**KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY**

**KUMASI**

**COLLEGE OF AGRICULTURE AND NATURAL RESOURCES**

**FACULTY OF AGRICULTURE**

**DEPARTMENT OF HORTICULTURE**

# EFFECTS OF THRESHING AND POST-THRESHING RECOVERY METHODS ON POSTHARVEST LOSSES IN TWO VARIETIES OF RICE

**BY**

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**JULY, 2015**

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**A THESIS SUBMITTED TO THE SCHOOL OF RESEARCH AND GRADUATE**

**STUDIES, KWAME NKRUMAH UNIVERSITY OF SCIENCE AND**

**TECHNOLOGY, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS**

**FOR THE AWARD OF MASTER OF PHYLOSOPHY DEGREE**

**IN**

**POSTHARVEST TECHNOLOGY**

**JULY, 2015**

**DECLERATION**

I hereby declare that, except for specific references which have been duly acknowledged, this project is the result of my own research and it has not been submitted either part or whole for any other degree elsewhere.

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# DEDICATION

This thesis is dedicated to my parents (Sanna Sanneh, Nyomo Gassama, Binta Sanneh and Yafatou Ndure). Special dedication goes to beloved wife Sarjo Sanneh, my daughters Sereh and Binta Sanneh.

I am also extending dedications to Late Dr. Musa Bojang, Dr. Babou Ousman Jobe former DGs of National Agriculture Research Institute (NARI) The Gambia. I ish to dedicate it to Ansumana Jarju acting DG of National Agricultural Research Institute (NARI) The Gambia.

**ACKNOWLEDGEMENTS**

The author wish to thank Almighty Allah for giving me the strength and wisdom to carried out this work. My profound appreciation goes to my sponsors; Coordination unit of West Africa Agricultural Productivity Programme (WAAPP) The Gambia through the management staff of the National Agriculture Research Institute (NARI) for financing my studies at the Kwame Nkrumah University Of Science and Technology in Ghana.

I wish to express my sincerest appreciation and gratitude to my supervisor Mr. Parick Kumah and Dr. Ben .K Banful for their patience and positive criticisms as a result of accomplishing the work. I am also grateful to Mr. Lamin S.M Jobe former Director of Research at National Agriculture Research Institute (NARI), Yasin Khan, Momodou Mbaye Jabang, Mama Mariama Saho, Lamin Dibba and Mary Mendy. I am expressing my indebtedness to my family members and friends in The Gambia, for their prayers and courage. A special thanks goes to all the lecturers at the Department of Horticulture. Am grateful to Mr Felis and Asanti Bismark filed workers at Nobewam rice farm, including all The Gambian students under WAAPP sponsorship.

## LIST OF ABBREVIATIONS

APHLIS- Africa Postharvest Losses Information System.

CCSE- Canadian Center Of Science And Education.

CORAF/WECARD- Consel Ouest et Center African Pour La Recherche et le Development Agricoles/West And Central African Council for Agricultural Research and Development.

CSIR-CRI- Council for Scientific and Industrial Research /Crop Research Institute.

FAO- Food and Agricultural Organization.

FARA- Forum for Agricultural Research in Africa.

IGNOU-Indian Gandhi National Open University.

IJB- International Journal of Biosciences.

IJRD- International Journal for Rural Development.

IRRI- International Rice Research Institute.

MC- Moisture Content.

MCDB- Moisture Content Dry Basis.

MCWB- Moisture Content West Basis.

NASS- National Agricultural Sample Survey.

R4D- Research for Development.

SRI- System of Rice Intensification

SSA- Sub Saharan Africa.

PHL- Postharvest Losses.

WARDA- West Africa Rice Development Agency.

WOM- Word of Mouth.

# ABSTRACT

Rice is the most important cereal crop for human consumption. Over three (3) billion people are depending on rice as a staple food. The consumption of rice in Africa is far more than its production level on the continent, several hundred million people are depending on rice cultivation and post-harvest activities as their main source of employment particularly in the rural areas. In the developing countries, significant volumes of grain are lost after harvest, aggravating hunger and resulting in expensive inputs-such as fertilizer, irrigation water, and human labor-being wasted and therefore postharvest system for rice deserves special attention, where the implementation of postharvest technologies is urgent in order to prevent food rice losses. The main objective of the research was to determined the influence of various processing methods on postharvest losses in two varieties of rice at Nobewam lowland irrigated rice field in the Ashanti Region of Ghana. The design of the experiment was 2 x 3 x 3 factorial arrangement in randomized complete block design with three replications. The factors were variety at two levels : Jasmine 85 and Sikamo; threshing methods at three levels: Bambam, Drum, Sack and post-threshing recoveries at three levels Pounding, Pounding plus hand-picking and straight had-picking. The result indicated that, Jasmine 85 recorded the highest threshing losses from the various threshing methods and recoveries employed. Sikamo recorded the least losses. Between the threshing methods + recoveries employed, the Drum-based methods, resulted in the highest losses whereas the least losses were obtained from the Sack-based methods. Threshing of Sikamo using

the sack method took the longest time to complete threshing significantly longer than the time by the other treatment combinations. The shortest threshing time was produced by threshing Sikamo using the bambam method though not significantly different from the time spent to thresh Jasmine 85 using either bambam or drum method. Threshing Sikamo using the sack method used 2.9 times more time than threshing Sikamo using the bambam method. Among the varieties, the time spent on threshing Jasmine 85 was 32 % significantly less than that spent on threshing Sikamo. In terms of the threshing methods, using the bambam took significantly less time than either the drum or sack, the differences being 32.4 % and 58.4%, respectively. In addition, for the post-threshing recoveries, large quantity of grains were recovered from pounding + hand-picking of Sikamo and small quantity was resulted from the straight hand-picking of Jasmine while the methods, the Drum recorded the highest recovery of grains and the lowest was from the Sack. The greatest economic benefit was accrued from the Sikamo - sack + recoveries technology. The Jasmine - bambam + recoveries technology resulted in the least economic benefit. Between the methods, there was a 13.8 % increased benefit from using the Sack-based methods as compared to the Bambam-based methods. Similarly, there was a 7.3 % increased benefit from using the Sack-based methods as compared to the Drum-based methods. Comparing the Drum-based and Bambam-based methods, there was a 6 % increased benefit of using the Drum-based methods. Among the varieties, there was no economic advantage of using one variety over the other.

**TABLE OF CONTENTS**

TITLE PAGE....................................................................................................i

DECLARATION ............................................................ **Error! Bookmark not defined.**

DEDICATION........................................................................................................ 4

ACKNOWLEDGEMENTS ................................................................................... 5

LIST OF ABBREVIATION ....................................................................................v

ABSTRACT..........................................................................................................vi

TABLE OF CONTENTS......................................................................................vii

LIST OF TABLES...............................................................................................viii

LIST OF PLATES..................................................................................................x

LIST OF APPENDICE.........................................................................................xi

1.0-INTRODUCTION..............................................................................................1

2.0-LITERATURE REVIEW...................................................................................3

2.1-Brief Description Of Rice....................................................................................3

2.2-IMPORTANCE O.F RICE IN THE WORLD.........................................................3

2.3-LEVEL OF RICE PRODUCTION AND CONSUMPTION IN SUB-



SAHARAN AFRICA ..............................................................................................4

2.4-VARIETAL DESCRIPTION OF THE TWO RICE UNDER CONSIDERATION..

.......................................................................................................................5

2.4.1-Jasmine Rice.......................................................................................5

2.4.2-Sikamo Rice.......................................................................................6

2.5-QUALITIES OF RICE...............................................................................6

2.6-PREHARVEST AND POSTHARVEST LOSSES IN RICE..................................8

2.7-POSTHARVEST MANAGEMENT PRACTICES OF RICE................................10

2.7.1-Harvesting.......................................................................................10

2.7.2-Stage Of Rice Harvesting...................................................................11

2.7.3-Threshing....................................................................................... 12

**2.7.3.** 1-Manual threshing...........................................................................13

2.7.3.2-Machine threshing...........................................................................15

2.7.3.3 Threshing losses...............................................................................16

**2.7.4.** Drying...............................................................................................17

2.7.4.1-Sun drying.......................................................................................18

**2.7.5.** Milling...............................................................................................19

2.7.5.1-Traditional method..........................................................................20



2.7.5.2-Mechanical method...........................................................................21

2.7.5.3-Milling losses...................................................................................22

2.8-PADDY CLEANING ........................................................................................23

2.9-EFFECTS OF MOISTURE CONTENT AT MILLING.........................................24

3.0- MATERIALS AND METHODS...............................................................25

3.1- DESCRIPTION OF EXPERIMENTAL SITE.........................................................25

3.2- EXPERIMENTAL DESIGN.......................................................................25

3.3-EXPERIMENTAL PROCEDURE...........................................................25

3.4-DATA COLLECTED..........................................................................................28

3.4.1-Percent Threshing Losses...........................................................................28

3.4.2 Time Of Threshing.............................................................................2.9

3.4.3 Post Threshing Recoveries

3 .4.4 Economic benefits accrued from the use of threshing and recovery methods..30

3.5.DATA ANALYSIS...........................................................................................31

4.0 RESULTS.............................................................................................3
2

4.1 Threshing Losses .................................................................................32

4.2 Time Spent On Threshing.....................................................................33

4.3 Recovery from Primary Post-threshing by Pounding..................................34

4.4 Recovery from Secondary Post-threshing by Pounding + Hand-Picking...............36

4.5 Recovery from Secondary Post-threshing by Straight Hand-Picking.....................38

4.6 Threshing Losses After First Recovery by Pounding.............................................,38



4.7 Threshing losses after Second Recovery by Pounding + Hand-Picking..................39

4.8Threshing losses after third recovery by Straight hand-picking...............................40

4.9 Economic losses of initial Threshing....................................................................41
4.10 Economic losses after (pounding)...........................................................................42
4.11 Economic losses after (Pounding and Hand-Picking)..........................................43
4.12 Economic losses after Alternative recovery (Straight Hand-picking)...................44
4.13 Total threshing losses from varieties and threshing + recovery methods.............45
4.14 Economic Benefits of varieties and total threshing methods............................46
4.15 :Milling yield of different rice varieties at moisture content of 12.6%..............48
5.0 DISCUSSIONS...........................................................................................49
5.1 Threshing losses as influenced by varieties and initial threshing methods..........49
5.2 Threshing losses from different post-threshing recovery methods......................50
5.3 Time and labor implications of threshing and recovery methods..........................51
5.4 Grain recoveries from post-threshing methods....................................................52
5.5 Economic losses from initial and post-threshing recoveries..................................52
5.6 Economic benefits from varieties and threshing methods....................................52
6.0-CONCLUSIONS AND RECOMMENDATIONS.............................................53
6.1-CONCLUSIONS..........................................................................................54
6.2-RECOMMENDATIONS...............................................................................54

**LIST OF TABLES**

Table 4.1: Effects of varieties and threshing methods on the percentage of initial threshing losses of rice....................................................................................................33

Table 4.2: Effects of varieties and threshing methods on the time spent on threshing of rice.............................................................................................................................34

Table 4.3. Effect of varieties and threshing methods on the post-threshing recovery by pounding......................................................................................................................35

Table 4.4: Effect of varieties and threshing methods on the recovery from secondary post-threshing by pounding and hand-picking..............................................................36

Table 4.5. Effects of varieties on the post-threshing Recovery by straight hand-picking ......................................................................................................................................37

Table 4.6 Effects of threshing methods on the post-threshing Recovery by straight hand-picking..........................................................................................................................38

Table 4.7: Effects of variety and threshing methods on the percentage of threshing losses after pounding as first recovery...................................................................39

Table 4.8. Percentage of threshing losses after pounding + hand-picking as second recovery.........................................................................................................................40

Table 4.9: Percentage of threshing losses after Straight Hand-Picking...........................41

Table 4.10: Economic losses of initial threshing of two rice variety...............................42

Table 4.11 :Economic losses after first post-threshing recovery (pounding)..................43

Table 4.12-Economic losses after Second Post-threshing Recovery (Pounding and Hand-picking)......................................................................................................................44

Table 4.13 -Economic losses after Post-threshing Recovery (Straight Hand-picking)....45

Table 4.14-Total losses encountered from varieties and initial threshing + recovery methods.....................................................................................................................46

Table 4.15-Economic benefits from using varieties and various threshing and recovery methods.....................................................................................................................47

Table 4.16 -Milling yield of different rice varieties at moisture content of 12.6.............48





**LIST OF PLATES**

| **Plate** | **page** |
|---|---|
| 3-1 Bambam threshing method (wooden Box) | 28 |
| 3-2 Drum threshing method | 29 |
| 3-3 Sack threshing method | 29 |
| 3-4 Post threshing recovery ( Straight Hand-Picking) | 31 |
| 3-5 Post threshing recovery (Pounding) | 32 |

**LIST OF APPENDICE**

1. Appendix A: Analysis of Variance (ANOVA) Table

2. Total cost of preharvest production for two varieties of rice

3. Total  cost of postharvest production for two varieties of rice

# CHAPTER ONE

## 1.0 INTRODUCTION

Oryza glaberrima known as African rice is believed to have originated from the Delta of River Niger, where the main centre of diversification was found to be in the swampy basin of the Upper Niger River in West Africa, probably around 1,500 BC (CCSE, 2012**).** Rice is the second widely cultivated crop and also considered as the most important cereal crop for human consumption which is more than half of the world's population, almost more than three billion people, are dependent on rice as a staple food (IJB, 2013). In developing countries, several hundred million people are dependent on its cultivation and postharvest activities as their main sources of employment particularly in the rural areas. More than four-fifths of the world's rice is produced by small-scale farmers and consumed locally (FAO, 2004). However, rice consumption in Africa is far more than its production level. Consequently, importation of rice has grown extensively at an average annual rate of 6.3% per annum from 4.15 million tons in 2000 to 6.12 million tons in 2007 with the share of imported rice relative to total consumption standing at about 34% (FARA, 2009). In Ghana, rice is considered a major staple food due to the increasing per capita consumption which in 2011 to 2012, was estimated at 25.83 kg. This high consumption rate resulted in an increased importation from 320,000 metric tons in 2010/2011 to 330,000 metric ton in 2011/2012, an increment of 10,000 metric tons in just one year. Rondon *et al.*, (2011) attributed this disturbing trend to a continued shortfall in domestic production partly due to postharvest losses along the rice value chain. Presently, 35% of postharvest crop losses have been reported and this may be due to by inefficiency of manual threshing of rice by small scale farmers leading to poor grain quality and rejection of locally produced rice

(Africa-Rice, 2008). Badawi (2001) indicated that if efforts are made to reduce post harvest losses of rice, the world supply of rice can be increased by 30-40 % without cultivating additional hectares of land or increasing any additional expenditure on seed, fertilizer, irrigation and plant protection measure to grow the crop. Against this background, the main objective of this study was therefore to determine the influence of various processing methods on the post harvest losses of two varieties of rice.

Specifically, the objectives were to determine:

1. the effects of three different threshing methods on postharvest losses in (two improved) varieties of rice;

2. to determine how some post-threshing recoveries could reduce postharvest losses in the two varieties of rice; and

3. to estimate the economic benefits resulting from the postharvest losses in the two varieties of rice.

# CHAPTER TWO

## 2.0 LITERATURE REVIEW

## 2.1 BRIEF DESCRIPTION OF RICE

Rice belongs to the family *Graminae*. After maize, it is the most important cereal grain because of the annual expansion of production level. In many part of the world rice is widely consumed as a staple food, especially in Asia and Africa. Usually the plant is cultivated as an annual crop, however it can be grown as a perennial in tropical areas and can produce a ratoon crop for up to 30 years. Depending on the variety and its related soil fertility, the rice plant can reach a height up to 1–1.8 m (3.3–5.9 ft) tall. The crop is capable of producing small wind-pollinated flowers are produced in a branched arching to pendulous inflorescence 30–50 cm long. The edible seed is a grain (caryopsis) 5– 12 mm long and 2–3 mm thick (Anon, 2014).

## 2.2 IMPORTANCE OF RICE IN THE WORLD

Because of the higher consumption rate, Africa is now performing an important role in international rice markets, an estimation of 32% of total imports, at a figure recorded l of 9 million tonnes in 2006. It has become the most rapidly fast growing food source for the fact that during the last ten years, the continent served as the main rice importer due to its low production (Africa-Rice, 2008). Rice is a good source of thiamine, riboflavin and niacin. Significant amount of dietary fibre happen to be found in an unmilled rice. For the profile of rice, glutamic and aspartic acid contain higher amount of amino acid, while lysine is the limiting amino acid (FAO, 2004).

The universal human per capita energy of rice supplies 21% and 15% of per capita protein. Among cereals, the total protein of rice indicated high in nutritional quality and its content is modest. Apart from the carbohydrates which is been reduced by milling, rice is capable of providing the following elements (minerals, vitamins, and fiber), although all constituents. Rice eaters and growers constitute the bulk of the world's poor because approximately 70-90% d’s 1 3 s s s d 2009).



**2.3 LEVEL OF RICE PRODUCTION AND CONSUMPTION IN SUB-SAHARAN AFRICA**

Africa-Rice (2007), stated that in 2006, an estimation of 14.2 million tonnes paddy rice was produced in the continent. Its production grew at 3.23% per annum from 1961 to 2005, indicating that the growth rate was higher than the annual population growth rate of 2.90% during the same period. However, the development of rice production strategy increased up with an average yearly growth rate of 5.81% between 2001-2005 The average volume of milled rice produced in Sub-Saharan Africa over the past five years (2001-2005) was 8.1 million tonnes in each year. West and Eastern Africa are the main rice producing sub-regions in Sub-Saharan accounting for about 95% of the total rice produced whilst Southern Africa sub-region had the highest rate of production expansion since the 1990s.

Coincidentally, rice consumption continues to rise steadily, with the fastest growth in Sub-Saharan Africa. Africa as whole, annual per capita rice consumption increased from 11 kilograms in the 1970s to 21 kilograms in 2009 (Diange *et al*, 2013).. Between 1961 and 2005 the annual increase in rice consumption was 4.52% in Sub-Saharan Africa mostly faster than rice production growth during the same period. In 2006, the total quantity of milled rice consumed in Sub- Saharan Africa was 14.7 million tonnes. During 2001-2005 rice consumption in Sub- Saharan Africa grew at 5.84% per year. The positive development in rice consumption can be largely attributed to the strong demand in Southern and West Africa where the consumption grew on average 11.68% and 6.55% per year respectively, whereas the per capita consumption stood at 18kg (AfricaRice, 2007).

## 2.4 VARIETAL DESCRIPTION OF THE TWO RICE UNDER CONSIDERATION

### 2.4.1 Jasmine Rice

The variety is believed to be originated from Thailand. It is a long-grain variety of rice sometimes known as *Thai fragrant rice,* due to the fact that it has a nutty aroma and a slight *pandan*-like (*Pandanus amaryllifolius*-leaves) flavor caused by 2-Acetyl-1pyrroline. During cooking the grains usually sticky compare to other rice it is less sticky because of the lower amylopectin. Jasmine rice is harvested by cutting the long stalks as to facilitate easy threshing. It can then be stay in a hulled form and sold as brown rice or shucked and sold as white rice. The white variety type of jasmine rice is mostly accepted by the Southeast Asians. Brown jasmine rice retains the light tan outer layer on the rice grain. It has greater health benefits than white jasmine rice because it still has the bran. Brown jasmine rice has a flavor like oats and contains gamma oryzanol which can decrease cholesterol in blood vessels. Brown jasmine rice has vitamins such as vitamin A, vitamin B and beta-carotene and it contains antioxidants which support the working of nervous system and help fight cancer while white jasmine rice is white, has a jasmine aroma and, when cooked, a slightly sticky texture. The aroma is caused by the evaporation of 2-Acetyl-1-pyrroline (Anon, 2014).

### 2.4.2 Sikamo Rice

The word "Sikamo" is a local name given by Ghanaian rice breeders, meaning moneyrice. The rice variety belongs to the family of *Oryza Sativa* which is originated from Asia. It was released as a variety in 2010 by CSIR-Crops Research Institute in Ghana, after evaluating it for adaptation to the local lowland ecology. The plant height is of medium tall, with dark green erect leaves, good tillering capacity, highly resistant to blast and lodging. Sikamo can attain 50% flowering between 80-85 days and matures around 115-120 days after transplanting, with a potential yield of 8.0 t $ha^{-1}$ . The shape of the grains are long and slender with a very low panicle shattering at 3%, which makes it very difficult to thresh. Consequently, many rice farmers in Ghana have replaced it with Jasmine 85. Sikamo has a good milling capacity at 70 %, aromatic and a good cooking quality (WOM, 2014).

## 2.5 QUALITIES OF RICE

Qualities of rice can be determined by different characteristics, (physical and chemical) factors are required for a specific use by a specific user. Genetically the characteristics are equilibrium moisture content, chalkiness, shape, flow ability, size, color, , thermal conductivity and bulk density (Fitzgerald *et al.*, 2008). Reports revealed that breeding a high yielding rice variety with the best marketability for grain quality is not that easy and before the rice is consumed, it needs to be polished after threshing (Badi, 2013). Chalkiness is a trait appearance in grain mostly leading to consumers rejecting the rice. The symptom look like a opaque spot located inside of the endosperm usually varies in size and position. Depending on its location chalkiness may be referred to as white belly white core or white back within the endosperm. It almost invariably detracts from overall appearance and generally results in lower milling yields. This is because chalky grains are weak and tend to break on milling (Manful, 2010).

Rice is generally consumed as a polished grain. Nutritional components like minerals and vitamins are either absent or present at low levels in polished grains (Lucca *et al*., 2006). Averagely, the world population benefits a good portion of energy, protein, and other nutrients supplied from the rice. More than 90% of rice seeds consist of starch and protein by dry weight. The volume and property of starch and protein therefore contributed a major role in the yield and quality of rice. In eating and cooking quality, the amylose content of starch is considered as one of the determining factor, whereas the nutritional quality of rice is affected by amount of storage proteins (IFPRI, 2010).

In addition, chalkiness is one of the most important grain quality of rice that affects good milling quality and consumer acceptance of rice. Mostly the presence of chalkiness occur in grains at high temperatures during grain development, thereby leading to the rejection of hybrid rice (FAO, 2004).

## 2.6 PREHARVEST AND POSTHARVEST LOSSES IN RICE

Postharvest losses (PHL) means reduction in food quality and weight along the value chain, right from the time of harvest before reaching the final consumer or other end uses. Quantitative food loss can be defined as reduction in weight of edible grain or food available for human consumption. The quantitative loss is caused by the reduction in weight due to factors such as spillage, consumption by pest and also due to physical changes in temperature, moisture content and chemical changes. Qualitative losses, on the other hand, can occur due to incidence of insect pest, mites, rodents and birds, or from handling, physical changes or chemical changes in fat, carbohydrates and protein, and by contamination from mycotoxins, pesticide residues, insect fragments, or excreta of rodents and birds and their dead bodies. When this qualitative deterioration happens, the food is considered unfit for human consumption and is rejected, thus contributing to food loss (Jaspreet and Regmi, 2013) .

In rice, grains may be lost before harvesting, harvest and postharvest stages. Preharvest losses occur before the process of harvesting begins and may be due to insects, weeds and rusts. Harvest losses occur between the beginning and completion of harvesting, and are primarily caused by losses due to shattering. Postharvest losses occur between harvest and the moment of human consumption. They include on-farm losses, such as when grain is threshed, winnowed and dried, as well as losses along the chain during transportation, storage and processing (Santiniketan, 2013).

In the irrigated systems, rice production is usually constrained by harvest and postharvest operations, because of the larger yield that has to be handled. Reports indicated that Postharvest crop losses of up to 35% and attributed to the inefficiency of manual threshing of rice by small scale farmers. This leads to poor grain quality and rejection of locally produced rice (Africa-Rice, 2008).

In Sub- Saharan Africa, the causes of the post harvest losses are manifold and can occur at any stage between harvest and consumption yet losses can greatly be influenced by pre-harvest (production) conditions. For instance, end-of-season drought and mechanical damage to spikelets during pre-harvest are important factors contributing to aflatoxin contamination and subsequent mold growth during post harvest operations (FAO, 2011). Postharvest grain losses also result from both the scattering of grain due to poor postharvest handling  harvesting, threshing, transport) and from bio-deterioration brought about by pest organisms that include insects, moulds and fungi, rodents and, sometimes, birds. The effects of bio-deterioration are made worse by mechanical damage during handling as broken grain is much more susceptible to other types of quality decline such as pest attack. Furthermore, inadequate storage protection allows the entry of water and facilitates easy access by insects and rodents, while in large-scale bag storage, chemical browning reactions may lead to grain discoloration called

‘s u ’ IJRD 2014)

Losses after harvest in terms of quantity (weight losses) and quality usually deprive farmers of their full benefits. Weight losses typically range from 5 to 40 percent of production, averaging about 13.5 percent (APHLIS, 2013). For eastern and southern Africa the value of this weight loss amounts to about 1.6 billion US dollars (USD) per annum, or possibly about four billion USD for all of sub-Saharan Africa. This exceeds the value of total food aid received by Sub-Saharan Africa in the decade 1998–2008 and equates to the value of cereal import to (SSA) in the period 2000–2007 (APHLIS, 2013).

In addition to physical loss, inappropriate post harvest management practices, delays caused by labor shortage, outdated post harvest equipment, and low operator skills lead to losses in quality and to contamination (mycotoxins), therefore reducing the market price of milled rice by 10–30% (IRRI, 2014).

## 2.7 POSTHARVEST MANAGEMENT PRACTICES OF RICE

Post harvest management of rice include harvesting, threshing, drying, transportation, milling, winnowing and storage of the rice crop. The various methods of post harvest practices of rice vary widely from farmer to farmer and also from country to country. The levels of mechanization, from country to country also differ widely. The methods may either be manual, animal or mechanical (Djojomartono *et al.*, 1979).

### 2.7.1 Harvesting

Rice harvesting is the process of collecting the mature rice crop from the field by either using the sickle for cutting the straw or panicles using knives. It is essential to employ good harvesting methods in order to make the most high yield and reducing grain spoilage and quality deterioration (JASRI, 2012).

There are two common methods of harvesting rice; manual and mechanical. For manual harvesting, the most common manual harvester is the sickle but sometimes the cutlass is used. When the knife is used, harvesting is panicle by panicle, making harvesting more laborious and time consuming. This method is mainly used where traditional varieties with uneven maturity times are grown. When sickles and cutlasses are used in harvesting, the entire plant is cut as opposed to panicle by panicle harvesting with knives. In areas where sickle or cutlass harvesting is unavoidable farmers are encouraged to engage as much labour as possible so as to reduce the harvesting period

(CORAF/WECARD, 2011).

Mechanical harvesting may be carried out by the use of combine harvesters or reapers. The problem with the combine harvester is the high initial and maintenance costs coupled with its unavailability and lack of spare parts in most areas in West Africa Also when these are used in fields with well dried grains, many of the grains fall or are broken by the tines. Generally the use of combine harvesters are most appropriated on farms that are relatively large with good leveling and water control. The rice variety should be one that matures evenly and should not be of short variety

**(**CORAF/WECARD, 2011**).**

### 2.7.2 Stage of Rice Harvesting

The appropriate time of harvesting is very important by avoiding early or late harvest in controlling the quality of harvested paddy (Khan, 2010). For direct seeded rice harvesting is appropriate between 110-120d ys d 100−110 d ys s anted rice depending on the soil and variety growth duration. Others indicators for optimum harvesting time for rice are as follows:

- W s d 80% u u y
- T s dy s d 20-25% moisture content.
- F g s d d s

• I g s d y

In Ghana, most of the farmers determined rice harvesting when the grains are fully discolored and difficult to break by testing with their teeth. the most commonly method of harvesting rice is done with the use of sickle mainly by men cutting the rice straw from around the base of the plant in order to make threshing so easy and fast. Reaping of the harvested rice is usually done by the women (Personal communication, 2014).

### 2.7.3 Threshing

T s s ddy g s s T d‘ s g’ y means to strike or to hit, meaning the action of separating seeds from the plant body mechanically, regardless of the type of action, either by striking, tearing, stripping or done by treading (trampling) by humans or animals or with animal-drawn sleds, rollers (Abdul *et al.*, 2005). Sometimes power tillers or four-wheel tractors are used in place of such animals. It is important not to mix or contaminate the threshed paddy with soil, sand, stones. Generally, long grain rice is easier to thresh than short grain rice, though there are exceptions. Easy-to-thresh paddy varieties may facilitate threshing operation, on the other hand, grain loss can be greater than for hard-to-thresh ones and therefore in order to reduce grain loss, it is preferable to select those varieties that are hard to thresh. However, for introducing such rice varieties, there should be proper arrangement of threshing devices (Yasumasa, 2009).

#### 2.7.3.1 Manual threshing

Generally, traditional threshing of rice is done by hand: bunches of panicles are beaten against a hard element (a handy wooden 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 (Olugboji O.A, 2004).

Threshing of rice is done either manually or mechanically using a pedal or motorized thresher. Manual threshing involves hitting the panicles against a stationary object (drum, log of wood, wooden box), beating the cut crop with a stick, or running animals or a tractor over the cut panicles to remove the grain. Manual threshing is popular because of its low cost; however, quantitative and qualitative losses can be as high as 20–30% Rickman *et al.,* (2013). This is a problem especially with excessively dry or wet panicles. Manual threshing requires the rice straw to be cut long to allow the paddy to be more easily held when hitting against a drum or threshing board to remove the grain from the panicle. Conversely, mechanical threshing requires short straw to avoid gg g s d du g ’s s g y R *et al.,* 2013).

Generally two methods of threshing are commonly used; local hand threshing is the separation of the grains from the panicle by impact. This is carried out by hand holding a bunch of straw hitting by lifting up and down against an object either wooden bambam box, heavy metals sticks Easily shattered rice are thresh by hand beating methods (Zingel *et al.,* 2007).

Foot threshing, is done by using the trampling action or animals to thresh the crop. In order to perform this method efficiently, the cut straw is place on a tarpaulin and farmers exercise force on the harvest crop manually by removing the grains from the straw. Animal treading or trampling is 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 (Abdul *et al*, 2005).Threshing with hand tractor is still practiced in Myanmar. The crop is spread on compacted soil in the field or in the village. The operator steers the tractor in circles over the crop until all grains are removed from the panicles. One problem with this method is the contamination of grains with spores of fungi from the soil.

Locally at village level, farmers threshed the rice holding the crop by the sheaves and thrashes it against a slatted bamboo, wooden platform, or any other hard object such as a steel oil drum. This is the predominantly used manual threshing method in South East Asia (Lantin, 1999).

The pedal thresher or treadle thresher contains the following materials threshing like the drum, base, transmission unit and a foot crank. During pedaling, the threshing drum keeps on rotating and the rice is threshed as the panicles are held against the threshing drum, following the dropping of the small straws, chaff, and foreign matter along with the threshed grain, grains are separated by using a sieve or by winnowing (Agmarket, 2015).

#### 2.7.3.2 Machine Threshing

Africa-Rice (2008) reported that mechanical threshing in West Africa is on the increase thanks to the ASI-Thresher developed by WARDA and its partners. ASI is the most widely used rice thresher in Senegal River Valley. It is a highly successful product of the partnership owned R4D system, which is lessening the load of drudgery previously associated with threshing and improving the usable yield and marketability of rice. Threshing machines can be categorized as either feed-in type or hold-on type machines. Most threshers for paddy are of feed-in type, where the whole crop is fed through the thresher ensuring high throughput but also having a high power requirement. Hold-on threshers, in which only panicles are fed into the machine, generally have a lower capacity than feed-in threshers and are primarily used in areas where rice straw is bundled and stored for later use. Most threshers for paddy have peg-tooth threshing drums, however threshing drums fitted with wire-loops are used if power is limited or in hold-on threshers (Olugboji O.A, 2004).

#### 2.7.3.3 Threshing Losses

Guisse R. *et al*., (2011) reported that, the threshing losses depicted in significant differences after the of interaction between variety and threshing method. Nerica 2 had significantly lower losses (0.92%) after using the bag-beating method for threshing, than Nerica 1 (3.98%). However, there were no indication of significant differences after using the bambam for threshing Nerica 1 and Nerica 2. Comparing the methods, bambam method resulted in higher threshing losses (between 5.33 and 6.96%) than the bag beating method (between 0.92 and 3.98), regardless of the variety. These values are lower than the

4 to 6% threshing losses reported for South-East Asian countries. These lower values (0.92 to 3.98%) contradict the perception of the rice farmers (30%) that the highest loss occur at threshing.

In addition, Ofosu *et al.*, (1998) concluded that, threshing losses was recorded from both qualitative and quantitative. Losses was significantly higher in terms of quantitative due to the shattering of grains and grains irretrievably mixed with the soil of the threshing floor and unseparated grains still attached to the straw while the qualitative losses was mainly from the contamination of paddy with soil and stones.

Losses that occur in threshing paddy rice may vary depending on the method used. Paddy sat in the field for weeks or even months waiting to be harvested and threshed, resulting in a loss of quality and yield due to exposure to the elements and shattering (Africa-Rice, 2013). But generally the following losses occur during threshing for various reasons (Lantin, 1999) :

- In manual threshing by beating, some grains remain in the bundle panicles and a repeat threshing is required.
- Easy to thresh varieties expose to higher scattering when the bundles are lifted just before threshing.
- Grains can easily be stick in a soil with higher moisture.
- Losses can occur when care is not taking during and after threshing as birds or domestic animals may feed on the grains .

### 2.7.4 Drying

Drying is a very important postharvest technology. For better milling and storage, the grain moisture content needs to reduce to approximately 14%. Despite the length of storage, rice containing excess of moisture content will cause quality deterioration, it is recommended that drying rice should be done as quickly as possible after harvesting - ideally within 24 hours with the availability of maximum sunlight (JIRCAS, 2012). Drying and storage are related processes. Storage of incompletely dried grain with a higher than acceptable moisture content will lead to failure regardless of what storage facility is used. In addition, the longer the grain is to be stored, the lower the required grain moisture content must be needed (Thompson, 1998)

#### 2.7.4.1 Sun Drying

Sun drying is the traditional method for drying cereal crops including rice and it is still preferred in Asia and many parts of the world particularly in Sub-Saharan Africa because of its low cost compared to mechanical drying despite its several disadvantages (IGNOU, 2013). The grain needs to be turned or stirred at least once per hour, better every 30 minutes to achieve uniform moisture content. On hot days the grain temperature can rise above 50-60ºC and therefore the grain should be covered at midday to prevent over-heating (IGNOU, 2013). In Ghana, farmers also dry their rice immediately after harvesting or threshing using the sun.

Generally after threshing, the collected grains are dried on cemented concrete platforms by spreading and turning it from time to time with a rake to ensure uniform drying and mostly for a period of three to four days with the availability of maximum sunlight (Personal communication, 2014). However Yasumasa (2009), indicated that when sun drying, paddy should not be placed directly on the ground but be spread on tarpaulin, plastic sheets, clean concrete floor. (in the same manner as for threshing), so as to minimize grain loss and to avoid mixing of stones, sand. The existence of small stones in white rice is mostly derived from directly spreading paddy on earth on threshing and for sun drying. The paddy layer spread under sunshine should be thick enough (more than 5cm) so that drying would not progress too fast, specifically when solar radiation is strong. The paddy layer should be mixed from time to time with a rake. If the drying speed (the rate of moisture reduction) is too fast, either by sun or ventilated dryer, paddy grains are likely to be cracked or fissure.

Africa-Rice (2008) also reiterated that immediately after threshing, drying of grain should follow and that drying should be on concrete floors or mats and should be carried out gradually for the first few days to reduce breakage during milling. In West Africa, most of the farmers practice sun drying known as traditional method, because it is freely available and may give better than or comparable results to conventional but costly methods. Stirring and tending of the paddy and scaring of birds, chickens and sometimes livestock is usually done by women during sun drying. Men play role  in transporting the bagged paddy to and from the drying area.

However, the viability of the grain as seed can be adversely affected by untimely sun drying. Most losses in drying occur because of either poor technical performance of the technology, or improper use of the technology, resulting in fissured grain. Fissured grain results in significantly lower milling recoveries (Padua, 1999). Yellow or discoloured grains result from a non-enzymatic browning type reaction and all varieties are affected. Over-dried paddy is more susceptible to breaking during husking and whitening. Poor postharvest handling of the grain also causes grain breakage during drying period. When very dry rice is stored it can absorb moisture from the surrounding humid air which may also increase cracking or fissuring in the grain resulting in low head-rice yields. In the Sahel, milled rice often contains 10–20% head rice, 30–40% large broken grains and 30–60% small broken rice. High grain moisture content of 15-18%, caused by high humidity and early rains, result in low milling recovery of 55–60%, powdered rice and frequent break-downs in the mill. These conditions may also act as a constraint to double cropping (Rickman *et al.*, 2013).

**2.7.5 Milling**

The purpose of milling rice is to separate the unwanted materials from paddy rice to make able clean white rice kernels that are sufficiently milled, free of impurities and contain a minimum number of broken kernels. The milling yield and quality of rice is dependent on the quality of the paddy, the milling equipment used and the skill of the mill operator (Ruiten H, 1976).

The degree of milling has an influence on the milling recovery, consumers acceptance, color and cooking behavior of rice. The type of rice mill, the quality of the paddy, s s d g y d 's s u g performance. Good-quality paddy processed in a multi-stage rice mill can yield 65–70% of white rice (milling recovery) and

50–60% whole grains (head rice). The ideal grain moisture level for milling rice is 12–14% (Badi .O, 2013).

Reidy (2012), indicated that, there are several methods of milling rice including traditional and improved methods. A system of rice milling may be a simple type, twostep method, or a multistage process. In a one step milling process, husk and bran removal are done in one pass and milled or white rice is produced directly out of paddy. In a two step process, removing husk and removing bran are done separately, and brown rice is produced as an intermediate product whereas the multistage milling, rice will undergo a number of different processing steps like producing edible rice that appeals to the customer- i.e. rice that is sufficiently milled and free of husks, stones, other nongrain materials and maximize the total milled rice recovery out of paddy minimize grain breakage.

**2.7.5.1 Traditional Method**

Pestle and mortar is the widely used traditional method for milling small quantity of rice particularly at the rural level. Before the initiation of mechanical milling, hand-pounding traditional method of rice milling was practiced for several years. In fact, hand-pounding rice has got more nutritive value as compared to machine milling rice. But the handpounding method has steadily decreased because it could not compete with machine mills. The pounding results in a high percentage of broken kernels. and the final cleaning is done by winnowing and gravity separation by hand (Tangpinijkul .N, 2010).

### 2.7.7.2 Mechanical Method

A one step milling known as the steel single pass mill process where the unwanted materials are removed in one pass and white rice is milled straight from the paddy.

- s g u y s s y d, and making brown

rice ready as an intermediate product.

- T u s g y s y d us s rice through a number of different stages and machines from paddy to white rice.

The single pass rice mill is an adaptation of the "Engleberg" coffee huller. Because of norms in the villages, this particular type is a very common method for household rice milling in many low income earning communities (Toshihiko, 1990). This mill is a steel friction type mill and uses very high pressure to remove the hull and polish the grain. This has been causing lot of broken kernels, leading to low recovery of 50-55% of white rice and head rice yields of less than 30% of the total milled rice. The bad performance of the Engleberg mill has led some governments to discourage its use in many Asian countries, the Engleberg mills can no longer be licensed to operate as service or commercial mills (Tangpinijkul .N, 2010) In Ghana the traders usually take the rice to small local mills of the Engelberg huller type, which is most common, for processing. The Engelberg type rice huller removes the husk and bran from the rice grain in one operation. This type of rice huller is either imported, manufactured in Ghana by the Intermediate Technology Transfer Unit (ITTU), which is partially financed by the government, or manufactured by local artisans who follow the Engelberg design

(Berisavljevic *et al.*, 2013).

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Two stage mills are sometimes called as compact rice mills and in many countries have superseded the Engleberg mill. The two-stage mill has separate hulling and polishing processes. Rubber rollers remove the husk and the brown rice is then polished with a steel friction whitener similar to the Engleberg. These mills have a capacity of between 0.5 to 1 ton per hour paddy input and are often used for custom milling in the rural areas. The milling performance of the compact rice mill is superior to the single pass Engleberg huller with milling recoveries normally above 60% (IOSR, 2014).

Reidy (2012) reported that the multiple pass rice milling can process larger volume of grains at the same time producing higher quality and higher yields of milled rice from a grain form or rough rice. The process is ensuring the paddy free from all foreign particles before milling as well as separating the outer layer from the paddy polishing or whiting the brown rice to remove the bran layer, separating the broken grains from the whole kernels, bagging the milled rice and managing the by-products.

**2.7.5.3 Milling losses**

Too dry or too moist rice grains are more susceptible to breakage in milling machines. The quality of milled rice is low when paddy is hulled at high moisture content (IJB, 2013). Milling rice with an Engelberg mill results in very high percentage of broken rice and low milling recovery. Milling recovery can be less than 55%, which is already 10% below the expected average. This 10% loss is caused by broken rice ending up in the bran and husk (Africa-Rice, 2013).

Padua (1999) also reported that losses in the milling process are due either to inherent poor technical performance of milling machinery, or operator incompetence, resulting in poor milling yields.

## 2.8 PADDY CLEANING

This is a very vital technology and obviously essential not only on a large and medium commercial scale, but also on a small scale. It consists of splitting of unwanted material, such as weed seeds, straw, chaff, panicle stems, empty grains, inmate and damaged grains, sand, rocks, stone, dust, plastic and even metal and glass particles (Lantin, 1999). The extent of cleaning the paddy reflects to some level the care applied during harvesting, threshing and handling. In developing countries, farmers clean the paddy straight after manual threshing. First, they use hand-raking and sifting to remove straw, chaff and other large and dense materials, then winnowing .A hand- or pedal-operated blower may be used with a cleaning capacity of 250 kg/hour. Alternatively, an enginepowered fan is used and can simultaneously perform both operations: grading and cleaning. The latter is expensive but has the advantages of being faster and requiring less u y ’s (Agmarknet, 2012). Cleaned paddy demands a higher price than non-cleaned paddy - an incentive for cleaning the paddy.

In contrast, lack of cleaning often results in a higher concentration of contaminants in the milled rice. Another consideration is that stones and other hard particles shorten the life of the milling equipment. Finally, milling recovery is low when paddy is not cleaned (FAO, 2001). In the hold-on type of thresher, a major portion of the straw does not pass through the machine, and only the removal of chaff and light impurities from the grain is necessary. This requires pneumatic means and in some cases the combination of screen and air is required (Lantin, 1999).

### 2.9 Effects of Moisture Content At Milling

Moisture content (m.c) influences all aspects of paddy and rice quality, making it essential that rice be milled at the proper moisture content to obtain the highest head rice yield (Stipe *et al.*, 1971). Paddy is at its optimum milling potential at a moisture content of 14% wet weight basis. Higher moisture contents are too soft to withstand hulling pressure, which results in breakage and possible pulverization of the grain. Grain that is too dry is brittle and has greater breakage. Moisture content and drying temperature is also critical, because it determines whether small fissures and/or full cracks occur in the grain structure (IRRI, 2012). Too dry grains posses sun cracks therefore breaks during milling whereas too wet cannot withstand milling pressure and break badly during milling. Hence optimum moisture content is a prerequisite for good milling to maximum head rice recovery (Kunze, 2008).

# CHAPTER THREE

## 3.0 MATERIALS AND METHODS

### 3.1 DESCRIPTION OF EXPERIMENTAL SITE

The experiment was conducted at the lowland irrigated rice field located at Nobewam, near Konongo in the Ashanti Region of Ghana. The area lies between latitudes $6^o$ 35'

$6^{o}$ 54’ N d g ud s $1^{o}$ 4’ $1^{o}$ 23’ W T y s u d s within an elevation of 180m to 200m and the width of 160m to 1000m.

### 3.2 EXPERIMENTAL DESIGN

The design of the experiment was 2 × 3 × 3 factorial arrangement in a randomized complete block design with three replications. The factors were variety at two levels : Jasmine 85 and Sikamo; threshing methods at three levels: bambam, drum, sack and three methods of post-threshing recovery at three levels: pounding, straight hand-picking and pounding plus hand-picking.

### 3.3 EXPERIMENTAL PROCEDURE

Seeds of Jasmine 85 and Sikamo, two improved varieties of rice, were purchased from CSIR-Crops Research Institute and nursed for three weeks before transplanting. Land preparation activities were carried out prior to transplanting. At three weeks old, the seedlings were transplanted to the field on plots measuring 45 m x 16 m. All recommended agronomic practices such as fertilizer application, weed control, pest and disease control and water management were carried out until harvesting. Each variety was harvested with a sickle when the grain reached physiological maturity with moisture content of 20 - 22 %. The three threshing methods were then applied to each of the varieties (Plates 1, 2 and 3). For each threshing method, 300 kg of freshly harvested rice crop was used.

**Plate 1. BamBam threshing method (Wooden-Box)**

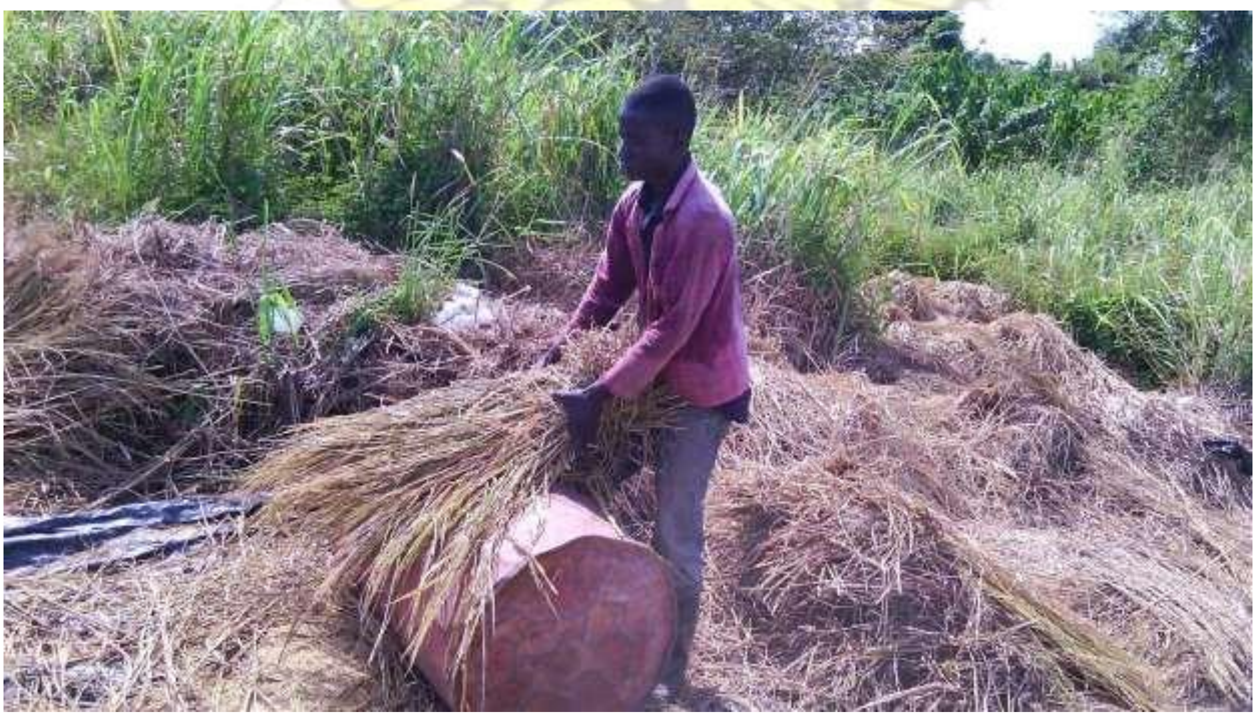

**Plate 2. Drum threshing method**

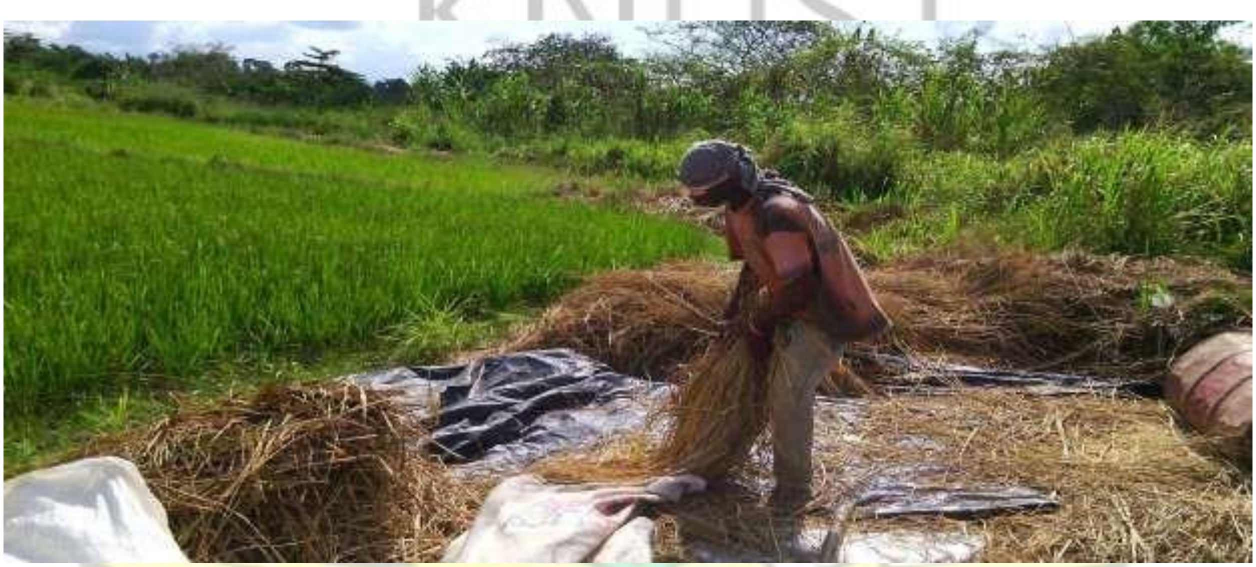

**Plate 3. Sack threshing method**

After threshing, rice grains were dried to reduce the moisture content to an acceptable level of 12-14% to avoid breakages during milling. After sweeping the ground to remove all foreign materials the grains were spread on a cement concreted platform where local brooms and a long hand rakes were used to remove the cut rice straws and leaves. The rice grains were dried for three days during which turning/stirring of the grains was done depending on sunlight intensity. The dried grains were collected, winnowed, weighed and moisture readings taken at different levels with the use of the moisture meter before milling. All the rice samples were milled with the Engleberg milling machine. The milled grains were weighed and recorded for each variety.

## 3.4 DATA COLLECTED

The data collected were recorded and entered in the excel sheet template, followed by data cleaning before the final arrangement in the factorial randomized complete block design (RCBD)

### 3.4.1 Percent threshing losses

The threshing losses were determined by using the formula ;

$$\text{Percent threshing loss} = \frac{\text{weight of the leftover}}{\text{total weight collected}} \times 100$$

### 3.4.2 Time of Threshing

This was determined by recording the time of three young men, each with a threshing method, used to thresh 300kg weight of paddy rice of each variety.

### 3.4.3 Post Threshing Recoveries

Three post-threshing recoveries; pounding, pounding plus hand-picking and straight hand-picking were used after the initial threshing methods and which had indicated significant reduction of losses. The collected grains from each post-recovery method were weighed and recorded for each variety.

**Plate 4. Post threshing recovery (Straight Hand-picking)**

**Plate 5. Post threshing recovery (Pounding)**

**3.4.4 Economic benefits accrued from the use of threshing and recovery methods** The economic benefits was determined by summing-up the total rice weight collected after threshing and grains recovery and converting to hectare basis. The monetary calculations were based on the hectare values of the grain yields obtained from the various methods employed. The labour costs of carrying out the methods were taken into account in the calculation of the final profit made for each method.

### 3.4.5 Cost-benefit analysis

Cost-benefit analysis (CBA) is a technique use for evaluating a project or investment by comparing the economic benefits with the economic costs of the activity. Below are the following formula's used for deterring the cost-benefit analysis.

- Total cost= Total preharvest cost + total postharvest cost
- Total revenue= Yield in bags of milled rice X price of one bag of milled rice
- Total profit= total revenue - total cost

## 3.5 Data Analysis

The data collected was analyzed by performing an Analysis of Variance (ANOVA) using STATISTX version 9 software. Mean comparisons based on Turkey (HSD) were carried out to determine significances at set probability levels. For field experiments, P=0.05.

CHAPTER FOUR

## 4.0 RESULTS

### 4.1 Threshing Losses

There were significant ($P<0.05$) varieties x threshing methods interactions for percentage threshing losses (Table 4.1). The highest threshing losses were obtained from the drum method for both Sikamo (15.5 %) and Jasmine 85 (13.5 %) varieties. The least threshing loss (10 %) was obtained from Sikamo variety using the sack method. The threshing loss from Jasmine 85 using the bambam method was also significantly greater than that from Sikamo using the sack method. Among the threshing methods, using the sack resulted in the lowest threshing loss (11.4 %) in comparison to the drum (14.7 %) and bambam (13.5 %) methods. Among the varieties however, the percentage threshing losses were not different for both varieties (Table 4.1).

Table 4.1: Percentage of losses using different methods of threshing rice varieties

| | VARIETIES | | |
|---|---|---|---|
| Threshing methods | JASMINE 85 | SIKAMO | Mean |
| | Percent (%) initial threshing loss | | |
| Bambam | 14.3 | 12.8 | 13.49 |
| Drum | 13.8 | 15.5 | 14.65 |
| Sack | 12.8 | 10.0 | 11.37 |
| Mean | 13.6 | 12.8 | |

HSD (0.05%): Variety = 1.29 ; Method = 1.96 ; Variety X Method = 3.49

## 4.2 Time spent on threshing

There were significant (P<0.05) varieties x threshing methods interactions for time spent on threshing (Table 4.2). Threshing of Sikamo using the sack method took the significantly longest time to complete threshing than t the other treatment combinations. The shortest threshing time was produced by threshing Sikamo using the bambam method though not significantly (P<0.05) different from the time spent to thresh Jasmine 85 using either bambam or drum method. Threshing Sikamo using the sack method took 2.9 times more time than threshing Sikamo using the bambam method. Among the varieties, the time spent on threshing Jasmine 85 was 32 % significantly less than that spent on threshing Sikamo. In terms of the threshing methods, using the bambam took significantly less time than either the drum or sack, the differences being 32.4 % and

58.4%, respectively (Table 4.2).

Table 4.2: Effects of varieties and threshing methods on the time spent on threshing of rice

| | VARIETIES | | |
|---|---|---|---|
| Threshing methods | JASMINE 85 | SIKAMO | Mean |
| | Time (mins) spent on threshing | | |
| Bambam | 79.0 | 75.0 | 77.00 |
| Drum | 95.0 | 133.0 | 114.00 |

| | | | |
|---|---|---|---|
| Sack | 150.0 | 220.0 | 185.00 |
| Mean | 108.00 | 142.67 | |

HSD (0.05% ); Variety = 9.52 ; Method = 14.36 ; Variety x Method = 25.65

## 4.3 Recovery from Primary Post-threshing by Pounding

There were significant (P<0.05) varieties x threshing methods interactions for first postthreshing recovery by pounding (Table 4.3). Pounding of Sikamo straw after using bambam method produced significantly the highest volume recovery of rice grains which was similar to the recovery from pounding of Sikamo straw using the sack method. The least recovery was obtained from pounding of Jasmine 85 straw after bambam method usage. Among the varieties, there was significantly more recovery from Sikamo than from Jasmine 85. Recovery from the threshing methods were however similar (Table 4.3).

Table 4.3. Effect of varieties and threshing methods on the post-threshing recovery by pounding

| | VARIETIES | | |
|---|---|---|---|
| Threshing methods | JASMINE 85 | SIKAMO | Mean |
| | Recovery (kg) from primary post-threshing | | |
| Bambam | 7.7 | 15.2 | 11.4 |

| | | | |
|---|---|---|---|
| Drum | 10.4 | 11.1 | 10.7 |
| Sack | 11.8 | 10.9 | 11.3 |
| Mean | 9.6 | 12.7 | |

HSD(0.05%) Method =2.04; Variety =3.08; Method x Variety =5.49

## 4.4 Recovery from Secondary Post-threshing by Pounding + Hand-Picking

There were significant (P<0.05) varieties x threshing methods interactions for postthreshing recovery by pounding + hand-picking (Table 4.4). Pounding and hand-picking of Sikamo straw after using the bambam method produced significantly the highest recovery of grains which was not different from the recovery obtained from pounding and hand-picking of Sikamo straw after sack usage. The lowest recovery was from pounding and hand-picking of Jasmine straw after bambam usage (Table 4.4).

Table 4.4: Effect of varieties and threshing methods on the recovery from secondary post-threshing by pounding and hand-picking

| | VARIETIES | | |
|---|---|---|---|
| Threshing methods | JASMINE 85 | SIKAMO | Mean |
| | Recovery (kg) from post threshing by pounding and handpicking | | |
| Bambam | 8.6 | 17.9 | 13.17 |

| | | | |
|---|---|---|---|
| Drum | 11.5 | 12.3 | 11.86 |
| Sack | 15.7 | 11.8 | 13.72 |
| Mean | 11.87 | 13.97 | |

HSD (0.05%) Variety = 3.39; Method =5.09; Method x Variety =9.10

## 4.5 Recovery from Secondary Post-threshing by Straight Hand-Picking

There were significant (P<0.05) differences between varieties for recovery from secondary post-threshing by straight handpicking. Sikamo had the highest recovery of 4.72 kg, significantly greater than that from Jasmine 85 which had the lowest recovery of 2.81kg (Table 4.5). There were also significant differences between threshing methods for post-threshing recovery by straight handpicking (Table 4.6). The drum method resulted in significantly greater recovery than from the bambam and sack methods. Among the two latter methods, there were no differences (Table 4.6).

Table 4.5. Effects of varieties on the post-threshing Recovery by straight hand-picking

| Variety | Recovery (kg) |
|---|---|
| JASMINE 85 | 8.41 |
| SIKAMO | 14.33 |
| HSD (0.05%) | 3.09 |

Table 4.6 Effects of threshing methods on the post-threshing Recovery by straight handpicking

| Threshing methods | Straight hand-picking (kg) |
|---|---|
| Bambam | 10.35 |
| Drum | 14.95 |
| Sack | 8.81 |
| HSD (0.05%) | 4.66 |

**4.6 Threshing Losses After First Recovery by Pounding**

There were significant (P<0.05) varieties x threshing methods interactions for percentage threshing losses after pounding (Table 4.7). The highest percent of threshing losses was obtained after pounding recovery from Sikamo using drum threshing (11.9%), which was significantly different from the losses obtained after pounding recovery from Sikamo using both bambam and sack threshing methods. Jasmine 85 using the bambam method (11.7%) also recorded high threshing losses after pounding recovery and was similar to that of Sikamo using the drum method. Between the varieties, Jasmine 85 produced the highest percent of threshing losses (10.39%), significantly different from the least produced by Sikamo (8.54%). Similarly, between the threshing methods, the use of the drum resulted in the highest threshing losses
(11.09%), significantly different from the sack which resulted in the least losses (7.61%).

Table 4.7: Effects of variety and threshing methods on the percentage of threshing losses after pounding as first recovery

| | VARIETIES | | |
|---|---|---|---|
| Threshing methods | JASMINE 85 | SIKAMO | Mean |
| | Percent (%) threshing losses | | |
| Bambam | 11.7 | 7.7 | 9.69 |
| Drum | 10.4 | 11.9 | 11.09 |
| Sack | 9.2 | 6.1 | 7.61 |
| Mean | 10.39 | 8.54 | |

HSD(0.05%) variety = 1.53; Method = 2.29; Method /variety = 4.11



**4.7 Threshing losses after Second Recovery by Pounding + Hand-Picking** There were significant ($P<0.05$) varieties x threshing methods interactions for percentage threshing losses after second recovery by pounding + hand-picking (Table 4.8). The highest percent of threshing losses was obtained after pounding + hand-picking recovery from Sikamo using drum threshing (11.4 %), which was significantly different from least losses obtained after pounding + hand-picking recovery from Sikamo using both bambam (6.8 %) and sack (6.1 %) threshing methods (Table 4.8). Jasmine 85 (11.4 %) also recorded high threshing losses after pounding + hand-picking recovery using the bambam method and was similar to that of Sikamo using drum. Among the varieties, there were no significant ($P<0.05$) differences in threshing losses after pounding + handpicking recovery. Between the threshing methods however, the use of the drum resulted in the highest threshing losses (10.69 %), significantly different ($P<0.05$) from the sack which resulted in the least losses (6.79 %) (Table 4.8).

Table 4.8. Percentage of threshing losses after pounding + hand-picking as second recovery

| | VARIETIES | | |
|---|---|---|---|
| Threshing methods | JASMINE 85 | SIKAMO | Mean |
| | Percent (%) threshing losses | | |
| Bambam | 11.4 | 6.8 | 9.09 |
| Drum | 9.9 | 11.4 | 10.69 |
| Sack | 7.6 | 6.1 | 6.79 |
| Mean | 9.64 | 8.09 | |

HSD(0.05%) Variety = 1.77; Method = 2.67; Method /Variety = 4.76

## 4.8 Threshing losses after third recovery by Straight hand-picking

There were significant differences (P<0.05) between varieties for threshing losses after third recovery by straight hand-picking. Jasmine 85 had the highest loss (10.79%) which was significantly different from Sikamo which had the least (7.97%) (Table 4.9).

Table 4.9: Percentage of threshing losses after Straight Hand-Picking

| VARIETY | Threshing losses after Straight Hand-Picking ( %) |
|---|---|
| Jasmine 85 | 10.79 |
| Sikamo | 7.97 |
| HSD (0.05%) | 2.03 |

## 4.9 Economic losses of initial Threshing

There were significant (P<0.05) varieties x threshing methods interactions for percentage threshing losses (Table 4.10). Using the drum after threshing sikamo had d d g s ss s 88 4 HC) s y g s g j s 85 81 2 HC) d s d s g s 57 0 HC) g ds s d d s losses 64 79 HC) s s g y d 76 86 HC) d 83 51 HC) g s d u T 4 10)

Table 4.10: Economic losses of initial threshing of two rice variety

| | VARIETIES | | |
|---|---|---|---|
| Threshing methods | JASMINE 85 H₵) | SIKAMO H₵) | Mean |
| Bambam | 81.2 | 72.6 | 76.86 |
| Drum | 78.7 | 88.4 | 83.51 |
| Sack | 72.6 | 57.0 | 64.79 |
| Mean | 77.46 | 72.65 | |

HSD(0.05%) Variety = 7.39; Method = 11.15; Method /Variety = 19.92

**4.10 Economic losses after (pounding)**

There were significant (P<0.05) varieties x threshing methods interactions for percentage threshing losses (Table 4.11). The highest economic losses after pounding y s d d u s g s 67 4 H₵) s y g s g j s 85 66 6 H₵) T s ss s s su d s d s g s 34 7 H₵) Between the varieties, ss s g j s 85 59 22 H₵) s 48 62 H₵) g ds d u d d g s ss

s 63 22 H₵) d

55 19 HC) s ss s 43 34 H₵) s (Table 4.11).

Table 4.11 :Economic losses after first post-threshing recovery (pounding)

| | VARIETIES | | |
|---|---|---|---|
| Threshing methods | JASMINE 85 H₵) | SIKAMO H₵) | Mean |
| Bambam | 66.6 | 43.9 | 55.19 |
| Drum | 59.1 | 67.4 | 63.22 |
| Sack | 52.1 | 34.7 | 43.34 |
| Mean | 59.22 | 48.62 | |

HSD(0.05%) Variety = 8.72; Method = 13.14; Method /Variety = 23.45

### 4.11 Economic losses after (Pounding and Hand-Picking)

There were significant ($P<0.05$) varieties x threshing methods interactions for percentage threshing losses (Table 4.12). After pounding plus hand-picking using the bambam for threshing jasmine 85 and drum for threshing sikamo, both equally had obtained the g s ss s  64 9 H₵)  T       s              ss s  32 7 H₵) was resulted from sack in threshing sikamo.

Among the methods, the highest            ss s   s        d          d u   60 98 H₵)        d  y 51 84 H₵)   d  37 74 H₵)  s   e least economic losses from sack method (Table 4.12).

Table 4.12: Economic losses after Second Post-threshing Recovery (Pounding and Hand-picking)

| | VARIETIES | | |
|---|---|---|---|
| Threshing methods | JASMINE 85 H₵) | SIKAMO H₵) | Mean |
| Bambam | 64.9 | 38.8 | 51.84 |
| Drum | 56.9 | 64.9 | 60.98 |
| Sack | 42.9 | 32.7 | 37.74 |
| Mean | 54.92 | 45.45 | |

HSD(0.05%) Variety = 9.6; Method =  14.4; Method /Variety = 25.89

**4.12 Economic losses after Alternative recovery (Straight Hand-picking)**

There were significant differences (P<0.05) between the varieties (Table 4.13). The higher economic losses after straight hand-picking was obtained from jasmine 85

61 49 H₵)   d  45 43 H₵)  s        s       s

Table 4.13 :Economic losses after Post-threshing Recovery (Straight Hand-picking)

| VARIETY | Economic losses after straight hand-picking HȻ) |
| --- | --- |
| JASMINE | 61.49 |
| SIKAMO | 45.43 |
| HSD(0.05%) | 11.49 |

**4.13 Total threshing losses from varieties and threshing + recovery methods** Jasmine 85 recorded the highest threshing losses from the various threshing methods and recoveries employed. Sikamo recorded the least losses (Table 4.14). Between the threshing methods + recoveries employed, the drum-based methods, resulted in the highest losses whereas the least losses were obtained from the sack-based methods (Table 4.14).

Table 4.14 Total losses encountered from varieties and initial threshing + recovery methods

| Varieties | Total losses encountered (%) |
| --- | --- |
| Jasmine 85 | 44.42 |
| Sikamo | 37.40 |
| **Initial Threshing + Recovery methods** | **Total losses encountered (%)** |
| Bambam + three recovery methods | 35.72 |
| Drum + three recovery methods | 41.31 |
| Sack + three recovery methods | 28.70 |

**4.15: Economic Benefits of varieties and total threshing methods**

The greatest economic benefit was accrued from the Sikamo - sack + recoveries technology (Table 4.16). The Jasmine- bambam + recoveries technology resulted in the least economic benefit. Between the methods, there was a 13.8 % increased benefit from using the sack-based methods as compared to the bambam-based methods. Similarly, there was a 7.3 % increased benefit from using the sack-based methods as compared to the drum-based methods (Table 4.16). Comparing the drum-based and bambam-based methods, there was a 6 % increased benefit of using the drum-based methods. Among the varieties, there was no economic advantage of using one variety over the other (Table 4.16).

Table 4.16 :Economic benefits from using varieties and various threshing and recovery methods

| Threshing + recovery methods | Economic benefits ( H₵) |
| --- | --- |

| | |
|---|---|
| Jasmine- bambam + recoveries | 2,946.7 |
| Jasmine - drum + recoveries | 3,537.8 |
| Jasmine - sack + recoveries | 3,489.2 |
| Sikamo - bambam + recoveries | 3,306.4 |
| Sikamo - drum + recoveries | 3,090.7 |
| Sikamo - sack + recoveries | 3,625.5 |

**4.16 : Cost of threshing two rice varieties**

The result depicted that higher cost and longest time was recorded from Sack method after threshing Sikamo, which was similarly higher in Drum method after threshing Sikamo rice. The lowest cost and shortest time was spent on threshing the two rice varieties using the Bambam method. Between the varieties longest time and high cost was spent on threshing Sikamo than Jasmine 85. Among the methods Sack revealed higher cost and time after threshing varieties, this was followed by Drum and the lowest cost and shorter time was spent on threshing jasmine 85 after using Bambam method.

Table 4.17: Cost of threshing one hectare of rice using different threshing methods on two verities of rice

| Varieties |
|---|

| Threshing Methods | | | | | |
|---|---|---|---|---|---|
| | Jasmine | | Sikamo | | Mean |
| | Man hrs | Cost of threshing @18.6/hr | Man hrs | Cost of threshing @18.6/hr | |
| Bambam | 54.9 | 1021.2 | 52.2 | 969.5 | 1990.7 |
| Drum | 66.0 | 1228.0 | 92.5 | 1719.3 | 2947.3 |
| Sack | 104.3 | 1939.0 | 152.9 | 2843.9 | 4782.9 |
| Mean | 225.2 | 4188.2 | 297.6 | 5532.7 | |

**4.17: Revenue generated from threshing rice varieties.**

After threshing rice varieties, using the sack method for threshing jasmine 85 had the g s u H₵7315) s s d u d s g j s 85 and the least revenue was generated from the drum method after threshing Sikamo (5168) B s J s 85 s d g u H₵2139 4) to Sikamo with the lowest (1782.2). Among the methods, using the sack for threshing s d g s g H₵6707), followed by Bambam method d s s d d d u d H₵5168)

4.18:Revenue generated from threshing one hectare of rice using different threshing methods on two verities of rice

| | Varieties | |
|---|---|---|
| Threshing methods | Jasmine | Sikamo |

| | Bags of milled rice* | Total revenue selling price @ HC̶190/bag | Bags of milled rice | Total revenue Selling price @ HC̶190/  g |
|---|---|---|---|---|
| Bambam | 36.8 | 6992 | 31.3 | 5947 |
| Drum | 37.3 | 7087 | 27.2 | 5168 |
| Sack | 38.5 | 7315 | 35.3 | 6707 |
| | 112.6 | 2139.4 | 93.7 | 1782.2 |

*Where one bag of milled rice is 50Kg

**4.18 Cost benefit analysis**

The result indicated high lost of profit after using sack method for threshing Sikamo HC̶8351)  d y D u  d HC̶4788) d  s  ss s s recorded from Bambam method after threshing Jasmine 85. Between the varieties,

S  d  g s  s  HC̶17086)  J s  85

HC̶7814)  g  ds us g  s  d d  s  d  least was indicated from the Bambam method.

4.19 Cost benefit analysis producing one hectare of rice

| | Varieties | |
|---|---|---|
| Threshing methods | Jasmine | Sikamo |

| | Total revenue selling price @ H₵190/bag | Total cost | Total Profit | Total revenue Selling price @ H₵190/ g | Total cost | Total profit |
|---|---|---|---|---|---|---|
| Bambam | 6992 | 8620 | 1628 | 5947 | 9642 | 3947 |
| Drum | 7087 | 9000 | 1913 | 5168 | 9956 | 4788 |
| Sack | 7315 | 11588 | 4273 | 6707 | 15058 | 8351 |
| | 2139.4 | 29208 | 7814 | 1782.2 | 34656 | 17086 |

**4.17: Milling yield of different rice varieties at moisture content of 12.6%**

There were significant differences (P<0.05) in milling yield between the varieties (Table 4.18). After milling the varieties at 12.6% moisture content, Jasmine 85 hadthe higher quantity of milled rice (44.75kg) in comparison to Sikamo (38.50kg).

Table 4.18 :Milling yield of different rice varieties at moisture content of 12.6

| VARIETY | MILLING YIELD (Kg) |
|---|---|
| JASMINE | 44.75 |

| | |
|---|---|
| SIKAMO | 38.50 |
| HSD5% | 4.77 |



# CHAPTER FIVE

## 5.0 DISCUSSIONS

**5.1 Threshing losses as influenced by varieties and initial threshing methods.** Various rice threshing methods were carried out to determine the influence of threshing losses in two varieties of rice. Between the varieties, threshing had indicated negative effect on jasmine 85 having the highest losses, This may be due to the fact that Jasmine is a rice variety with long grains which makes it very easy to thresh, leading to higher percentage of threshing losses while Sikamo with medium grains was difficult to thresh and therefore had the lowest threshing losses. Koga (2009) also reported that, long grain rice is easy to thresh than short grain rice, though there are exceptions. Easy-to-thresh paddy varieties may facilitate threshing operation, on the other hand, grain loss can be higher compared to those varieties that are difficult to thresh.

Among the threshing methods, drum recorded higher percentage losses after threshing Jasmine and Sikamo due to higher rate of rice shattering resulting from the lifting up and down of the cut rice straw against the metal drum. Another reason was that, the farmers were not familiar with the drum method of threshing and as such that might have resulted in the increased losses. Alizadeh *et al.*, (2010) stated that using drum for threshing paddy resulted in higher losses due to the breakages and cracking of the grain as the grains hit against hard metal. The bambam method also led to high threshing losses. This method was described by the farmers as the fastest and the simplest method for threshing rice and therefore might have led to the high grain losses. Guisse (2010) also recorded higher threshing losses when the bambam method was used in threshing NERICA 1 and NERICA 2. The sack method was the least in terms of losses after threshing rice varieties. This could be related to structural nature, which does not facilitate shattering of the grains. Calverley, (1996) made a similar observation in a study in Eastern Africa, using the sack for manual threshing of rice.

## 5.2 Threshing losses from different post-threshing recovery methods.

Jasmine 85 had higher percentage of threshing losses even after recoveries compare to Sikamo. Yasumasa (2009) clearly recommended that difficult to thresh varieties should be encouraged for cultivation because of their lowest percentage of losses during threshing. For the methods, drum + three recovery methods had the highest threshing losses. This could be explained by the fact that it is the method with a high shattering rate resulting in high quantities of broken and cracked grains (Zami, 2000).

Raman, (2013) also reported that this method produced damaged and split grains that were more susceptible to storage damage and were of lower marketable value. Miah *et al.*, (2010) also reported that manual threshing loss can be as high as 2-6%, particularly, when using hard objects. Bambam + three recovery methods also illustrated similarly high percentage of threshing losses while the best method was indicated from Sack + three recovery methods.

## 5.3 Time and labor implications of threshing and recovery methods

The longest time and labour was spent on threshing sikamo, because of the fact that, it is a difficult-to-thresh variety. This is in agreement with the report of JICA (2009) which indicated that those varieties that are hard to thresh require more time and labor than easy to thresh ones. However among the methods, sack recorded the longest time for threshing the rice varieties because manual threshing like bag beating methods have been found to be time consuming and laborious (Ajayi, 2014). The drum and bambam methods consumed less threshing time.

## 5.4 Grain recoveries from post-threshing methods

After using the three recovery methods, greater quantities of grains were recovered from sikamo, as compared with Jasmine 85, since there were proven difficulties during the initial threshing which resulted in more grains which needed to be recovered. Ojha, (1989) projected that grain recovery are usually recorded higher from those varieties with short grains and difficult to thresh and the recovery can range from 1-15%. The least recovery was obtained from Jasmine 85 because of the higher percentage of threshing losses after the initial threshing.

Among the methods, a good quantity of grains were recovered from pounding + handpicking method than from the others. This could be attributed to the fact that pounding dislodged a lot of the grains from the spikelets coupled with careful hand picking which removed any other grains remaining after the pounding activity. Not surprising, the combined method was the most tedious and time consuming but the quantity of grains recovered compensated for such drudgery.

## 5.5 Economic losses from initial and post-threshing recoveries.

After recoveries, economic losses were generally reduced. Since losses were higher in initial threshing of rice varieties using drum for threshing Sikamo, had also translated the same in terms of economic losses which was followed by bambam threshing Jasmine 85. The least losses was reported from sack method after threshing Sikamo due to the same reasons as mentioned in the previous discussion tables above. Among the methods, losses were higher after using drum for threshing rice varieties and sack had the lowest economic losses. Among the post-threshing recoveries, economic losses were higher in Jasmine 85 as compare to Sikamo. The sack method had the least losses compare to other treatment combinations.

### 5.6 Economic benefits from varieties and threshing methods

Economically, there was no financial advantage of using one variety over the other. However, the differences in financial gains resulted from the threshing and recovery methods technologies. Sikamo - sack + recoveries had positive effect on economic benefits due to the fact that both the variety and method permitted very little or no exposure of grains to shattering. Consequently, less threshing losses were obtained which implied greater grain recovery and in turn higher financial benefits. The worst economic benefits was accrued from Jasmine- bambam + recoveries. This could be explained by the fact that Jasmine 85 is an easy-to-thresh variety and the bambam method is known by the farmers to be the fastest threshing method. Consequently, a combination of these two had the highest tendency of entertaining high threshing losses with a resultant low grain yield and subsequent low financial gains.

### 5.7: Cost-benefit analysis

The importance of cost benefit analysis is to realize or understand the differences between the cost of production and the cost of economic revenue after the season. The findings of this work revealed that between the varieties, higher amount of money was spent on producing Sikamo rice more than jasmine 85 even though each rice variety was cultivated under an area of one hectare of land. This may be attributed to the difficulties faced during post production and higher involvement of labour requirement. Jasmine 85 had generated higher amount of revenue than Sikamo. This was due to the higher quantity of rice grain produced from Jasmine 85. Among the methods, Sack method had recorded the highest amount of money as cost of production than other treatment combination due to time requirement and tediousness in threshing cut straw of rice. Ndiiri J.A, (2013) also did cost benefit analysis from two season of producing paddy rice and the reported stated that, the cost of production was higher in some units under system of rice intensification practice, although the average cost per ha per unit was higher due to labor requirement. System of rice intensification also gave a higher average net return in all units in both seasons (146% and 141%, respectively).

# CHAPTER SIX

## 6.0: CONCLUSIONS AND RECOMMENDATIONS

### 6.1 Conclusions

The following conclusions could be drawn from the series of experiments undertaken in this study.

1. Threshing losses were higher in Jasmine 85 as compared to Sikamo.

2. The drum + three recovery methods recorded the highest percentage of threshing losses with the lowest by the sack + three recovery methods.
3. The longest time was spent on threshing Sikamo and the use of the sack method took the longest time for threshing rice varieties.
4. For the post-threshing recoveries, large quantities of grain were recovered from pounding + hand-picking of Sikamo and the least quantity was from the straight handpicking of Jasmine. For methods, the drum recorded the highest recovery of grains and the lowest was from the Sack.
5. For cost-benefit analysis, huge amount of money was spent on Sikamo than jasmine 85. Among the methods, sack method incurred highest amount of money and the least was from bambam method
6. The greatest economic benefit was obtained from Sikamo - sack + recoveries, whereas the Jasmine - Jasmine- bambam + recoveries resulted in the lowest economic gain.

## 6.2 Recommendations for future research

1. The effects of threshing and post-threshing recovery methods should be studied on other rice varieties cultivated in the West Africa sub-region.
2. A detailed economic study should be undertaken with the use of the various threshing and post-threshing recovery methods on a number of rice varieties cultivated in the West Africa sub-region.

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## Appendix 1 (ANOVA)

**Analysis of Variance Table for Thresh**

| Source | DF | SS | MS | F | P |
|---|---|---|---|---|---|
| rep | 2 | 222.250 | 111.125 | var | 1 |
| 3.209 | 3.209 | 2.11 | 0.1773 | tmeth | 2 |
| 33.243 | 16.622 | 10.91 | 0.0031 | var*tmeth | 2 |
| 15.708 | 7.854 | 5.16 | 0.0289 | | |
| Error | 10 | 15.230 | 1.523 | | |

| | | |
|---|---|---|
| Total | 17 | 289.640 |

Grand Mean 13.167    CV 9.37

**Analysis of Variance Table for Thresh**

| **Source** | **DF** | **SS** | **MS** | **F** rep | 2 | **P** |
|---|---|---|---|---|---|---|
| 13.0 | 6.5 | | | | | |
| rice | 1 | 5408.0 | 5408.0 | 65.87 | | 0.0000 |
| tmeth | 2 | 36148.0 | 18074.0 | 220.15 | | 0.0000 |
| rice*tmeth | 2 | 4132.0 | 2066.0 | 25.16 | | 0.0001 |
| Error | 10 | 821.0 | 82.1 | | | |
| Total | 17 | 46522.0 | | | | |

Grand Mean    125.33 CV   7.23

**Analysis of Variance Table for FRP**

| **Source** | **DF** | **SS** | **MS** | **F** | **P** |
|---|---|---|---|---|---|
| rep | 2 | 13.897 | 6.9486 | var | 1 |
| 41.496 | 41.4961 | 11.01 | 0.0078 | tmeth | 2 |
| 1.795 | 0.8976 | 0.24 | 0.7924 | var*tmeth | 2 |
| 44.056 | 22.0281 | 5.85 | 0.0208 | | |
| Error | 10 | 37.681 | 3.7681 | | |
| Total | 17 | 138.925 | | | |

Grand Mean 11.122    CV 17.45

**Analysis of Variance Table for SPTR**

| **Source** | **DF** | **SS** | **MS** | **F** | **P** |
|---|---|---|---|---|---|
| rep | 2 | 69.564 | 34.7818 | var | 1 |
| 19.761 | 19.7611 | 1.91 | 0.1971 | tmeth | 2 |
| 10.892 | 5.4462 | 0.53 | 0.6063 | var*tmeth | 2 |
| 134.160 | 67.0801 | 6.48 | 0.0157 | | |

| | | | |
|---|---|---|---|
| Error | 10 | 103.499 | 10.3499 |
| Total | 17 | 337.876 | |

Grand Mean 12.914    CV 24.91

**Analysis of Variance Table for ALTER**

| Source | DF | SS | MS | F | P |
|---|---|---|---|---|---|
| rep | 2 | 44.209 | 22.105 | var | 1 |
| 157.650 | 157.650 | 18.24 | 0.0016 | tmeth | 2 |
| 122.391 | 61.195 | 7.08 | 0.0122 | var*tmeth | 2 |
| 33.834 | 16.917 | 1.96 | 0.1917 | | |
| Error | 10 | 86.440 | 8.644 | | |
| Total | 17 | 444.524 | | | |

Grand Mean 11.369    CV 25.86

**Analysis of Variance Table for TLA**

| Source | DF | SS | MS | F | P |
|---|---|---|---|---|---|
| rep | 2 | 214.642 | 107.321 | var | 1 |
| 15.512 | 15.512 | 7.39 | 0.0216 | tmeth | 2 |
| 36.887 | 18.443 | 8.79 | 0.0063 | var*tmeth | 2 |
| 25.418 | 12.709 | 6.06 | 0.0189 | | |
| Error | 10 | 20.984 | 2.098 | | |
| Total | 17 | 313.443 | | | |

Grand Mean 9.4594    CV 15.31

**Analysis of Variance Table for TLASPTR**

| Source | DF | SS | MS | F | P |
|---|---|---|---|---|---|
| rep | 2 | 159.948 | 79.9741 | var | 1 |
| 10.718 | 10.7185 | 3.80 | 0.0798 | tmeth | 2 |
| 46.152 | 23.0760 | 8.19 | 0.0078 | var*tmeth | 2 |
| 27.029 | 13.5144 | 4.79 | 0.0347 | | |
| Error | 10 | 28.189 | 2.8189 | | |
| Total | 17 | 272.036 | | | |

Grand Mean 8.8617    CV 18.95



**Analysis of Variance Table for TLAAL**

| Source | DF | SS | MS | F | P |
|---|---|---|---|---|---|
| rep | 2 | 186.522 | 93.2612 | var | 1 |
| 35.701 | 35.7013 | 9.72 | 0.0109 | tmeth | 2 |
| 8.475 | 4.2374 | 1.15 | 0.3542 | var*tmeth | 2 |
| 17.295 | 8.6475 | 2.35 | 0.1453 | | |
| Error | 10 | 36.741 | 3.6741 | | |
| Total | 17 | 284.734 | | | |

Grand Mean 9.3772    CV 20.44

**Analysis of Variance Table for ELAFRP**

| Source | DF | SS | MS | F | P |
|---|---|---|---|---|---|
| rep | 2 | 6961.6 | 3480.82 | var | 1 |
| 505.3 | 505.30 | 7.36 | 0.0218 | tmeth | 2 |
| 1201.2 | 600.62 | 8.74 | 0.0064 | var*tmeth | 2 |
| 826.8 | 413.38 | 6.02 | 0.0192 | | |
| Error | 10 | 686.8 | 68.68 | | |
| Total | 17 | 10181.8 | | | |

Grand Mean 53.916    CV 15.37

**Analysis of Variance Table for ELASPTR**

| Source | DF | SS | MS | F | P |
|---|---|---|---|---|---|
| rep | 2 | 5424.13 | 2712.06 | var | 1 |
| 403.37 | 403.37 | 4.82 | 0.0528 | tmeth | 2 |
| 1645.14 | 822.57 | 9.83 | 0.0044 | var*tmeth | 2 |
| 877.96 | 438.98 | 5.25 | 0.0277 | | |
| Error | 10 | 836.70 | 83.67 | | |
| Total | 17 | 9187.31 | | | |

Grand Mean 50.179    CV 18.23

**Analysis of Variance Table for ELATER**

| Source | DF | SS | MS | F | P |
|---|---|---|---|---|---|
| rep | 2 | 6062.23 | 3031.11 | var | 1 |
| 1160.98 | 1160.98 | 9.72 | 0.0109 | tmeth | 2 |
| 275.32 | 137.66 | 1.15 | 0.3545 | var*tmeth | 2 |
| 561.21 | 280.61 | 2.35 | 0.1457 | | |
| Error | 10 | 1194.40 | 119.44 | | |
| Total | 17 | 9254.14 | | | |

Grand Mean 53.453    CV 20.45

**Analysis of Variance Table for ELT**

| Source | DF | SS | MS | F | P |
|---|---|---|---|---|---|
| rep | 2 | 7220.90 | 3610.45 | var | 1 |
| 104.26 | 104.26 | 2.11 | 0.1773 | tmeth | 2 |
| 1080.08 | 540.04 | 10.91 | 0.0031 | var*tmeth | 2 |
| 510.35 | 255.17 | 5.16 | 0.0289 | | |
| Error | 10 | 494.82 | 49.48 | | |
| Total | 17 | 9410.40 | | | |

Grand Mean 75.050    CV 9.37

**Analysis of Variance Table for MY**

```
Source       DF        SS         MS       F        P
rep           2   346.687   173.344 var             1
175.781    175.781    8.55    0.0152 tmeth          2
32.062      16.031    0.78    0.4847 var*tmeth      2
51.188     25.594   1.24   0.3292
Error        10   205.687    20.569
Total        17   811.406

Grand Mean 41.625    CV 10.90
```



**Total cost of production for two varieties of rice**

| | VARIETIES | | |
|---|---|---|---|
| | ITEMS | JASMINE 85 | SIKAMO |
| | Land renting | 1390 | 1390 |
| | Usage fee to Irrigation Development Authority | 695 | 695 |
| | Slashing | 278 | 278 |
| | Gathering and burning | 139 | 139 |
| | Herbicide for initial weed control 1 | 347.5 | 347.5 |
| | Selective Herbicide for weed control | 347.5 | 347.5 |
| | Labour for spraying herbicide | 139 | 139 |
| | Tilling of the land | 556 | 556 |
| | Purchasing of seeds | 139 | 139 |
| | Nursery attendant | 139 | 139 |
| | Transplanting of seedlings | 556 | 556 |
| | Hiring of irrigating pumping H₵15 X 20 d ys | 1390 | 1390 |

| | | | |
|---|---|---|---|
| | Fuel for irrigation 1gal/day x 20 x H₵13 | 1112 | 1112 |
| | Purchasing of fertilizer (NPK) 1st application | 973 | 973 |
| | Transportation of fertilizer | 208.5 | 208.5 |
| | Insecticide | 347.5 | 347.5 |
| | Labour for spraying insecticide | 139 | 139 |
| | Picking of weeds at flowering/seeding | 139 | 139 |
| | Picking of weeds at before harvesting | 139 | 139 |
| | Labour for fixing of bird nets | 139 | 139 |
| **TOTAL COST** | | **9312.8** | **9312.8** |

**Total cost of postharvest activities for a hectare of Jasmine 85 rice**

| Cost item | Bambam threshing method | Drum threshing method | Sack threshing method |
|---|---|---|---|
| Harvesting | 1358 | 1154 | 1568 |
| Heaping of stubbles | 530 | 565 | 742 |
| Tarpaulin for threshing | 919 | 919 | 919 |
| Harvesting sacks | 764 | 880 | 1030 |
| Transportation of paddy to drying floor | 350 | 370 | 538 |
| Drying | 750 | 654 | 1085 |
| Winnowing | 1275 | 1493 | 1885 |
| Bambam box | 200 | - | - |
| Barrel | - | 300 | - |
| Sacks for threshing | - | - | - |
| Threshing | 1085 | 907 | 1668 |
| Milling | 1389 | 1759 | 2153 |
| Total | **8620** | **9000** | **11588** |

**Total cost of postharvest activities for a hectare of Sikamo rice**

| Cost item | Bambam threshing method | Drum threshing method | Sack threshing method |
|---|---|---|---|
| Harvesting | 1485 | 1254 | 1668 |
| Heaping of stubbles | 640 | 575 | 842 |
| Tarpaulin for threshing | 919 | 919 | 919 |
| Harvesting sacks | 964 | 850 | 1230 |
| Transportation of paddy to drying floor | 400 | 350 | 578 |
| Drying | 950 | 880 | 2085 |
| Winnowing | 1575 | 1893 | 2085 |
| Bambam box | - | - | - |
| Barrel | - | 300 | - |
| Sacks for threshing | - | - | 250 |
| Threshing | 1348 | 955 | 1658 |
| Milling | 1589 | 1980 | 3753 |
| Total | **9642** | **9956** | **15068** |