening the agricultural marketing system and scaling up best practices in the sector (Rupert and Tareke,2011).

Recent study conducted by Addis Ababa University and the Swiss Agency for Development and Cooperation (SADC) also showed that threshing losses can be as high as 30% to 50%(OABTTA, 2013). Out of total loss estimated, the threshing/shelling loss for cereals is estimated to reach up to 6% in Ethiopia (Rembold et al., 2011). In order to help small scale agriculture increase its contribution in ensuring food security in the country, all aspects of production including harvest, threshing and postharvest handling of the produce need equal and proper attention (Dubale, 2011). Ethiopian farmers are engaged in farm works the whole year beginning with land preparation to sowing, cultivating, harvesting, transporting, shelling/threshing and storing.

According to (Agidi et al., 2013) threshing is the process of loosening the edible part of cereal grain (or other crop) from the scaly edible chaff that surrounds it. It is the step in grain preparation after harvesting and before winnowing, which separates the loosened chaff from the grain. The term thresher is a general name for all machines that are involved in the process of detaching grains from the ear head. Threshing of grain crop which requires a set of processing conditions that must be achieved for appropriate threshing action through mechanical or manual operation.

It is important to minimize the damage done to grain during threshing as damaged grain is much more prone to attack by insects and fungi. Consequently, techniques that crush and damage grains such as beating with sticks or trampling by cattle are not recommended. Traditional threshing of crops like wheat, barley and sorghum is one of the time consuming, laborious and in which grain loss occurs (Rich and Tanya, 2012). The traditional methods which are used for seed separation from the stalks are laborious and time consuming. Therefore, the development of wheat threshers for seed separation from the stalk has an edge over conventional methods (Chaudhry, 1979).

The sheaves of wheat are carried to the threshing floor manually or on the backs of animals like camel donkeys and bullock. The threshing and separation of the grain from the straw is done in a variety of ways. The wheat crop may be beaten with sticks or trampled by a bunch of animals. Animals may be used to draw a wheat bundle/stone roller over the thick layer of harvested wheat crop.

The development of mechanical threshers for the purpose of threshing has clearly an edge over conventional methods and has reduced the drudgery of work to a great extent. The primary aim of threshing machines is to reduce the labour required for threshing process. The use of these portable threshing machines is based on the quick process, level of performance and economy.

Manual system of threshing is characterized with time wastage, threshing losses, and high drudgery. Mechanical threshing involves high technology which is very expensive, though it helps to maintain the quality of the final products; it eliminates drudgery associated with local threshing system and reduces threshing losses. The level of agricultural mechanization is influenced by the level of economic development, agricultural infrastructure, purchasing capacity of farmers, level of agricultural machinery industry and demand.

This study aimed to test the threshers in order to: identify what criteria are important for small scale threshing machines, measure machine performance and sensitivity to local operating conditions (e.g. wheat variety), collect feedback on the machines, guiding appropriate choice and use, eliminating poor-quality products and supporting development and improvement.

1.2. Statement of the Problem

In the mechanization process, many wheat thresher machines were developed and constructed by many agricultural research centers in Ethiopia. Small scale farmer uses this wheat thresher machines for threshing wheat crop. Many machines have been designed specifically for small scale farmers, and even when products are available, often farmers lack knowledge of or access to this machinery.

Testing and evaluation of portable wheat thresher machine manufactured within the country with a view to assess their functional suitability and performance reliability in determining the comparative performance of machines available in our country is not well evaluated in all enterprises or companies. Appropriate evaluation of wheat thresher machine which plays a fundamental role in aiming to reduce agricultural production costs, improve the quality of products and protect the environment is not done. Many poorly designed and poorly manufactured portable wheat thresher machines may poses serious problems at the individual farmer. In our country there is no neutral third party that test and evaluate portable wheat thresher machine manufactured by many agricultural research center.

In Ethiopia, a large number of portable wheat threshers are manufactured. These have been exhaustively evaluated and improvised to suitable local conditions by the state agricultural universities researchers and local manufacturers. There is an opinion regarding the performance of the portable wheat thresher machines that the breakage of grain is less and efficiency of the machine must be high. So, locally manufactured threshers failed to achieve the internationally acceptable thresher machine.

1.3. Objective of the Study

General objective

- The general objective of this study is to conduct comparative evaluation of engine operated portable wheat threshers.

Specific objectives

- To determine threshing efficiency, cleaning efficiency, grain loss and damaged of wheat.
- To provide data that can potentially be used for producing cost effective and affordable wheat threshers for small scale farmers.
- To determine the optimum cylinder speed and feed rate for each threshing machines.

1.4. Significance of the Study

The performance evaluation of wheat thresher is of great importance. It could serve as a source of credible information for wheat farmers to compare the advantages of using a thresher to manual methods of threshing. It would also enable users to know the predetermined parameters of the thresher. The importance of this study is also used for minimizing losses during wheat threshing and save energy input in threshing operation. Determining and selecting appropriate threshing speed and feed rate for reducing grain damage and producing better quality of grain.

The performance evaluation of the engine operated portable wheat thresher was to produce data that can be used to adapt the thresher for wheat varieties. The process of measuring, collecting, storing and analyzing the test data is a fundamental part of the engineering design process.

Finally details of the performance evaluation and summary report were presented. Another significance of this test will help to ensure quality of machines reaching farmer as well as pin pointing improvement need for higher efficiencies/enhanced quality to manufacturer and to get an authentic data on the performance of similar machines of other manufacturers to improve the productivity.

1.5. Scope of the Study

This study was not cover design, manufacture and development of engine operated portable wheat thresher.

CHAPTER TWO: LITERATURE REVIEW

In production of grain crops for marketing and consumption, it is necessary that the seed be separated from the stalk on which they grow. The wheat crop must have the seed stripped from its straw. Threshing is the process of separating the grains from the stalk of harvested crop. Different types of machines are necessary for the separation of the seed from the holding agent in the different crops. Thresher loosens the grain from the stalk and separates them from the straw and chaff. The threshing effectiveness and performance of thresher is related to the rate at which material is fed into the machine and type and condition of the crop (Ezzatollah et al., 2009).

Olaoye (2011) concluded that mechanical threshing involves high technology which is very expensive, though it helps to maintain the quality of the final products; it eliminates drudgery associated with local threshing system and reduces threshing losses. Threshing is a major post-harvest operation which is carried out after all crops have been gathered from the field.

Sharma et al. (1983) developed a multi-crop thresher suitable for wheat, paddy and maize. The long duration tests indicated average grain output varying from 4.49 q/hrs to 7.78 q/hrs

Chaudhry (1979) found the total loss of wheat from bullock threshing, mechanical threshing; tractor threshing and combine harvester amounted to 3.11%, 2.68%, 2.01%, and 1.2% respectively. The maximum losses were of bullock threshing and minimum for combine harvester. It was estimated that about 2.65% of the potential production of wheat was lost during harvesting, threshing and winnowing operation for all modes of wheat threshing.

There are two main types of stationary threshing machines which have been developed. The machine of western design is known as "Through-Flow" thresher, because of passing stalks and ears through it. It contains of a threshing device with a pegs and a cleaning-winnowing method which is based upon shakers, sieves and centrifugal fans. In the 70s IRRI developed an axial flow thresher, which has been commonly made at local level (Sexana et al., 1971). Threshing is still unnoticeable problem among the grain losses; these losses do not merely generate negative repercussions for the farmers, but also have serious effects on the economy.

Mahmoud et al.(2007) examined that wheat crop is very sensitive to threshing operations due to the high percentage of grain that affects the total yield. They also concluded that cylinder peripheral speed, feeding rate and moisture content are main factors affecting the performance of threshing machines. The above mentioned factors directly affected the crop losses, energy requirements, and efficiency, which in return, influenced the total operational cost.

Singh et al.(1992) reported that the handling of thresher efficiency, grain damage, losses and capacity has been a major challenge. This is due to the variable operating conditions and machine parameters. The grain characteristics go a great length in determining the general performance of cereal threshers. Various researchers attained success by proper adjustment of these operating conditions.

Threshing of grain crop which requires a set of processing conditions that must be achieved for appropriate threshing action through mechanical or manual operation. Portable grain crop threshers are the threshers which use the threshing cylinders in a confined position. This type of thresher is of two types based on feeding method of the crop in to the thresher. These two methods are throughput and hold on types.

Manual threshing operation is an inappropriate method of threshing because it reduces the grain output as well as it requires high energy input. In a mechanical process of threshing, the inappropriate conditions of threshing not only affect the grains recovery from the other plant materials but it also results in high grain loss. The grain losses are measured by damage to the grain kernel and loss to the mechanical elements. Threshing is a unit operation which involves the removal of grains from the plant residues. Threshing is the most important process in grain production (Klenin et al., 1986); Olaoye et al. (2004).

Various researchers have determined the proper operating conditions for a mechanical thresher for successful threshing of grains and to minimize losses in a mechanical thresher. The key variables of interest for the researchers are crop parameters, environmental conditions and machine parameters (Olaoye et al., 2004).

Olaoye and Oni (2001) investigated the effect of crop parameters on threshing efficiency of thresher in Nigeria. The results showed that mechanical properties of grains, grain size and geometrical dimensions of grains are the important parameters that can increase the separation of grains from the plant residue.

Dual mode thresher in Egypt under the United States of design supported National Agricultural Research Project (NARP) which could be operated both as beater or axial flow type machine was developed (Khan, 1990). This machine could thresh all popular cereal crops that are growing in the developing countries. The dual mode machine had generated much interest among farmers and the manufactures had started commercial production in Egypt.

The cleaning efficiency increased with increased speed at constant feed rate from 98.3% to 99.7% and threshing efficiency increased with speed of threshing drum at constant feed rate from 98.51% to 99.45% and decreased with increase in feed rate at constant speed (Saeed et al., 1995).

Sharma et al. (1984) developed a multi-crop thresher for threshing wheat as well as paddy. The thresher was operated by a 5 hp electric motor. It gave an output of 200 and 400 kg/hrs in case of wheat and paddy respectively. Total grain losses were observed to be less than 1 percent for both the crops.

The threshing efficiency increased with the increase of cylinder speed but decreased with the increase of feeding rate and concave clearance. Energy consumption was directly proportional to cylinder speed, feed rate, and remained constant at selected concave clearance. At higher speeds, the visible grain damage was 5% and the germination percentage was low (Sharma and Devnanl, 1980).

Huynh et al. (1982) stated that the seed separation from the stalks and passage of seed through the concave gate is a function of some variables such as crop feed rate, threshing speed, concave length and cylinder diameter and concave clearance. These variables also related to the threshing losses and seed separation efficiency.

The percentage of wheat grain damage increased with an increase in cylinder speed for all feed rates and concave clearance combinations. The mean grain damage decreased with increasing concave clearance and feed rate. The percentage of total machine losses increased as cylinder speed ranged from 480 rpm to530 rpm (Anwar and Gopta, 1990).

Ajayi (1991) indicated that, the material capacity of a thresher influenced by its speed of the threshing beater drum, the feed rate and the moisture contents of the material. At lower speeds of 300 rpm and 500 rpm of the beater drum, the material at 13.3% moisture gave slightly decrease in capacity as the speed increased to 500 rpm.

The multi-crop threshers which are used to handle number of crops are highly successful for threshing cereal crops and pulses. The advantage of multi-crop threshers is that with minor adjustments it can be used to thresh different crops, whereas other threshers can thresh a particular crop only. Inefficient threshing not only requires substantial time but also cause considerable threshing losses of grain. An improved mechanical thresher would improve timelines of operation and also reduce threshing related losses.

Mazumadar (1985) conducted an experiment on multi-crop thresher that was operated by 5hp electric motor and reported that the output of the capacities of thresher at maximum feed rate were 348,276, 635 and 392 kg/hrs for wheat, soybean, sorghum and paddy crop respectively. The threshing efficiency were approximately 99 percent in most cases, cleaning efficiencies were 99, 97, 99 percent for wheat, sorghum and slightly lower for other crop, respectively.

Threshing efficiency, cleaning efficiency and seed damage of wheat grain increased by decreasing moisture content. Also he indicated that the best of moisture content it gave the lowest of seed damage and seed losses and highest of threshing and cleaning efficiency of 14 %(Khater, 2000).

Harrington (1970) conducted tests with a multi-crop thresher and concluded that the unthreshed grain were below one percent for the entire wheat, paddy, mustard and maize crop. On threshing kalyan sona wheat variety at 7.5 percent moisture content and a cylinder speed of 1200 rev/min there was 1.1 percent unthreshed and 1.4 percent broken grain.

Metha et al., (1995), suggested the acceptable limits of various efficiencies and losses for wheat threshers. The main performance criteria as per Bureau of Indian Standards for wheat thresher were reported as threshing efficiency > 99% , cleaning efficiency > 96%, grain breakage < 2% total grain loss < 5%, split straw > 95%, average length of stalk 12-15 mm.

Gill et al. (2002) studied the effect of various operational factors like feed rate and cylinder speed on grain loss, sieve loss, cleaning efficiency, threshing efficiency of a spike tooth cylinder type plot thresher. The observations were taken at feed rates of 150, 252 and 348 kg/hrs and with cylinder speed of 777 rpm, 900 rpm and 1050 rpm. The optimum combination of feed rate and cylinder speed was found to be 252 kg/hrs and 900 rpm respectively, at which the threshing efficiency, cleaning efficiency and total grain loss were observed 99.14%, 99.97% and 1.3 % respectively.

Salokhe and Vejasit (2004) studied the effect of machine - crop variables on performance of a threshing unit. Test results indicated that the threshing efficiency varied from 98 to 100%. The grain damage and grain loss were less than 1% and 1.5% respectively at drum speeds of 600 to 700 rpm and 540 to 720 kg/hrs feed rates and at 14.3% to 22.8% (w.b.) seed moisture contents. The maximum power requirement was 2.29 kW at grain moisture content of 32.9% (w.b.) at a drum speed of 700 rpm. The best combination of feed rate, drum speed at 14.3% (w.b.) seed moisture content to obtain higher output capacity, threshing efficiency and grain losses was 600 to 700 rpm drum speed (13.2 to 15.4 m/s) at a feed rate of 720 kg/hrs.

Agha (2004) studied grain losses of wheat as affected by threshing timings. The meteorological characteristics were slightly different during observation dates. The data revealed that grain losses were considerably affected by time of threshing and it increased with late as well as early threshing. Minimum grain losses were recorded during middle of the day. Comparison of loss types indicated that the maximum were un-threshed grain followed by un - broking grain losses.

Engine powered threshing are gradually being replaced by combine-harvesters, motorized threshing machines still have an important place in the separation and 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.). The use of motorized threshers may require two or three workers. 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 kg/hrs to 5000 kg/hrs (Olayanja et al., 2009).

2.1. Threshing Methods

Threshing methods are the various means by which wheat ear head are separated from the plant. The in-field storage method results in a pre-drying of the wheat ears before threshing, the purpose of which is to separate seeds from panicles. Threshing is the process of separating the grain from the straw. It can be either done by hand, by using a treadle thresher or mechanized (Agidi et al., 2013).

2.2. Traditional Manual Threshing

Traditional wheat 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. One of the simplest systems for threshing wheat is to pick up the sheaf of wheat and strike or beat the panicles against a hard surface such as a tub, threshing board or rack; or beating the sheaves spread out on a threshing-floor with a flail or a stick or tramples it under foot. The threshing floors on which the sheaves are spread must have a hard, clean surface (Olayanja et al., 2009).

The traditional threshing of wheat is generally done by hand: bunches of panicles are beaten against a hard element (e.g. a wooden bar log, bamboo table, or stone). In many countries in Asia and Africa, and in Madagascar, the crop is threshed by being trodden underfoot (by humans or animals); this method often results in some losses due to the grain being broken or buried in the earth (Ouezou, et al., 2009).

2.2.1. Threshing Rack

Threshing racks in threshing refers to the use of racks as a means of threshing. It is accomplished when individuals hold the crop by the sheaves and beat it against a slatted bamboo, wooden plate form, or any other hard object such as a steel oil drum. It is labour intensive (Mohammed and Alireza, 2013).

2.2.2. Threshing with Animal

Trampling involves the use of bare feet or animals to thresh crop. If draught animals are available and there are large quantities of wheat, threshing can be done by driving the animals (harnessed, in that case, to threshing devices) over sheaves. This operation, which is also called “treading out”, and can equally be well, be accomplished with vehicles. This method of threshing wheat is adopted in some countries, using a tractor for power instead of draught animals (Ramatoulaye, 2010).

2.3. Types of Threshers

Engine powered threshers can be classified using different standards such as feeding type, crop flow inside the machine and last but not least threshing elements. Small-scale mechanical threshing methods may be grouped into two categories; hold on threshers and feed in threshers. Both types of thresher were tested, alongside hand threshing.

2.3.1. Throw-in Thresher

This is the type of thresher whereby the whole crop is feed into the machine. They can also be referred as the feed-in thresher. In a conventional threshing cylinder, stripping may also be used for grain threshing; impulsive pass through the machine and some designs use straw walkers to initially separate the loose grain from the bulk of the straw and chaff (Ouezou et al., 2009).

2.3.2. Hold-on Thresher

For the hold-on thresher, the wheat is still held still in the cylinder whiles performing impact threshing. The head of the cut crops are fed into threshing drum with the lower part of the straw being mechanically or manually fed. Maximum care should be taken when farmers are using this kind of thresher. Harvested panicle should be kept in a definite order. The simplest of these are mechanized version of the treadle thresher in which the drum is rotated by 1-3 hp engines (Tamiru and Teka, 2015).

Therefore, this study was undertaken with the purpose of determining and selecting appropriate threshing speed and feed rate for reduced grain damage and producing better quality of grain in post-harvest operations. The study has been designed to achieve the following objectives: to evaluate the effect of threshing cylinder speed on wheat grain breakage and cleaning efficiency; to evaluate the effect of crop feed rate on grain breakage and cleaning efficiency.

2.4. Previously Manufactured Machine Data

This study was planned to compare the performance of portable wheat thresher of different manufacturer Chinese thresher (thresher II) and Melkassa made thresher (thresher I). Opinions, views and response of the participants about the technology as compared with the traditional practice were collected. The machine consists of the following components: A structural frame, top cover with feed hopper, threshing cylinder, centrifugal blower, and power transmission unit and bottom tray to collect grain. Threshing was achieved by giving impact to the crop from a rotating drum (threshing cylinder) which causes grains to separate from the ear head. The separation and cleaning of grain from the chaff was achieved with the help of air flow (blower) for Chinese wheat thresher machine and finally separation and cleaning of grain from chaff achieved manually. But for Melkassa made thresher machine all process of separation and cleaning were done manually because this haven’t air flow (blower).

CHAPTER THREE: MATERIALS AND METHODS

3.1. The Experimental Site

The experimental testing and evaluating engine operated portable wheat thresher was carried out at Melkassa Agricultural Research Center (MARC). Field sites were purposely selected, considering wheat grain types. The center was geographically located in the central valley of Ethiopia around 117 km east of Addis Ababa along Sodere road, and one of the emerging town of Oromia regions. It was found at an altitude of 1466 m above sea level and lies on the geographical coordinates of 8° 24' 0" N and 39° 20' 0" E Latitude and Longitude respectively. The mean annual rainfall is 700 mm and average annual minimum and maximum temperatures are 12 and 36 ℃ respectively.

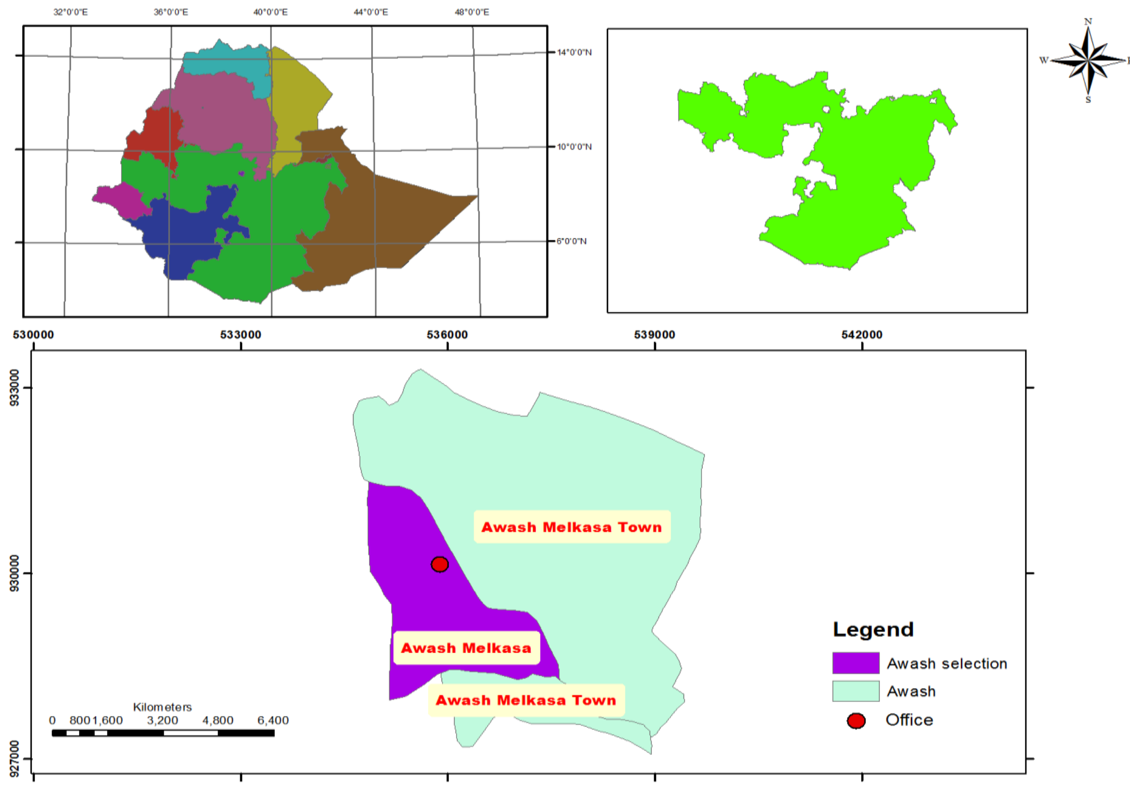

Figure 3.1 Geographical location of study site

3.2. Materials

The machineries used in the experiment were the following:

1-Melkassa made engine operated portable wheat thresher, the machine was previously designed and constructed and available at Melkassa Agricultural Research Centre (MARC).

2-Chinese engine operated portable wheat thresher, the machine was imported by METEC from China and available at Melkassa Agricultural Research Centre (MARC).

Materials and instruments used for evaluating/testing of engine operated portable wheat thresher Melkassa made thresher and Chinese thresher were listed below.

Table 3.1 Materials and their uses

No	Materials	Uses
1	Engine operated locally manufactured portable wheat thresher	This machine was used for threshing the wheat mechanically. It was engine powered.
2	Harvested wheat crop	Harvested Wheat crop was used for testing and performance evaluation
3	Stop watch	Timing the duration of threshing
4	Electronic balance	Weighing threshed wheat.
5	Plastic bucket	Collect the threshed wheat from the outlet of the wheat thresher.
6	Spread canvas sheet	Collect scattered grain of the wheat.
7	Digital tachometer	Measuring the speed of the threshing drum
11	Oven	Determine the moisture content of wheat grain.
12	Graduated cylinder	Determine fuel consumption

3.3. General Conditions for Test and Inspection

3.3.1. Test Site Conditions

The thresher was installed on a stable level ground on a site with sufficient working space, and was positioned in such a way that the wind was blow the straw and other impurities away from the clean grain.

Figure 3.2.Melkassa made thresher (thresher I) and Chinese thresher (thresher II)

3.3.2. Test Preparation

Before the start of the test, the thresher and engine was undergone a running-in period. The thresher was operated at the test site. The power requirements of different functional parts of thresher were determined under load and no load conditions at three different speeds of the thresher cylinder. The cylinder concave clearance was kept constant during whole test.

3.3.3. Test Instruments

The suggested list of minimum field and laboratory test equipment and materials needed to carry out the thresher test should be calibrated regularly. Those instruments were stop watch, electronic balance, tachometer and oven. Those instruments were physically checked for operation before each test and were cleaned after each test. A checklist of instruments and materials were prepared to be used before departure to and from the testing area.

3.4. Experimental setup

3.5. Test Procedure

Two portable threshers were obtained for testing wheat crops in Melkassa Agricultural Research Center and both threshers are powered by diesel engines. One of the threshers was manufactured by Melkassa Agricultural Research Center and the second thresher was imported by Metal and Engineering Corporation. The procedures used to evaluate the two threshers were from Philippine Agricultural Engineering Standards PAES 205:2015. The Standard for testing calls for the comparative testing of one machine relative to another in a particular crop condition. To ensure various components functioned properly, the machine was set up and was easily powered. This was done five minutes without load, and the bearings were well mounted, with a smooth movement of the drive shaft after adjustments were made.

3.6. Performance Test

3.6.1. Operation of the Thresher

First, the thresher was allowed to run for a short period of time. This time was required to make adjustments to the working parts and feeding methods. After the test trial, the threshing area was cleaned and then prepared for the next trial.

The portable wheat thresher works on the principle of impact and rubbing of cylinder and concave over the wheat crop detaching grains and allowing grains separated straw to pass through the threshing mechanism into a separation unit. Due to the rubbing action between cylinder and concave which varies due to cylinder speed and feed rate the grain were separated from straw. In wheat threshing impact force due to cylinder causes shattering action and then rubbing action take place between the concave and bars. The primary function of the concave appears to be bringing the material into the cylinder-bar path for repeated impacts. The separation of grain from straw was achieved manually. A 7 hp diesel engine provides power to the threshing drum shaft which rotates with the help of v-belts.

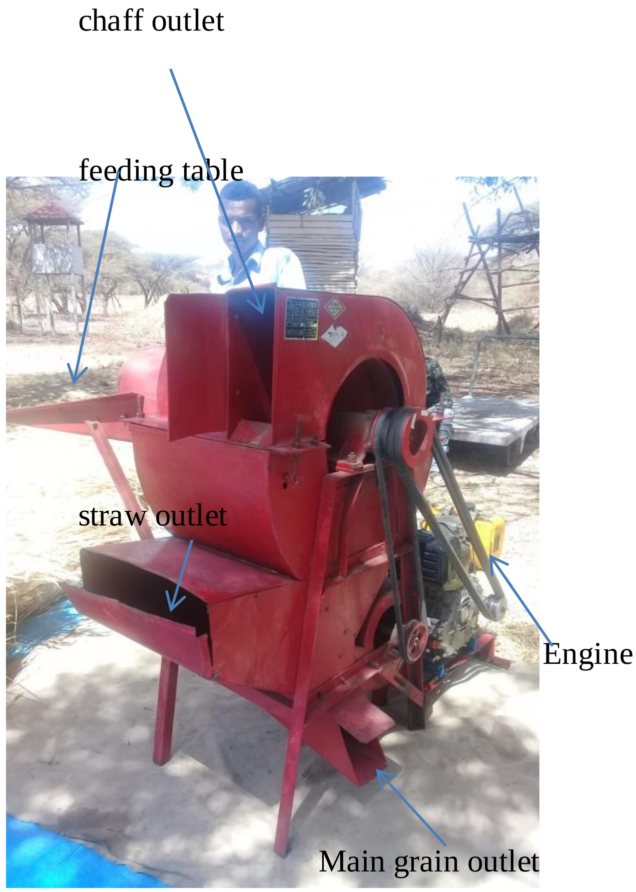

Figure 3.3.view of Chinese thresher (thresher II) illustrating main grain outlet, chaff outlet, blower outlet, feeding table and engine.

Figure 3.4.view of Melkassa made thresher (thresher I) illustrating main grain outlet, feeding table and chaff outlet.

3.6.2. Sampling

Samples were collected during each test trial. Scattering loss was collected after each test trial. Two thresher machine samples were selected purposively. One was Melkassa made wheat thresher (thresher I) and the second machine is Chinese wheat thresher (thresher II).

3.6.3. Sampling Procedures

The conditions of crop such as grain-straw ratio and moisture content of grain to be used in each test trial were taken using “representative samples”, which represent the different conditions of the test lot. This can be done by taking samples randomly from harvested wheat crop. Samples representing the materials for each test trial were placed in appropriate containers for laboratory analysis.

During each test trial, samples were collected from outlets to be analyzed in the laboratory for losses, purity and grain quality. The minimum amount of sample to be taken was twice as much as what was needed for a particular analysis. Keeping in view the capacity of thresher the samples were collected from all outlet of the machine to compute the various dependent parameters. Scattered loss was collected by spreading a plastic sheet on the ground where the thrower material was falling. The samples of grains collected from all outlets were analyzed for threshed, unthreshed and broken grains. The grains collected at various outlets of thresher were weighted using electronic digital balance.

3.6.4. Collection of Scattered Grains

For testing purposes, scattered grains were gathered since these grains were part of the total grain input. Spread canvas sheets were setup around the threshing floor area to catch these grains after each test trial. Place the collected grains in appropriate containers and label them as scattered grains.

All samples to be taken to the laboratory were placed in appropriate containers and properly labelled.

3.7. Measurement of Fuel Consumption

To get the amount of fuel consumed, the tank was filled to a certain marked level before the test. After the test, fill the fuel tank with measured fuel to the same level before the test. When filling up the tank, careful attention was made to keep the fuel tank at the same position as the first measurement. After threshing, the engine was stopped and the fuel tank was refilled up to the same level with the graduate cylinder to determine the quantity of diesel fuel needed to refill the fuel tank up to the same level.

3.8. Data Collection

Samples were taken for the two threshers to measure their threshing efficiency and capacity. Opinions, views and response of the participants about the technology as compared with the traditional practice were collected.

3.8.1. Duration of Test

The duration of each test trial were start with the first feeding of the harvested crop and ends after the final feeding. However, all discharge from the outlets was included after the all sample of wheat taken threshed. Actual operating time for each of the test was measured by using a stopwatch.

3.8.2. Speed of Components

The speed of the threshing cylinder, blower, and other driven components, with and without load, were measured using a tachometer, expressed in rpm.

3.9. Laboratory Analysis

Laboratory analysis were made to determine the grain moisture content, grain-straw ratio, purity, cracked grain, broken grain and losses (blower, separation, unthreshed, and scattering). Grains scattered around the thresher with a maximum distance of 1.0 m away from the base of the machine, were collected after each trial, cleaned and weighed for the determination of scattering loss.

3.10. Evaluation of Physical Parameter

3.10.1. Threshing Efficiency:

It was the ratio of threshed grain received from all outlets with respect to total grain input expressed as percentage by weight. For determination of threshing efficiency samples from the straw outlet and main grain outlet was collected at equal intervals for each experiment at the outlets. The total quantity of materials obtained at these outlets was processed for eliminating unwanted materials from the grain. The grain from the straw was separated manually and the grain with chaff collected at chaff outlets was winnowed manually and weighed separately. The clean grain was weighed on an electronic balance. Unthreshed grain was threshed again by hand beating, cleaned and weighed. They are used for finding the threshing efficiency. The percentage of threshing efficiency was calculated using equation (3.1) (Mohammed, 2009):

$$\text{T.E} = 100 - \frac{\text{UM}}{\text{TM}} \times 100 \qquad (3.1)$$

Where: T.E = threshing efficiency (%)

UM= weight of unthreshed material in unit time (kg)

TM =weight of total material input in unit time (kg)

3.10.2. Threshing Losses

Threshing losses are defined as scattering loss, threshing loss and grain breakage. While these losses may be significant for small 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 were a good judge of threshing quality and therefore can be asked to evaluate the output and threshing loss instead of using quantitative measurements.

3.10.3. Broken/Damaged Grain

From each of the threshed crop sample of kernels were randomly selected. All physically damaged/broken grains were visually observed, manually sorted and weighed using digital balance. Damage due to mechanical threshing was determined as the ratio of weight of the actual damaged kernels to the weight of a sample taken by using equation (3.2) (Mohammed, 2009):

$$\text{Broken grain (\%)} = \frac{\text{weight of broken (damaged)}\,grains(g)}{weight\ of\ sample\ taken(g)} \times 100 \qquad (3.2)$$

3.10.4. Scattered Grain Loss

The scattered grain loss of the machine was evaluated using equation (3.3) (Mohammed, 2009):

$$Sg = \frac{E}{\mathrm{TG}} \times 100 \qquad (3.3)$$

Where: Sg =scattered grain loss (%)

E = weight of scattered grain collected in unit time (kg)

TG = total grain input per unit time by weight (kg)

3.10.5. Cleaning Efficiency

It was defined as the ratio of the weight of clean grain and the grain containing straw expressed in the percentage. For the determination of cleaning efficiency a representative sample of amount of grain was taken from the main grain outlets and grains are separated from the sample and weighed.

After cleaning, the grain and chaff was weighed and the cleaning efficiency of the thresher was determined. The cleaning efficiency of the machine was evaluated using equation (3.4) (Mohammed, 2009):

$$C.E = \frac{B}{D} \times 100 \qquad (3.4)$$

Where: C.E = cleaning efficiency (%)

B = weight of whole clean grain in unit time at grain outlet (kg)

D = weight of whole material collected in unit time at the grain outlet (kg)

Chinese thresher machine was cleaning machine, but AIRIC made thresher was non-cleaning machine.

3.10.6. Determination of Moisture Content

Seed moisture content was one of the most important factors influencing seed quality and storability, therefore, its estimation during seed quality determination was important. Seed moisture content can be expressed either on wet weight basis or on dry weight basis. In seed testing, it was always expressed on a wet weight basis. For the purpose of this experiment, seed moisture content was determined by oven method. In this method, the seed moisture was removed by drying at a specified temperature for a specified duration the moisture content was then expressed as a percentage of the original weight (wet weight basis). Samples were randomly selected from each and taken to the laboratory for moisture content determination.

Procedures for measuring MC with oven drying method

1. Pre-heat the oven at 130°C;

2. Weigh three wheat samples of 0.1kilograms each and place them inside the oven;

3. Remove the samples after approximately 19 hours, and obtain the final weight of each sample;

4. Compute the MC for each sample:

MC = (0.1kg - Final weight of dried sample in grams)*100/ (0.1kg);

5. Compute the average MC of three samples.

And moisture content can be calculated by using equation (3.5) (ASAE Standard, 2003)

$$\text{Moisture content} = \frac{W1-W2}{W1} \times 100 \quad (3.5)$$

Where: W1= Initial weight of the sample

W2= Final weight of the sample after drying

3.10.7. Grain -Straw Ratio

Grain straw ratio was determined by grain were separated from each sample manually and weight of grain and straw was measured separately by using physical balance. After that it was determined using equation (3.6) (Manfred, 1993)

$$\text{Grain straw ratio} = W1/W2 \quad (3.6)$$

Where: W1= Weight of grain separated from crop.

W2= Weight of straw separated from crop.

3.11. Cost Operation

Cost operation was very important factor to judge the performance of any machine over its counterpart machines and methods performing the same operation. Thus, in order to compare the economics of the wheat crop thresher over traditional threshing, the cost of operation was calculated. Economic importance of wheat threshers in large farms, threshers are components of the combined harvesters, but the combine harvester was an expensive machine and they are meant for big farms. The cost and capacity was beyond the ability of the local farmers, this was one extreme, the other extreme which we must do was the use of the traditional methods. Both the purchase and running cost of the machines should be considered, as well as the cost of additional components such as motors. The cost of using farm machinery consists of expenses for ownership and operation, and overhead charges. It may also include a margin for profit. Ownership costs are independent of use and are often called as fixed costs. Costs for operation vary directly with use and are referred to as variable costs.

3.12. Comparative Cost Analysis of Portable Wheat Threshers (Thresher I and Thresher II)

Cost analysis was an important element for management of machinery. The main purpose of this study was to recommend an economically feasible thresher within the reach of a common farmer of Ethiopia. Using standard procedures, cost analyses of both the threshers (Melkassa made thresher and Chinese thresher) were performed and economic return was estimated using the procedures reported by Hunt, (2013). Both machines were compared for their economic feasibility in the wheat threshing operation. Ownership costs or fixed costs were considered as the initial costs .Operating costs were the expenses incurred as a result of actually using the machine for field operation. Factors affecting fixed costs included depreciation, interest, taxes; housing and insurance. Factors affecting operational costs/variable costs were labor hired to operate the machine, fuel & lubricants and repair & maintenance. These costs consist of two types:

3.12.1. Ownership Costs

Ownership costs were the initial purchase prices of the machines. These costs were therefore considered fixed; ownership costs were hereafter referred to as fixed costs (Hunt, 2013).

3.12.2. Operating Costs

These costs were the expenses which occur as the result of actually using a machine. They vary with the amount of annual use thus were identified variable cost (Hunt, 2013).

3.12.3. Factors Affecting Fixed Costs

Fixed costs always occur on the ownership of a machine, regardless of how much it was used. Fixed costs are more affected by how long a machine was owned than how much it was used.

Fixed cost may vary from 60% to 80 % of the total machinery cost (Hunt, 2013). Factors affecting the fixed cost were;

- Depreciation,
- Interest,
- Taxes,
- Housing, and
- Insurance.

3.12.4. Depreciation

The major cost of a machine was its purchase cost. However, a machine was last several years. Fixed cost was therefore amortized over a number of years. Purchasing a machine may involve borrowing money and paying it back on installments. As a machine gets older, it loses value, or depreciates. The age of a machine therefore reflects its value. A new machine was worth more than an old one. Depreciation was the loss in the value of the capital item due to change in model, wear and tear, breakdown etc. This cost reflects the reduction in value of a machine with use and time, while actual depreciation would depend on the sale price of the machine. There were various methods to determine the depreciation cost, here was used most common method, straight-line method (Hunt, 2013).

Straight line deprecation method was the most conventional and easiest too. It was determined by first assigning an appropriate salvage value to the machine. According to (Hunt, 2013) it was usually 10% to 15 % of the purchase cost. The salvage value was then subtracted from the purchase cost and remainder divided by the number of years of useful life, then deprecation was calculated by using equation (Hunt, 2013).

$$Ds = \frac{\mathrm{P-S}}{\mathrm{L\times H}} \qquad (3.7)$$

Where, Ds= depreciation by straight line method,

P= purchase value,

S= salvage value,

L= life as useful years and

H = Annual working hours.

3.12.5. Interest

The cost of owning machinery includes a charge for interest. Interest was considered as an opportunity cost. This means that by investing in machinery, we have lost the opportunity for the money to earn interest in a saving account or other interest earning investment. Annual charges of interest should be calculated on the basis of the actual rate of interest payable otherwise 10 % of average purchase price should be taken. The amount of interest charged, including financing, was determined by taking one-half of purchase and salvage value times the interest charge and interest was calculated by using equation (Hunt, 2013).

$$I = \frac{\mathrm{i(P+S)}}{2\mathrm{H}} \qquad (3.8)$$

Where, I= interest (birr),

P= purchase value (birr),

S= salvage value (birr),

i= interest rate (birr).

H= Annual working hours

3.12.6. Taxes

Machinery was considered personal property and was taxed according to state and local laws. Normally, taxes vary from 1% to 2 % of the value of the machine at the beginning of the year (Hunt, 2013).

3.12.7. Housing

The need for machinery housing varies with the climatic condition of the country. It was generally agreed that machines protected from weather was require fewer repairs. Housing for machinery must include the service center for maintenance and repair. For this reason, an annual charge of 1% to 2 % of the remaining value of the machine was made for housing.

3.12.8. Insurance

Insurance policies were usually carried on more expensive machines while the risk is usually assumed on the simpler, less expensive machines. Even through an insurance policy may not be carried on some of the older and less costly machines, a charge of 0.25 to 0.50 percent was usually added to the remaining value of the machine (Hunt, 2013).

3.12.9. Factors Affecting Operational Cost

As implied, operational costs were those costs which develop as a result of using the machine. The cost includes;

- Labor to operate the machine,
- Fuels and lubricants and
- Repair and maintenance.

3.12.10. Labor to Operate the Machine

There was some hesitation to charge the cost of labor to operating costs when we were doing our own work. However, labor was a major operating cost and should always be assigned a value. The cost of labor becomes an important factor when evaluating the size of machine to purchase. The hours used by saving a large machine often prove to be an important decision making factor. When hired labor was used to operate the machine, the actual hourly rate was used for labor costs (Hunt, 2013).

3.12.11. Fuel and Lubricants

Wheat thresher machines are powered by engine which requires fuel and lubricants to operate. Fuel consumption varies with the power rating of the engine and the type of fuel being used. A properly maintained engine was produce the most power for the fuel used (Hunt, 2013). The amount of fuel consumed depends on: - the energy requirement of operation, the efficiency of power source, determined by transmission and thresher efficiency, fuel efficiency of the power source and the type of fuel used (Goense, 1995).

3.12.12. Repair and Maintenance Cost

Repair and maintenance of machinery was needed to keep them reliable and to guarantee performance and work of good quality (Goense, 1995). It was a tendency to increase as the machinery gets aged and represents the largest impact on the diagnostic cost benefits. Over the life of the machine components become worn. Excessive wear adversely affects output and increases the likely hood of the failures. This introduces the financial risk by prolonging a critical operation either through slowly rate of work or through unforced break down.

Agricultural machinery must be maintained in the proper operating condition. Lubrication cost, repair and maintenance charges taken as 5 percent of purchase cost (Hunt, 2013). The total cost of operation was determined by adding the fixed and variable cost.

3.13. Data Analysis

Data was analyzed using Microsoft excel to assess the effect of the variables and to determine the most appropriate cylinder speed and feed rates among the selected ones.

CHAPTER FOUR: RESULTS AND DISCUSSION

This chapter deals with evaluation result of the two types of portable wheat threshers (Melkassa made thresher and Chinese thresher). The results were presented in tables and graphs. The result obtained were analyzed and discussed in this section.

4.1. Capacity of Thresher

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

Table 4.1 Capacity determined results for Melkassa made thresher (thresher I)

Sample	Quantity of wheat threshed (kg)	Time taken to threshed (hrs)	Cylinder speed (rpm)
Sample 1	24	0.1833hrs	1200
Sample 2	25	0.1333hrs	1376
Sample 3	23.6	0.2667hrs	1180
Mean	24.2	0.19445hrs	1252
SD	0.72	0.067	107.85

Capacity $= \frac{24.2kg}{0.19445hr}$ =124.45kg/hrs

From the test evaluation results in Table 4.1 above, the average capacity of Melkassa made thresher (thresher I) was determined to be 124.45 kg/hrs. Meaning in every hour it would thresh 124.45 kg of wheat grain on the average. Speed of 1180 rpm the time taken was 16 min and its capacity stands at 88.48 kg/hrs. However, at higher speed of 1376 rpm, the time taken was 8 min and its capacity stands at 187.96 kg/hrs.

Table 4.2 Capacity determined results for Chinese thresher (thresher II)

Sample	Quantity of wheat threshed (kg)	Time taken to threshed (hrs)	Cylinder speed (rpm)
Sample 1	28	0.0833hrs	1114
Sample 2	27	0.11667hrs	1020
Sample 3	25	0.1333hrs	1015
Mean	26.67	0.111hrs	1049.66
SD	1.53	0.025	55.8

Capacity $= \frac{26.667kg}{0.111\text{hr}}$ =240.243kg/hrs

From the test evaluation results in Table 4.2 above, the average Chinese thresher (thresher II) capacity was determined to be 240.243 kg/hrs. Meaning in every hour it would thresh 240.243 kg of wheat grain on the average. At speed of 1015 rpm the time taken was 8 min and its capacity stands at 187.96 kg/hrs. However, at higher speed of 1114 rpm, the time taken was 5 min and its capacity stands at 336.13 kg/hrs. Chinese thresher (thresher II) is performed better as compared to Melkassa made thresher (thresher I) machines in terms of capacity of thresher. However the thresher was preferred due to its high output capacity.

4.2. Fuel Consumption of Thresher

Fuel consumed by the thresher is directly proportional to the mass of wheat threshed. The higher the mass threshed, the higher the fuel consumed. It was however relised that Chinese thresher (thresher II) was fuel efficient. The figures 4.1 and 4.2 indicate that fuel consumption increases with increase in feed rate. The table 4.3 below represents three specified mass threshed and their fuel consumption.

Table 4.3 Fuel consumption results for Melkassa made thresher (thresher I)

Sample	Mass threshed (kg)	Fuel consumed (lit/hrs)
Sample 1	25	50
Sample 2	24	49
Sample 3	23.6	45
Replication	3	3
Mean	24.2	48
SD	0.72	2.65

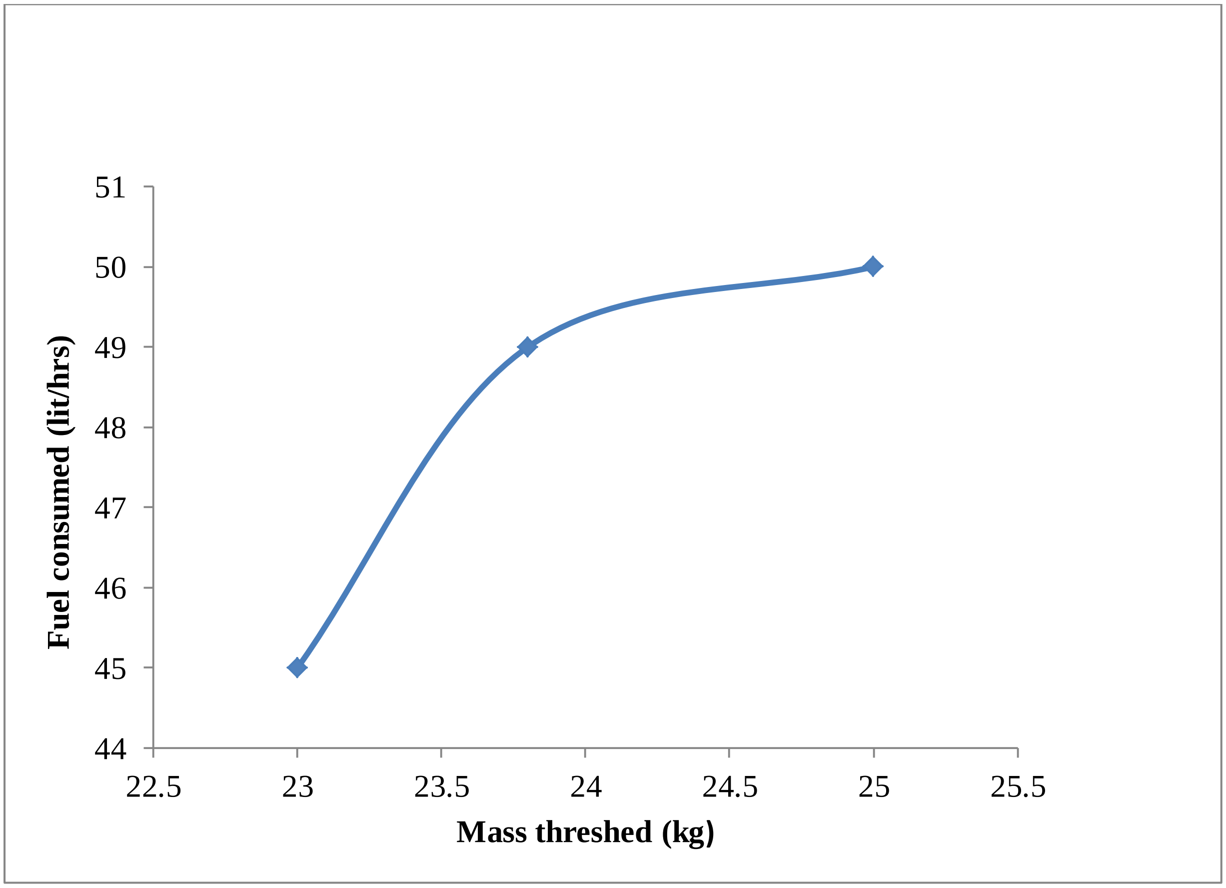

Figure 4.1. Mass threshed versus fuel consumption of Melkassa made thresher (thresher I)

Table 4.4 Fuel consumption results for Chinese thresher (thresher II)

Sample	Mass threshed (kg)	Fuel consumed (lit/hrs)
Sample 1	28	52
Sample 2	27	50
Sample 3	25	49
Replication	3	3
Mean	26.67	51
SD	1.53	1.41

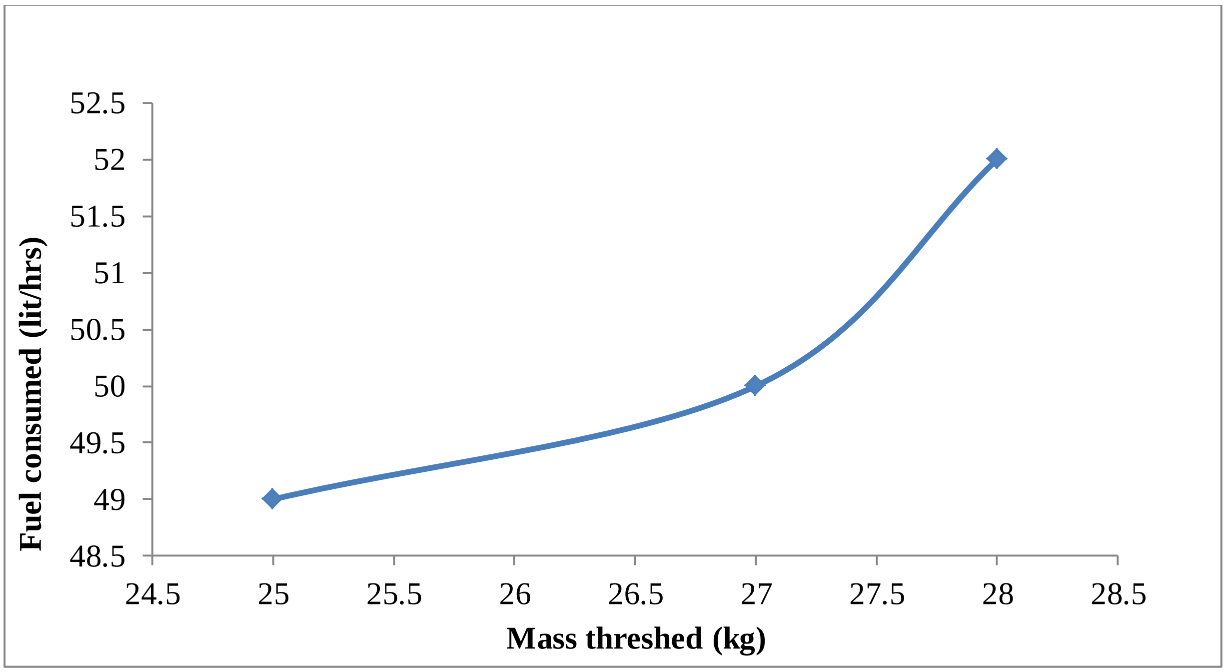

Figure 4.2. Mass threshed versus fuel consumption of Chinese thresher (thresher II)

4.3. Threshing Efficiency

Threshing efficiency evaluates the percentage of grains detached from the crop feed by the beaters of the wheat thresher. It ranges from 94.2 % to 95.5 % for Melkassa made thresher (thresher I) and from 97 % to 98 % for Chinese thresher (thresher II) when threshing was done at different levels of cylinder speed and feed rate. The efficiency of the machine was directly affected by the threshing speed of the cylinder drum. Threshing efficiency increases with increase in cylinder speed from 1180rpm to 1376rpm, after increment of the curve up to

1200rpm the curve tried to level out at higher cylinder speeds (1200rpm). This was due to the reason that the grain needed certain force to be detached from the ear head. Since the impact and rubbing forces imparted by rotating cylinder to the grain varied with speed, therefore, at a particular speed only a fraction of grains present in the ear head would be threshed and this fraction of threshed grain increased at higher speeds.

The increased in threshing efficiency due to increase in speed may be attributed to higher energy imparted by the threshing drum resulting in better threshing of the crop material in the threshing unit. However, on further increasing the threshing drum speed from 1200rpm to 1376rpm, threshing efficiency was reduced from 95.5% to 95.3%. This could be due to the reasons that at very high cylinder speed parts of the material carried away by the rotating threshing drum thus lower efficiency with improper threshing of the crop mass. At high threshing speed excessive grain breakage was also observed.

The unthreshed grain from thresher increased with increase in feed rate. This increase was due to time available for threshing reduces, due to accumulation of more crops in threshing mechanism which causes more unthreshed grain to pass through with a mixture containing grain and crop residues.

Figure 4.3 and 4.4 indicates that threshing efficiency increases with increase in speed, up to reach optimum speed and then decreased.

Table 4.5 Cylinder speed and threshing efficiency for Melkassa made thresher (thresher I)

Cylinder speed (rpm)	Threshing efficiency (%)
1376	95.3
1200	95.5
1180	94.2

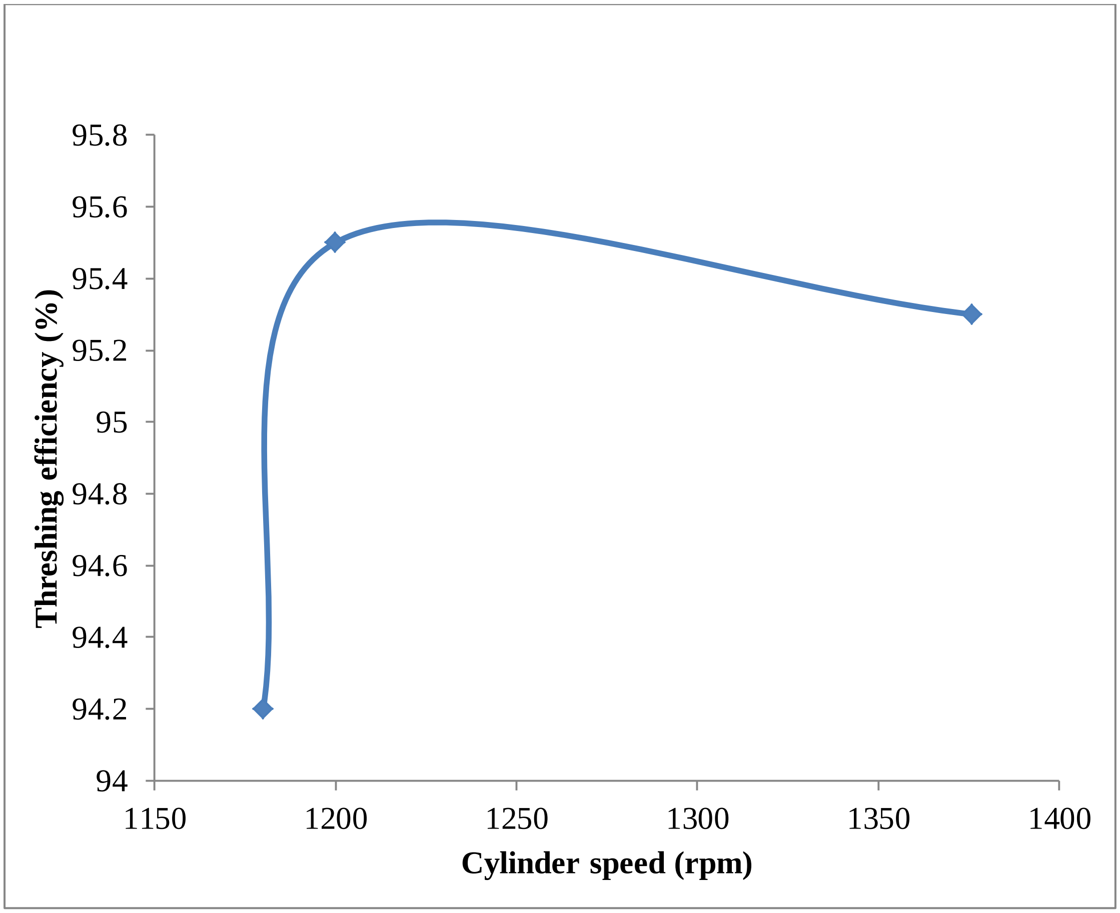

Figure 4.3. Effect of cylinder speed on threshing efficiency for Melkassa made thresher (thresher I)

Table 4.6 Cylinder speed and threshing efficiency of Chinese thresher (thresher II)

cylinder speed (rpm)	Threshing efficiency (%)
1114	97.8
1020	98
1015	97

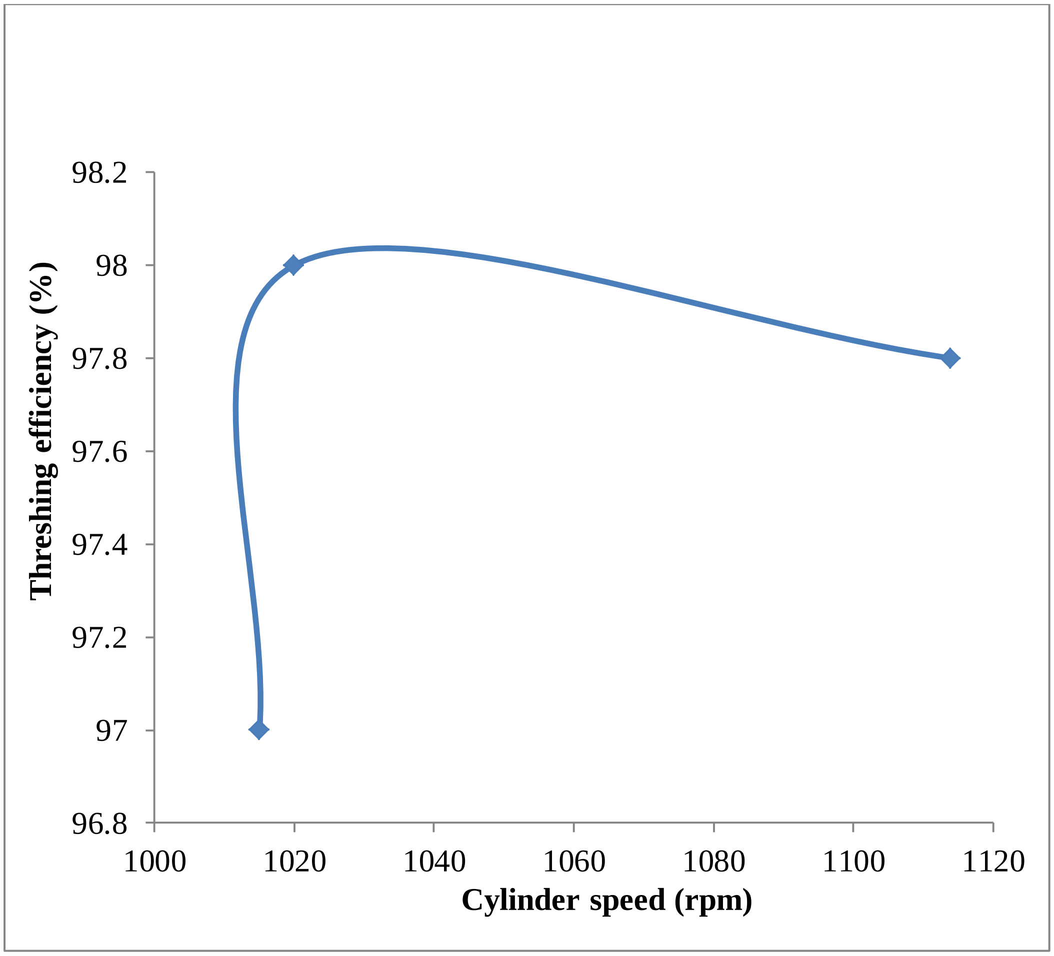

Figure 4.4. Effect of cylinder speed on threshing efficiency for Chinese thresher

(thresher II)

4.4. Relationship of Cylinder Speed with Feed Rate and Grain Output

The relationship of cylinder speed with feed rate and grain output was shown in figure 4.5 and 4.6. It was observed that the feed rate increase with the increase in cylinder speed. The average feed rate at a cylinder speed of 1180 rpm was found to be 128.75 kg/hrs whereas the grain output was 42.79 kg/hrs for Melkassa made thresher (thresher I). For Chinese thresher (thresher II) it was observed that the feed rate increase with the increase in cylinder speed. The average feed rate at a cylinder speed of 1015 rpm was found to be 300 kg/hrs whereas the grain output was 123.708 kg/hrs. The feed rate increase linearly as the cylinder speed was increased from 1180rpm to 1376rpm.

Figure 4.6 and 4.8 indicates that grain output increases with increase in speed and feed rate

Table 4.7 Cylinder speed, feed rate and grain output for Melkassa made thresher (thresher I)

Cylinder speed (rpm)	Feed rate (kg/hrs)	Grain output (kg/hrs)
1376	25	9.153
1200	24	8.558
1180	23.6	7.844

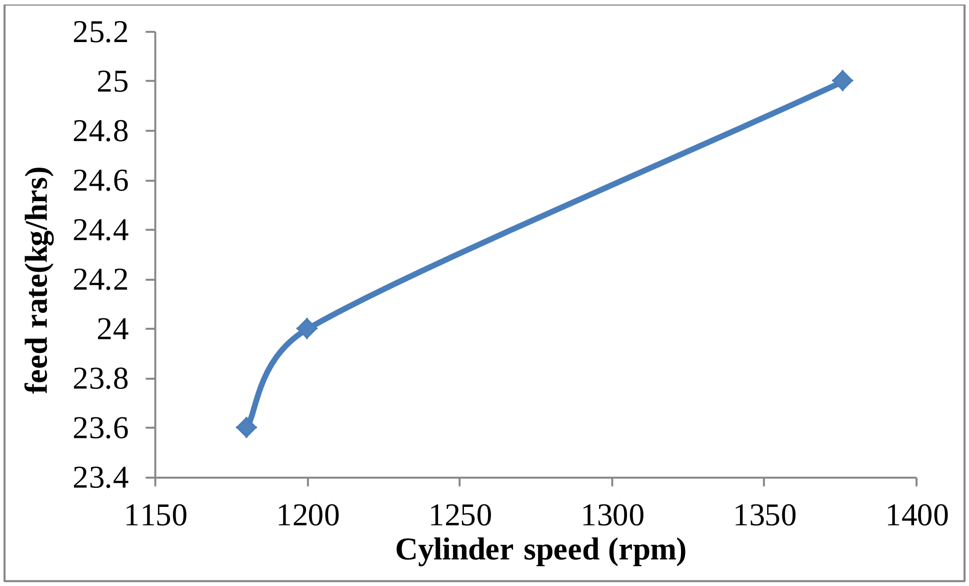

Figure 4.5. Cylinder speeds versus feed rate for Melkassa made thresher (thresher I)

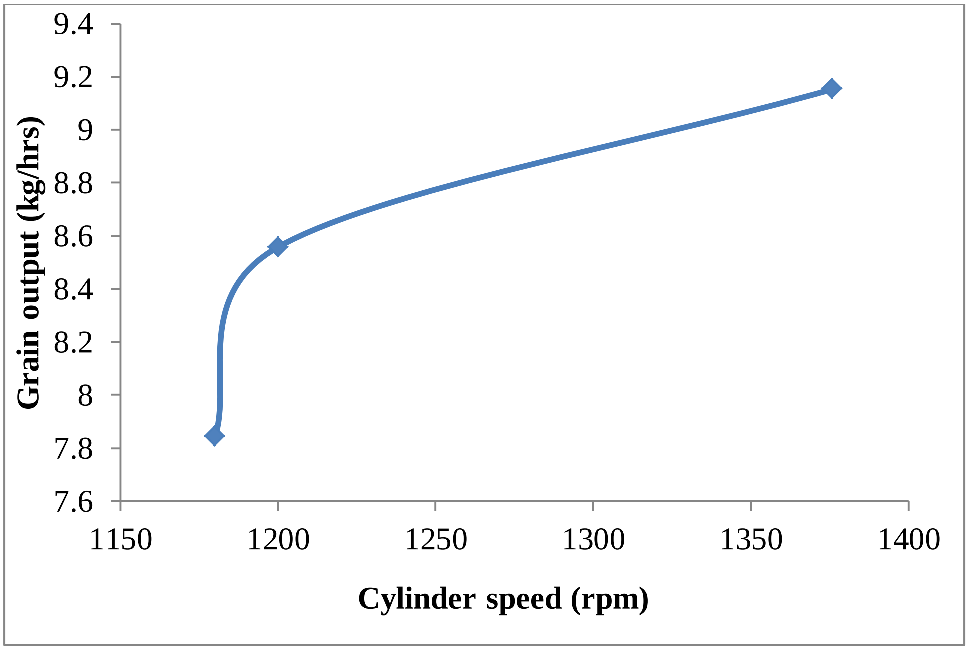

Figure 4.6. Cylinder speeds versus grain output for Melkassa made thresher (thresher I)

Table 4.8 Cylinder speed, feed rate and grain output for Chinese thresher (thresher II)

Cylinder speed (rpm)	Feed rate (kg/hrs)	Grain output (kg/hrs)
1114	28	10.659
1020	27	10.592
1015	25	10.309

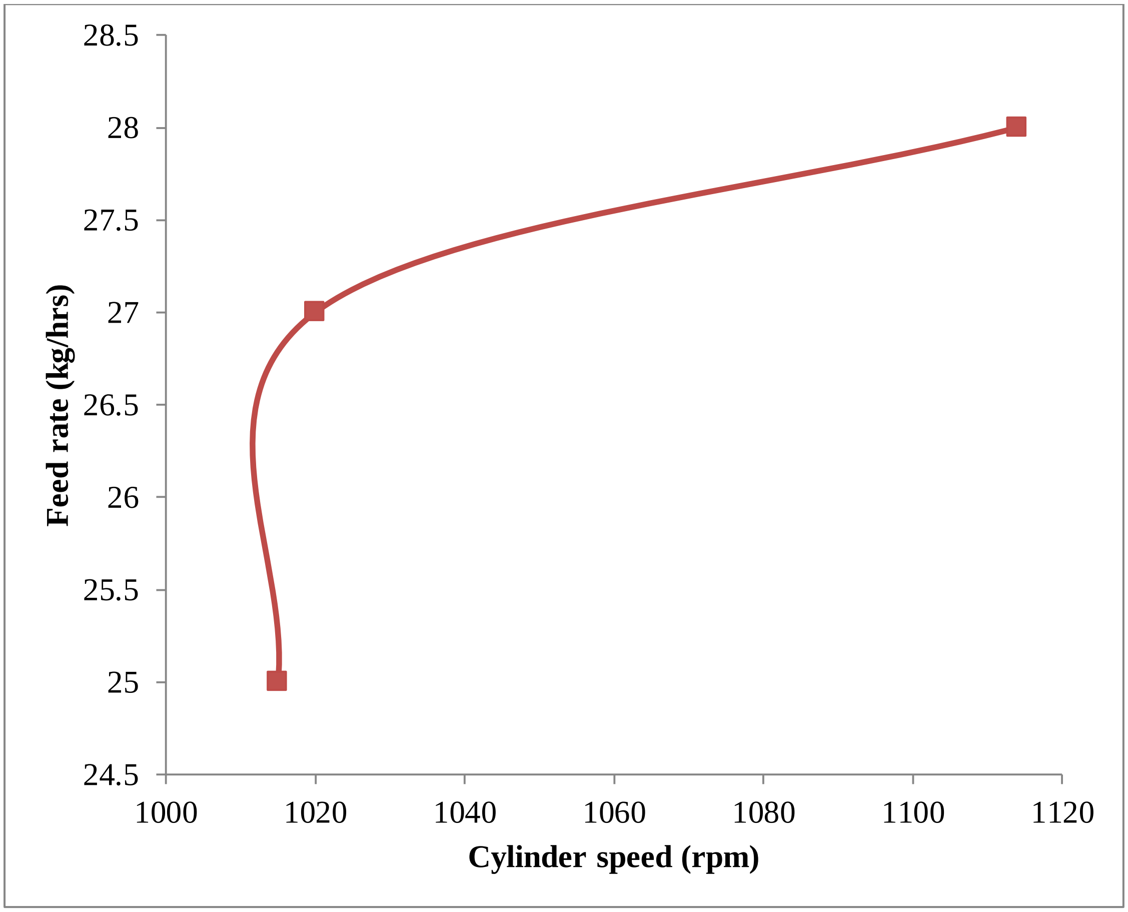

Figure 4.7. Cylinder speeds versus feed rate for Chinese thresher (thresher II)

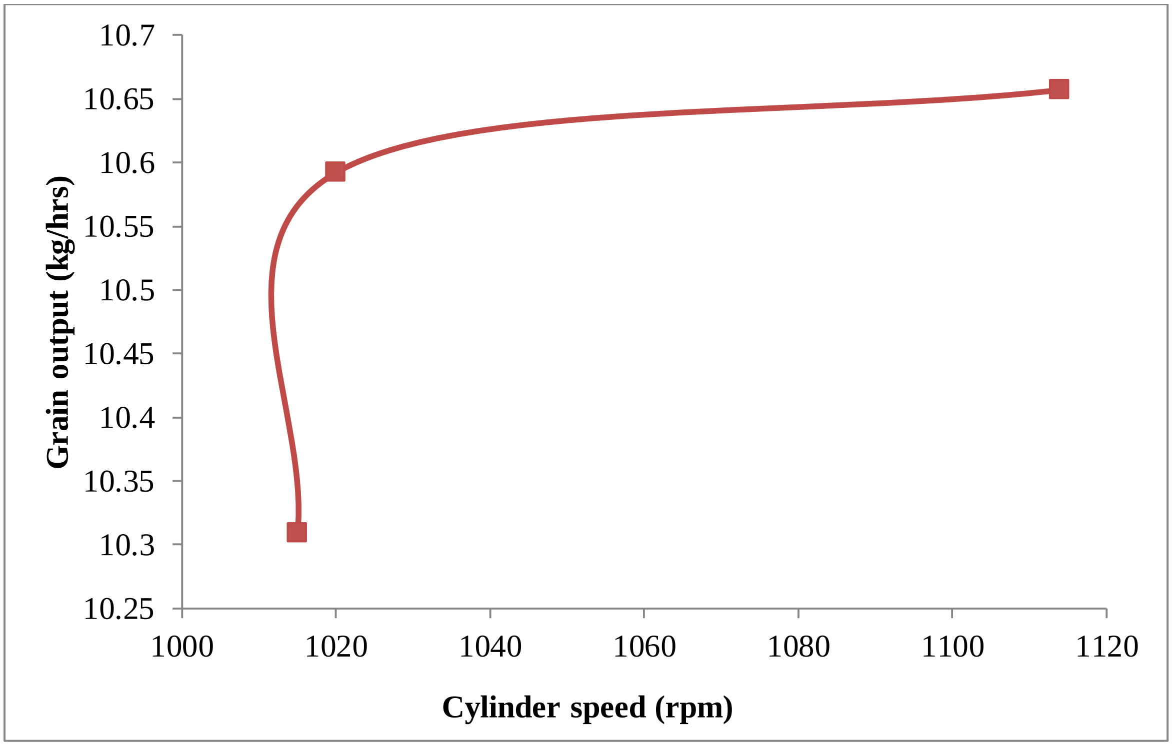

Figure 4.8. Cylinder speeds versus grain output for Chinese thresher (thresher II)

4.5. Grain Damage/Broken

Grain damage evaluates all the broken grains present within the clean grains collected at the throughput. It was as a result of direct impact between the beaters of the threshing cylinder and the crop fed. It ranges from 0.128 % to 0.140 % for Melkassa made thresher (thresher I) and from 0.093 % to 0.105 % for Chinese thresher (thresher II) when threshing was done at different levels of cylinder speed and feed rate. Grain breakage was less in Chinese thresher (thresher II) (0.093-0.105 %) as compared to Melkassa made thresher (thresher I) (0.128-0.140 %). Figure 4.9 and 4.10 shows the effect of drum speed on seed damage at different feed rates. The result indicated that the percentage of seed damage increased gradually with the increase in drum speed due to high impact. This was because as drum speed was increased, there was increased impact force on the grains to aid threshing which causes significant breakage on some of the grains. Figure 4.9 and 4.10 indicates that grain damage increases with increase in speed.

Table 4.9 Damaged/broken grain for Melkassa made thresher (thresher I)

Cylinder speed, rpm	Damaged/broken grain (%)
1376	0.140
1200	0.132
1180	0.128

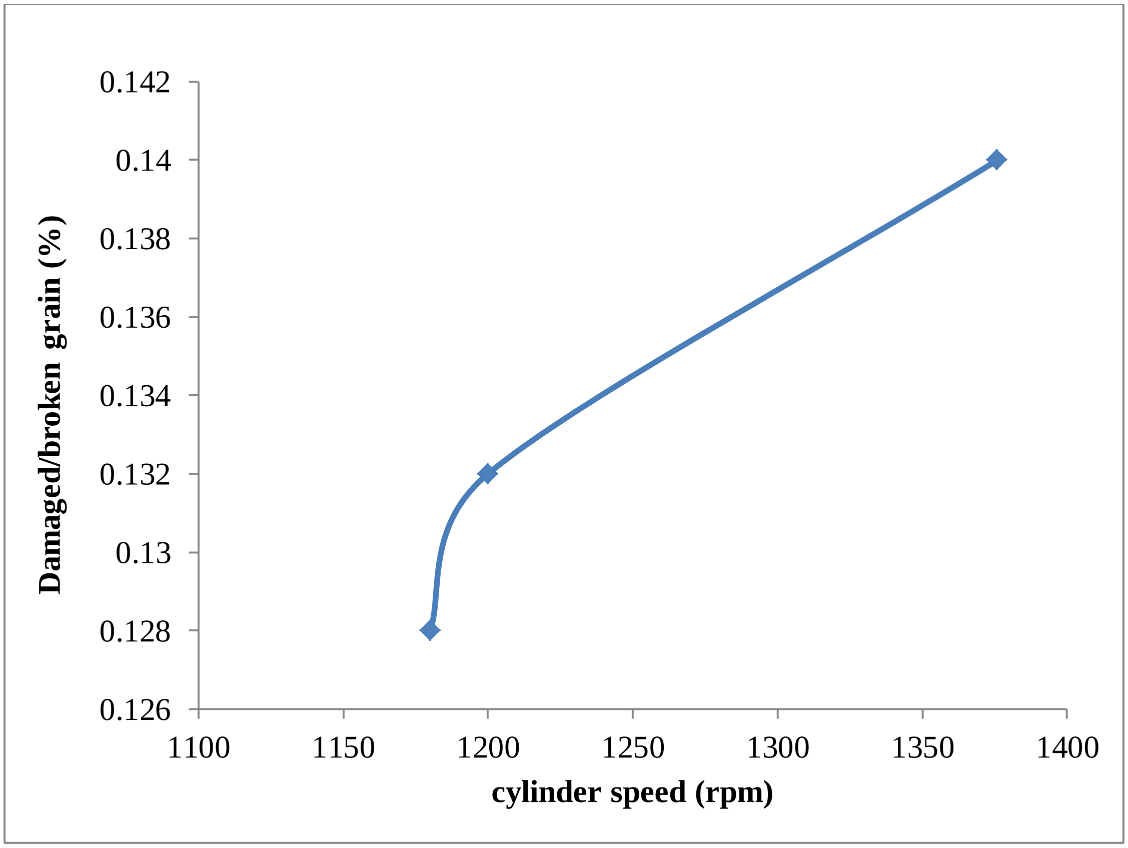

Figure 4.9. Graph of cylinder speed versus damaged/broken grain for Melkassa made thresher (thresher I)

Table 4.10 Damaged/broken grain for Chinese thresher (thresher II)

Cylinder speed, rpm	Damaged/broken grain (%)
1114	0.105
1020	0.101
1015	0.093

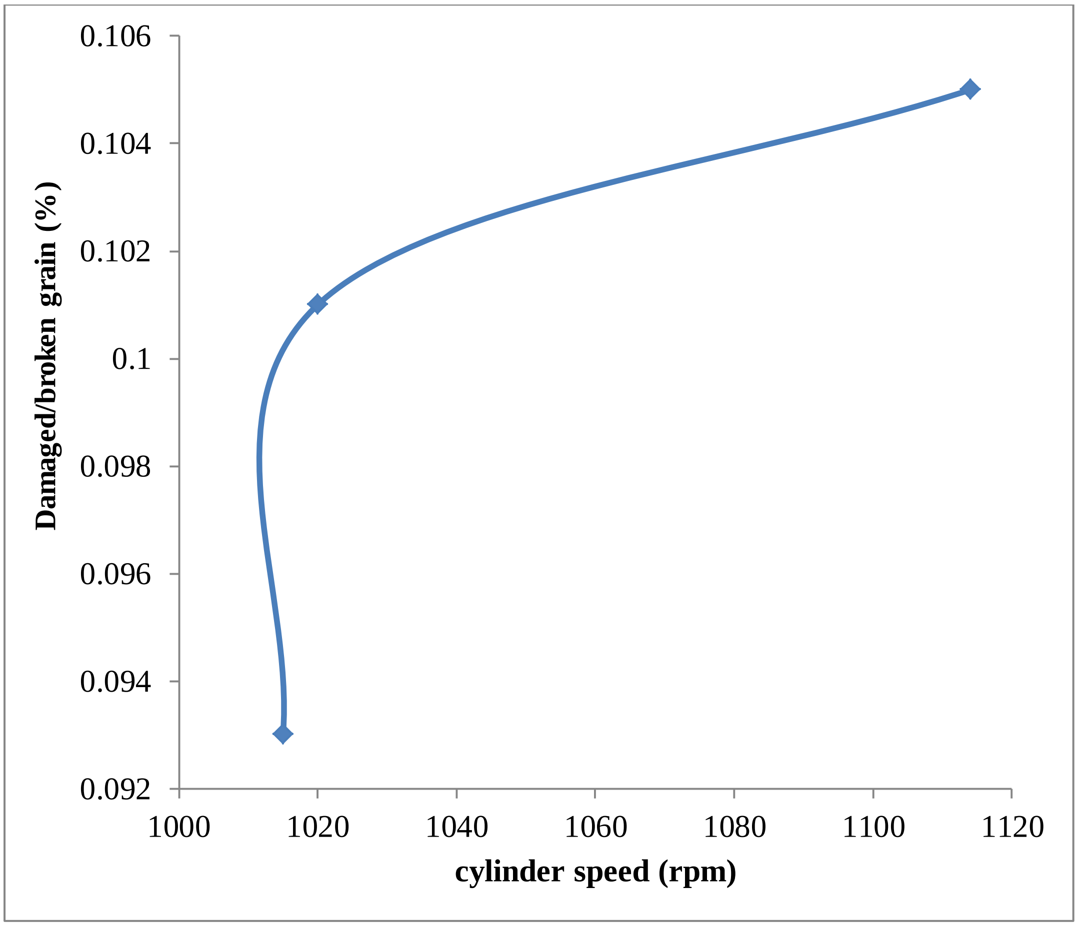

Figure 4.10 Graph of cylinder speed versus damaged/broken grain for Chinese thresher (thresher II)

4.6. Comparison between Melkassa Made Thresher (Thresher I) and Chinese Thresher (Thresher II)

Evaluation test shows that there was a significant difference between the efficiencies of the machines. The comparison between the Melkassa made thresher (thresher I) developed by Melkassa Agricultural Research Centre and Chinese thresher (thresher II) imported by Metal and Engineering Cooperation showed that threshing efficiency and output capacity are both significant. Grain loss and damage was minimum for Chinese thresher than Melkassa made thresher. The performance of Chinese thresher (thresher II) was superior to that of Melkassa made thresher (thresher I) (Table 4.11).

Table 4.11 Comparison between Melkassa made thresher (thresher I) and Chinese thresher (thresher II)

	Mean value	
	Melkassa made thresher (thresher I)	Chinese thresher (thresher II)
Threshing efficiency (%)	95	97.6
Grain damage (kg)	0.133	0.09967
Unthreshed grain (kg)	0.021	0.000333
Scatter loss (kg)	0.206	0.240
Output capacity (kg. hr^{-1})	134.393	240.243

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

5.1. Conclusion

This study compares the performance of two types of threshers for Ethiopian farmers. The production rates (quantity threshed) and quality (seed loss and mechanical damage) were analyzed for both Melkassa made thresher (thresher I) and Chinese thresher (thresher II) using actual research data. The observed advantages and disadvantages based on production rate, quality, and cost are outlined as a guide to farmers. The result of the analysis was also used to improve the performance of portable wheat thresher. Studies based on performance evaluation of these two machines to determine the capacity of threshers and quality of threshing. Cylinder speed affects threshing loss, damaged grains percent and threshing efficiency of the thresher.

The optimum cylinder speed for threshing wheat crop was found to be 1200 rpm for Melkassa made thresher (thresher I) and 1020 rpm for Chinese thresher (thresher II). The threshing efficiency was 95.5 % for Melkassa made thresher (thresher I) and 98% for Chinese thresher (thresher II) at grain straw ratio of 0.577. The efficiency of the wheat threshing machine was significantly affected by cylinder speed and feed rate.

Based on the test results it may be summarized that Chinese thresher (thresher II) was more efficient and economical than Melkassa made thresher (thresher I) for threshing wheat crop.

5.2. Recommendation

In order to solve the existing problem of locally manufactured portable wheat thresher the following recommendations are forwarded based on the study:-

1. For a portable thresher where the input is accomplished manually, the total feed rate is more difficult to control. The threshing of wheat which was usually done by manual feeding in threshers led to the reduction of threshing capacity due to half filling of threshing drum. This drawback had given rise to mechanical feeding system for wheat threshers which increased their threshing capacity.
2. A sieve should be designed for Melkassa thresher and fixed in front of air blower to enhance the cleaning efficiency of machine. And also to improve on the cleaning efficiency additional fan housing in form of a suction mechanism should be developed to remove finer particles from the threshed grains.
3. There can be viable enterprises manufacturing and selling the portable wheat thresher after it has been continuously refined and scaled-up as a marketable product.
4. The size of the hopper should be increased to accommodate more materials at a time so as to improve the feeding rate for the Melkassa thresher.

REFERENCE

Agha, (2004). Grain Losses of Wheat as Affected by Threshing Timings. Agril. Biol. J., 6(3):6.

Agidi,G.,Ibrahim,M.G.and Matthew S.A. (2013). Design, Fabrication and Testing of a Millet Thresher. Net Journal of Agricultural Science vol. 1(4), pp. 100-106, October 2013. 2315-2319.

Ajayi, O. A. (1991). Design of Threshing for Locust Bean, AMA. 22(3):21-24.

Anwar, M.T and G. P.Gopta. (1990).Performance Evaluation of Chick-Pea Thresher in Pakistan. A.M.A. Vol. 21 (5): 23-28

ASAE Standards. 2003. S352.2FEB03. Moisture Measurement Unground Grain and Seeds. St Joseph, Michigan. ASAE.

Chaudhry, M.A. 1979. Wheat Losses at the Threshing and Winnowing Stages. J. Agric. Mech. Asia Africa and Latin America 10:67-70

CSA (Central Statistical Agency), 2007. Agricultural Sample Survey Report on Area and Production of Crops (Private Peasant Holding, Meher Season). Statistical Bulletin, No.388, Addis Ababa, Ethiopia.

Dubale, B.2011. Management Practices and Quality of Maize Stored in Traditional Storage Containers: Gombisa and Sacks in Selected Districts of Jimma, MSc. Thesis, Haramaya University, Haramaya, Ethiopia.

Ezzatollah, A.A-A, Yousef, A-G. and Saeid, A. (2009). Study of Performance Parameters of Threshing Unit in a Single Plant Thresher. American Journal of Agricultural and Biological Sciences. 4(2): 92-96,

Gill, R.S., Singh, S., and Singh, (2002). Performance Studies on Plot Thresher for Wheat. Journal of Research, PAU, 39(3): 408-708.

Goense, D, (1995). Fundamental of Farm Mechanization System, Lecture Note, Wageningen Agricultural University, Netherlands.

Harrington,R.E. (1970).Threshing Principles Confirmed with Multi- Crop Thresher. J. Agric. Engg. India, 2: 49-61.

Hunynh, V. M; Powell, T. and Siddal, J. N. (1982).Threshing and Separating Process -A Mathematical Model, Trans. ASAE, 25 (1) S: 62-73

Hunt, D.R. (2013). Farm Power Machinery Accumulated R&M Costs to be Lower than the Actual Data Management. 10th Ed., Iowa State University for the first period of Machine Life and also Predicts Some Press. Ames. IOWA. U.S.A.

Khan, A.U. (1990). Dual Made all Crop Thresher for the Egyptian Conditions, AMA, 21: 1114.

Khater, A.E. A. (2000). Mechanization of Sunflower Threshing. MSc. Thesis. Agric. Eng.,Mansoura Univ.

Klenin N I,Popov I F, Sakun V A, (1986). Agricultural Machines. Amerind Publishing Company. Pvt. Ltd., New Delhi,

Lamp, B.J. and Buchelle, W.E. (1960). Centrifugal Threshing of Small Grain Transaction, ASAE, 3: 24-28.

Manfred, H. 1993. Harvest Index versus Grain/Straw-Ratio. Theoretical Comments and Experimental Results on the Comparison of Variation. Euphytica, 68:27-32.

Mahmoud,M.A.and M.A.Moheb, El-Sharabasy and M.A. Khattab. 2007. Development of Feeding Device in a Turkish Threshing Machine. Misr J.of Agri. Engg. 24(2):235-258.

Mazumadar, K.L. (1985). Design Development and Evaluation of CIAE Multi-Crop Thresher. ISAE, 1 (2): 100-108.

Metha, M.L. and Sharma, V.K. (1995). Studies on Threshing System of Chaff-cutter Type Thresher. Journal of Research, PAU (India), 22(4): 735741.

Mohammed J. (2009). Development of an Axial Flow Maize Dehusker Thresher. Unpublished Masters Degree Thesis Submitted to the Department of Agricultural Engineering, Ahmadu Bello University, Zaria.

Mohammad, R.A., and Alireza, B. (2013).Field Performance Evaluation of Different Rice Threshing Methods. International Journal of National and Engineering Science 3(3): 155-159, ISSN: 1307-1149, www.nobel.gen.t

OABTTA (Office of Agriculture, Biotechnology and Textile Trade Affairs). 2013. Postharvest Loss Challenges. Discussion Paper: Bureau of Economic and Business Affairs, Accessed 28/04/ 2015].

Olaoye J O. (2004). An Analytical Modeling of the Performance of Tooth Peg Grain Crop Thresher. PhD

Olaoye J O, Oni K C. 2001. Some Physical and Mechanical Properties of Selected Grain Crops. In: Proceedings of the 2nd International Conference & 23rd Annual General Meeting of the Nigerian Institution of Agricultural Engineers (A division of NSE),; 23: 315—329

Olaoye, J. O. 2011. Development of a Treadle Operated Abrasive-Cylinder for Threshing Cowpea. International Journal of Engineering Science and Technology, 3(12): 8548-8557.

Olayanja, T.M.A., Adewuyi, S.A., and Omotayo, A.M. (2009). An Assessment of the Status of Small Rice Thresher in Nigeria.

Osueke.C.O. (2011). "Simulation and Optimization Modeling of Performance of a Cereal Thresher," International Journal of Engineering & Technology, vol. 11, pp. 143-152.

Ouezou, Y.A., Makennibe, P. and Koji Y. (2009). Design of Throw-in Type Rice Thresher for Small Scale Farmers. Indian Journal of Science and Technology. Vol.2. 0974-6846

Ramatoulaye, G. (2010). Post Harvest Losses of Rice (Oriza Spp) From Harvesting to Milling: A Case Study In Besease and Nobewam in the Ejisu Juabeng District in the Ashanti Region of Ghana. M.Sc. Dissertation, Kwame Nkrumah University of Science and Technology.

Rembold, F., R. Hodges, M. Bernard, H. Knipschild and O. Léo. 2011. The African Postharvest Losses Information System (APHLIS): An Innovative Framework to Analyze and Compute Quantitative Postharvest Losses for Cereals Under Different Farming and Environmental Conditions in East and Southern Africa, JRC Scientific and Technical Reports No. 62618, Publications office of European Union, Luxembourg.

Rick, H. and Tanya, S. 2012. How to Get High Quality Grain on Farm. Training Manual for Improving Grain Postharvest Handling and Storage. Food and Markets Department, Natural Resources Institute, UK.

Rupert Simon, and Tareke Berhe. 2011. Strengthening the Grain Value Chain in Ethiopia, Ethiopia Agricultural Transformation Agency.

Saeed, A.M., Khan, A.S. and Rizvi, H.A. (1995). Testing and evaluation of hold on the paddy thresher. AMA, 26 (2): 47-51.

Salokhe, V.M. and Vejasit, A. (2004). Studies on Machine –Crop Parameters of an Axial Flow Thresher for Threshing Soybean. Agriculture Engineering International: The GIGR J. of Scientific Research and Development, 4(4):23-30.

Sexana, J.B., B.S, Sirohi, and A.K. Sharma, 1971.Power Requirements of Ludhiana Type Threshers. J. Agric. Engg. 8:35-43.

Sharma, K.D.and R.SA.Devananl (1980).Threshing Studies on Soybean and Cowpea A, M.A.33 (2)65-68.

Sharma, V.K., Ahuja, S.S, Sandhar, N.S., Garg, I.K. and Dhaliwal, I.S. (1984). Design, Development and Evaluation of PAU Wheat Cum Paddy Thresher. Journal of Agric. Engg., 21(3): 15-23.

Sharma. V. K. (1983). Studied on Design Development and Evaluation of Multi-crop Thresher. J..Agril.Engg. 3(20):16-26

Singh, M.P. and S. Bachchan, 1992, Performance Evaluation of a Pigeon Pea Thresher. Proceedings of International Agri. Engg. Conference, Bangkok, Thailand, pp.403-409.

Tamiru, D., and Teka, T. (2015). Evaluating and Selecting of Existing Machines for Rice Threshing. Journal Multidisciplinary Engineering Science and Technology (JMEST) ISSN: 3159-0040, vol.2 Issue 7, July-2015.

APPENDIX

Appendix-1 Data Record Sheet for both Thresher Machine

Sample for moisture content

Sample	Weight of wet grain(w1),kg	Weight of dry grain(w2),kg	$MC(\%) = \frac{w1-w2}{w1} \times 100$
Sample 1	0.1	0.090	10
Sample 2	0.1	0.091	9
Sample 3	0.1	0.091	9
Average			9.333

Sample for grain straw ratio

Total weight of sample, kg	Weight of grain, kg	Weight of straw, kg	Grain straw ratio
25	9.153	15.847	0.577

Appendix-2 Data Record Sheet for Melkassa Made Thresher Machine (Thresher I)

Before testing

Amount of crop ready for threshing, 72.6kg

Max. Length of crop, 68cm min. length of crop, 51cm

Average length of harvested crop, 59.5cm

No of labor required for the test, man.hr, 10

During testing

Starting and stoppage time

Sample	Starting time (min)	Stoppage time (min)	Duration of test (min)
Sample 1	2:20pm	2:28pm	11
Sample 2	2:42pm	2:58pm	8
Sample 3	3:12pm	3:23pm	16

Total amount of crop feed, kg

Sample	Total amount of crop feed, kg	Revolution of threshing drum/cylinder (rpm) without load	Revolution of threshing drum/cylinder (rpm) with load
Sample 1	24	1381	1200
Sample 2	25	1547	1376
Sample 3	23.6	1342	1180

Total amount of output, kg, damaged/broken grain, kg and scattered grain, kg

Sample	Total amount of grain input, kg	Total amount of output, kg	Scattered grain, kg	Damaged/broken grain, kg
Sample 1	24	8.558	0.198	0.132
Sample 2	25	9.153	0.215	0.140
Sample 3	23.6	7.844	0.205	0.128
Total, kg	72.6	25.555	0.618	0.400

Sample for unthreshed grain, kg

Sample	Total amount of sample taken, kg	Unthreshed grain, kg
Sample 1	0.4	0.018
Sample 2	0.5	0.016
Sample 3	0.5	0.029
Average	0.4667	0.021

Output from main outlet and chaff outlet

Output, kg	Sample 1	Sample 2	Sample 3
Output from main outlet, kg	7.523	8.743	8.143
Output from chaff outlet, kg	0.321	0.410	0.415

Fuel consumption, ml

Sample	Fuel consumption, ml	Rate of fuel consumption.ml/hrs
Sample 1	49	267
Sample 2	50	375
Sample 3	45	169

Threshing efficiency (%)

Sample	Total feed rate, kg	Cylinder speed, rpm	Threshing efficiency (%)
Sample 1	24	1200	95.5
Sample 2	25	1376	95.3
Sample 3	23.6	1180	94.2
Average	24.2	1252	95

Appendix- 3 Data Record Sheet for Chinese Thresher Machine (Thresher II)

Before testing

Amount of crop ready for threshing, 80 kg

Max. Length of crop, 75cm min. length of crop, 49cm

Average length of harvested crop, 62cm

No of labor required for the test, man.hr 8

Blower speed

Sample	Blower speed (km/s)
sample 1	0.208
sample 2	0.27
Sample 3	0.31

During the testing

Starting and stoppage time

Sample	Starting time (min)	Stoppage time (min)	Duration of test (min)
Sample 1	3:24pm	3:32pm	5
Sample 2	3:39pm	3:46pm	7
Sample 3	3:50pm	3:55pm	8

Total amount of crop feed, kg

Sample	Total amount of crop feed, kg	Revolution of threshing drum/cylinder(rpm) without load	Revolution of threshing drum/cylinder (rpm) with load
Sample 1	28	1314	1114
Sample 2	27	1226	1020
Sample 3	25	1125	1015

Total amount of output, kg, damaged/broken grain, kg and scattered grain, kg

Sample	Total amount of input, kg	Total amount of output, kg	Scattered grain, kg	Damaged/broken grain, kg
Sample 1	28	10.659	0.253	0.105
Sample 2	27	10.592	0.244	0.101
Sample 3	25	10.305	0.225	0.093
Total, kg	80	31.556	0.722	0.299

Sample for unthreshed grain, kg

Sample	Total sample taken, kg	Unthreshed grain, kg
Sample 1	0.1	0.002
Sample 2	0.2	0.005
Sample 3	0.1	0.003
Average	0.1333	0.003333

Output from main outlet and chaff outlet

Output, kg	Sample 1	Sample 2	Sample 3
Output from main outlet, kg	9.338	9.408	9.750
Output from chaff outlet, kg	0.320	0.899	0.842

Fuel consumption, ml

Sample	Fuel consumption, ml	Rate of fuel consumption.ml/hr
Sample 1	52	624
Sample 2	50	428
Sample 3	49	367

Threshing efficiency (%)

Sample	Total feed rate, kg	Cylinder speed, rpm	Threshing efficiency (%)
Sample 1	28	1114	97.8
Sample 2	27	1020	98
Sample 3	25	1015	97
Average	26.667	1049.667	97.6

Appendix-4 Capacity of Both Portable Wheat Thresher Machines (Melkassa made Thresher and Chinese Thresher)

	Quantity of wheat threshed (kg)	Time taken to threshed (min)	Cylinder speed (rpm)	Capacity of thresher (kg/hrs)
	24	11(0.1833hrs)	1200	130.93
Melkassa	25	8(0.133hrs)	1376	187.96
Made	23.6	16(0.2667hrs)	1180	88.96
Thresher				
Average	24.2	11.667(0.1944hrs)	1252	135.95
	28	5(0.0833hrs)	1114	336.13
Chinese	27	7(0.116hrs)	1020	232.75
Thresher	25	8(0.133hrs)	1015	187.96
Mean	26.667	6.667(0.111hrs)	1049.667	252.28

Appendix-5 Data recorded for Chinese thresher during testing at Assela and Holeta district

Test location		Assela			
Crop type		Wheat			
1.	Length of crop harvesred.cm	84	82	83	78
2.	Threshing drum rpm without load	1150	1200	1200	1200
	Threshed with loading.	1100	1150	1050	1050
3.	Moisture content (%)	11	11	11	11
4.	Grain /straw ratio.	1:0.83	1:0.89	1:11	1.0.96
5.	Total amount of crop feed kg.	197	195	374	376
6.	Total amount crop feed kg.	10	15	20	284
7.	Total amount of grain collected.kg.	107.5	120.5	177	182
8.	Total threshing time min.	29	32	33	37
9.	Net threshing time min	22	24	27	31
10.	Feed rate kg/hrs	537	487	831	727
11.	Threshing efficiency, %	92.5	95.5	90	96
12.	Total fuel consumed ml.	260	246	302	326
13.	Rate of fuel consumption,ml/hrs	538	461	549	528
14.	Output capacity kg/hrs	293	257.5	393	352
15.	No of labors involved in test	6	5	4	6

Data collected during testing for Chinese thresher at Assela (2010)

Test location		Holeta		
Crop type		Wheat		
	Test No.	1	2	3
1.	Length of harvested crop,cm	86	90	87
2.	Threshing drum RPM			
	2.1 under no load condition	1200	1100	900
	2.2 In operation	1100	1000	800
3.	Moisture content(db)			
	3.1 grain (%)	5.8	1.3	4.7
	3.2 straw (%)	4.8	1.4	8.3s
4.	Grain/straw ratio	1:2.5	1:7.0	1:1.4
5.	Total amount of crop feed, kg	47	50	58
6.	Total amount of grain collected ,kg	14.7	18.5	26
7.	Time			
	7.1 total threshing time ,min	6.2	5.36	6.7
	7.2 net threshing time ,min	5.6	4.8	6
8.	Feeding rate ,kg/hrs	503.5	625	580
9.	Efficiency,%			
	Threshing efficiency	97	98	97.5
10.	Output capacity , kg/hrs(wb)	157.5	231.2	260
11.	Labor			
	Number of labors involved in the test	4	4	4
12.	Fuel consumed , ml	6.4	8.8	14.6
13.	Rate of fuel consumption during whole testing period , ml/hrs	140	190.5	222
14.	Net fuel consumption/on load/, ml	5	7	12

Data collected during testing of thresher II at Holeta (2010)

Appendix -6 Data Sheet For Calculation of Cost of Both Machines (Melkassa made Thresher and Chinese Thresher)

The following assumptions were made for calculating the cost operation of the thresher.

I. Calculation of cost of operation for Melkassa made thresher per hour

Cost items	Melkassa made Thresher (thresher I)
Cost of thresher (P),ETB	45000
Life of portable thresher (L),years	10
Annual working hours (H),h	300
Salvage values (S)	10% of capital cost
Interest rate (i)	10%percent per annum
Fuel cost	1litre=16ETBirr
Wage per day of 8hr	80 ETBirr

Fixed cost

Depreciation (Ds**),** ETB/hrs

$$\mathrm{Ds} = \frac{\mathrm{P-S}}{\mathrm{L \times H}}$$

$$Ds = \frac{45000EB - 4500EB}{10year \times 300hr/year}$$

$$= \underline{13.5\ \mathrm{ETB/hrs}}$$

Interest (I)

$$\mathrm{I} = \frac{\mathrm{i(P+S)}}{\mathrm{2H}}$$

$$\mathrm{I} = \frac{\frac{0.1}{\mathrm{year}}}{\mathrm{300hr/year}} \times \frac{\mathrm{45000EB+4500EB}}{2}$$

I=<u>8.25 ETB/hrs</u>

Taxes and Housing (TH) TH= 2% of the initial cost of the machine per year

$$\mathrm{TH} = 0.02 \times 45000\mathrm{ETB} \times 1/300/\mathrm{hrs}$$

$$\mathrm{TH} = 3\ \mathrm{ETB/hrs}$$

Insurance (I) I=0.05% of the initial cost of the machine per year

$$\mathrm{I} = 0.0005 \times 45000\mathrm{ETB} \times 1/300/\mathrm{hrs}$$

I=<u>0.075ETB/hrs</u>

Total fixed cost (TFC), ETB/hrs TFC=13.5 ETB/hrs +8.25 ETB/hr$s$ +3ETB/hr$s$ + $0.075\mathrm{ETB/hrs}$

TFC=<u>24.825ETB/hrs</u>

Variable cost

Fuel cost (FC), ETB/hrs FC=1litre per hour=16 ETB/hrs

Lubrication cost (LC) LC=5% of fuel cost

LC = 0.05× 16 ETB /hrs

LC=0.8 ETB/hrs

Repair and maintenance cost, (RMC) RMC=5%initial machine cost

RMC=5%$\times$ 45000×0.00333

RPM=0.74925 ETB/hrs

Wages of the operator, ETB/hrs 10 ETB/hrs

Total variable cost per hour 16 ETB/hrs +0.8 ETB/hrs +10 ETB/hrs +0.74925 ETB/hrs

TVC=<u>27.549 ETB/hrs</u>

Total cost (TC) =Fixed cost (TFC) + Variable cost (TVC)

TC= 27.549 ETB/hrs + 24.825ETB/hrs

TC =<u>52.374 ETB/hrs</u>

II. Calculation of cost of operation for Chinese thresher (thresher II) per hour

Cost items	Chinese Thresher (thresher II)
Cost of thresher (P),ETB	50000
Life of portable thresher (L),years	10
Annual working hours (H),h	300
Salvage values (S)	10% of capital cost
Interest rate (i)	10%percent per annum
Fuel cost	1litre=16 ETBirr
Wage per day of 8hr	80 ETBirr

Fixed cost

Depreciation (Ds**),** ETB/hrs

$$\mathrm{Ds} = \frac{\mathrm{P-S}}{\mathrm{L \times H}}$$

$$Ds = \frac{50000EB - 5000EB}{10year \times 300hr/year}$$

$$= \underline{15 \text{ ETB/hrs}}$$

Interest (I)

$$\mathrm{I} = \frac{\mathrm{i(P+S)}}{2\mathrm{H}}$$

$$\mathrm{I} = \frac{\frac{0.1}{\mathrm{year}}}{300\mathrm{hr/year}} \times \frac{50000\mathrm{EB}+5000\mathrm{EB}}{2}$$

I=<u>9.1575 ETB/hrs</u>

Taxes and Housing (TH) TH= 2% of the initial cost of the machine per year

$$\mathrm{TH} = 0.02 \times 50000\mathrm{ETB} \times 1/300/\mathrm{hrs}$$

$$\mathrm{TH} = 3.333 \text{ ETB/hrs}$$

Insurance (I) I=0.05% of the initial cost of the machine per year

$$I = 0.0005 \times 50000\text{ETB} \times 1/300/\text{hrs}$$

I=<u>0.0833 ETB/hrs</u>

Total fixed cost (TFC), ETB/hrs TFC=15 ETB/hrs +9.1575 ETB/hrs + 3.333 ETB/hrs +0.0833 ETB/hrs

TFC=<u>27.5738 ETB/hrs</u>

Variable cost

Fuel cost (FC), ETB/hrs FC=1litre per hour=16 ETB/hrs

Lubrication cost (LC) LC=5% of fuel cost

LC = 0.05× 16ETB /hrs

LC=0.8 ETB/hrs

Repair and maintenance cost, (RMC) RMC=5%initial machine cost

RMC=5%$\times$ 50000 $\times$ 0.00333

RPM=0.8325 ETB/hrs

Wages of the operator, ETB/hrs 10 ETB/hrs

Total variable cost per hours 16 ETB/hrs +0.8 ETB/hrs +10 ETB/hrs +0.8325 ETB/hrs

TVC=<u>27.6325 ETB/hrs</u>

Total cost (TC) = fixed cost (TFC) + variable cost (TVC)

TC= 27.6325 ETB/hrs + 27.5738 ETB/hrs

TC = <u>55.2063 ETB/hrs</u>

Appendix-7 Description Both of Portable Wheat Thresher used in the Test (Melkassa made Thresher (thresher I) and Chinese Thresher (thresher II)

Item	Description	
	Melkassa made Thresher (thresher I)	Chinese Thresher (thresher II)
Type of thresher	Axial flow	Tangential flow
Model	Melkassa made prototype	Chinese thresher
Type of threshing drum	Peg type	Peg type
Drum diameter (mm)	33cm	34cm
Feeding Table		
Length (mm)	94cm	80cm
Width (mm)	70cm	67cm
Height from the ground (mm)	94cm	95cm
Description of threshing elements on cylinder		
No. of rows	8	6
No. of spike in a row	7	5
Total spikes	56	30
Spike diameter (cm)	1.6cm	1.8cm
Cylinder concave clearance (cm)	2.2cm	3cm
Engine power (hp)	7hp	7hp
Feed opening	13cm	28cm

Appendix-8 Picture of Melkassa Made Thresher (thresher I) and Harvested Wheat Crop

Appendix -9 Picture of Chinese Thresher (thresher II) and Harvested Wheat Crop