STUDY OF GRAIN STORAGE STRUCTURES METHODS AND LOSSES IN BENUE STATE, NIGERIA

BY

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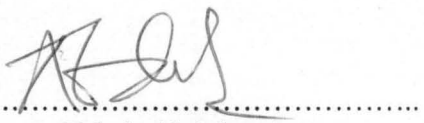
DECLARATION

I hereby declare that this project is a record of research work that was undertaken and written by me. It has not been presented before for any degree or diploma or certificate at any University or Institution. Information derived from personal communications, published and unpublished works of others were duly referenced in the text.



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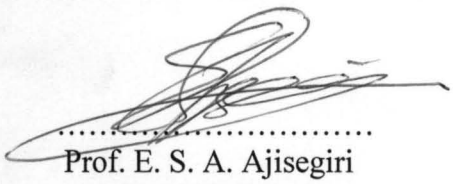
CERTIFICATION

This project entitled "Study of Grain Storage Structures, Methods and Losses in Benue State'' by Zubair, Abdulganiyu meets the regulations governing the award of Bachelor of Engineering (B.ENG.) of the Federal University of Technology, Minna, and it is approved for its contribution to scientific knowledge and literary presentation.



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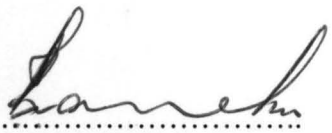

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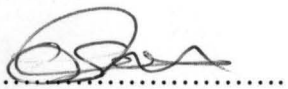

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DEDICATION

This project is dedicated to Almighty Allah who saw me through out my academic career and to my affectionate Parents: Mr. Zubair Shaibu and Mrs. Mary Zubair for their tireless effort to see that I succeed in life.

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May Almighty Allah bless your home, guide and protect you all.

ABSTRACT

In Benue State, the major crops grown are grains. From the survey carried out on the estimation of storage losses during storage which consist of twelve local government of the twenty-three in Benue State Questionnaires were administered and also using appropriate techniques such as count and weigh method, and weigh-in-weigh-out method. From the survey study, it revealed the distribution of various crop grown showing that Rice and Maize (23.1% and 22.1%) are the most widely grown grain in Benue State. It also shows less attentive were paid to the cultivation of soyabean. The study also revealed the distribution of different storage methods on each local government and their relative effectiveness. This shows that bag is the most predominant storage structure used. The study also shows that insects record the highest form of grain losses. Jerry can is said to provide the best performances in most local government area. Fire hazard recorded the least form of losses with record of 4.8%. Maize recorded the heaviest quantity of losses (28.97%) while Soya bean recorded the least (4.9%). From the study which revealed from projections that a sum of twenty one million, five hundred thousand naira is being lost annually in Benue state.

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CHAPTER ONE

1.0 INTRODUCTION

Various studies have repeatedly demonstrated that the present day situation of food economics allows the world's richest countries not only to purchase the yearly available crops of noble grains for primary nutrition but also to use these vital grains for livestock fodder, whilst at the same time, the third world countries cannot even get hold of the minimum quantities for direct human use. In many developing countries like in Nigeria, adequate warehousing is non-existent such that a high percentage of grains produced is lost or damaged. The oldest technique of grain storage has been documented by archaeological findings and excavations. The ancient Greeks used large earthward vessels. They also made use of specially dug holes. Only the application of reinforced concrete at the beginning of the 20^{th} century made it possible to erect larger units. In Benue State, a survey carried out revealed that grains are stored both by traditional rural methods and modern methods. The survey was carried out covering a wide range of areas ranging from farmers in the village farming settlements to some establishments in Benue State. There establishment includes the also Nigeria limited new land foods limited, Benue brewery factory, Taralu mills and the National strategy grain reserve in Benue state.

1.1 Definition

The word grain is said to be the collective name for the most important farming plant that can be classified in the grass family. Grain as a plant can as well be grown with relatively little work on most farming lands in varied climatic condition. The high nutritional value of grains and its multiple application limited by human imagination has made grains, man's most important source of food. Generally grains

contain 70% Carbohydrates (Starch, Sugar) 10% Protein and the remainder 20% of fats, vitamins, mineral and water.

Storage on its own can be defined as the act of preservation of grains or other agricultural produce after harvesting for use as food, feed or for replanting.

1.2 Need For Storage

With the perilous food situation in the world today, no other problem seems deserving of more immediate attention than stored grain losses. The amount of food available is literally a matter of life and death to people of developing to be well stored, they have to be properly harvested, handled and processed. The storage of grain such as rice, Maize, Sorghum and Soya beans under different, often precarious conditions is no easy matter, since many factors of deterioration are responsible for losses, which as in important to keep to minimum. How can there grains be preserved under best conditions, what facilities should be made of, precautions to be made, what moistures should be avoided to ensure minimum or no damage or lost. Grain need to be properly stored for ample reasons.

1. Because of its diverse needs, demand and economic importance.
2. It can be used as food and as feed.
3. It can be replanted to boost agricultural production.
4. It can be used for other sub foods during secondary processing. Storage of grain should be the most important thing to any farmer after harvesting. Take for instance rice is a predominant grain grown in Benue State in all localities depending on the level of wetness or dryness of the soils for such areas. Storage is so necessary here because all varieties of rice have poor cooking qualities after harvest. On cooking they are apt to become party fail to swell

properly, loose more solids in solution and fragmentation. Proper storage can be achieved by the use of proper scientific facilities.

1.3 Storage Losses

During land clearing operations as well as planting and maintenance of the farm most especially harvesting and handling of the crops grown, a lot of hard work is being put towards this action. From survey studies by (Jelle 1974), it was observed that about 35% of the crops harvested from the farm are mostly lost during handling and storage process. Various factors are said to be responsible for the deterioration of farm produce after harvest. Due to the fact that the behaviours characteristics (internal forces) of food grains vary, the grain suffers external forces exposure which are oxygen supply, biological agencies such as bacteria, rodents and of course, man with his method of sorting, handling, transportation and disinfecting products.

1.4 Objectives of the Study

Crop storage has been identified as a major aspect of increasing agricultural food production, and any effort that is aimed at increasing agricultural production must be matched with equal if not greater efforts at providing adequate and efficient storage facilities. To success fully store therefore, there more be good structures. The followings are same of the objectives of the study.

1. Evaluating and identifying the different structures and methods of grain storage in Benue state.
2. Collection of storage data in the study area which covers Apa, Gboko, Makurdi, Kwande, Agatu, Ado, Guma, Konshisha, Vandekiya, Tarka, Gwer east and Otukpo local government area in Benue state.

3. Estimating the quantity of grain lost annually in the state.
4. Estimating the monetary cost of grain losses.
5. Suggestion given as to how best to minimize the storage losses and to recommend the best storage structures.

1.5 Justification of the Study

As regards the survey carried nut, it was observed that losses of grain in the local communities can be due to lack of finance to erect structures that will store their grains better.

It is paramount to determine the present methods and structures of storage with an aim of suggesting possible solutions to this storage problems and thereby isolating area with these storage problems.

1.6 Limitations of the Study

The followings are the limitations encountered where carrying out the survey.

1. Considerations were for rice and maize since there was the major grain grown.
2. Only (12) twelve local governments were selected randomly out of the twenty-three local government in Benue state for the study.
3. Considerations are for 2005 harvest season only.
4. The method of evaluation comprises of personal inspection, distribution of questionnaires and collection of samples. There were the methods used in evaluation.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Major grain grown in Benue State

The various grains predominantly grown in Benue State whose storage systems are discussed here are Rice, Soya bean, Maize and Sorghum.

2.1:1. Rice

Rice is an important food cereal that produces a large proportion of the total nourishment of the world's population. The nucleus of origin of cultivated rice is thought to have been in south west Asia and probably in Africa. Rice is generally considered to be a topical crop which is comparatively high in calorific value. It can be cultivated both in upland and low land areas. (Annis and Sakurdi 1984). In Benue state, it is grown in an extensive capacity in almost every local government area.

2.1:2. Maize

Maize is an important agricultural grain product due to its wide use. It is virtually grown in all parts of Benue State because of its climatic requirements. It is able to with stand high temperatures, has a remarkable high fat content.

2.1:3. Sorghum

Sorghum has been cultivated in china for over 500 years and in now the most important breed grown in most arid areas of Africa and Asia.

2.1:4. Soya bean

The earliest principal growers of Soya bean were china (500BC), Eastern Asia. Soya been is relatively easy to cultivate and more lucrative than rice soybean is grown in many past of Benue state because of its climatic requirements, it needs almost no fertilizer, produces its own nitrogen in the soil. It is an important source of protein.

2.2. Grain Storage Problems

Storing produces under certain conditions leads to deterioration and some quality/quantity problems especially when adequate measures are not been taken before storage.

The followings are crucial grain storage factors.

2.2.1. Moisture Content

(Jelle, 1990), stated that biological activities occur in grain due to presence of moisture content. This is important because moisture content is closely related to keeping grain quality in storage, primarily because of the relationship between moisture and the growth of storage fungi. Grain is hygroscopic and therefore in store absorbs or losses moisture according to the initial moisture content too high for storage, they can provide a site of entry for storage moulds that can eventually spoil the grain.

2.2.2. Temperature

Temperature of a grain bulk is frequently used as an indicator of grain quality in storage, particularly in large commercial silos that have no provisions for aeration. It is found that most grain pests are of tropical and Subtropical origin, their optimum temperature lying between 28^0C and 35^0C and their maximum usually between 32^0C

and 39^0C. It also noted that grain could also be kept in store as far below the optimum temperature, say 18^0C, (Hall, 1970).

2.2.3. Relative humidity

Grains are living things, so they respire and water is given off and absorbed in form of vapour from surrounding environment. At a particular temperature the surrounding air has a limit of moisture capacity and cannot absorb any more water vapour at a given temperature. It is said to have relative humidity of 100 %.

2.3. Agents of Storage Losses

Stored grain is subjected to the deleterious effects of grain pests, in particular to moulds, insects, rodents, birds, man, fire, and mites. The degree of pest activity is a function of the moisture content and temperature of the grain and the interstitial atmosphere around the grain. In general the lower the moisture content, the temperature, the damage level and the foreign material content of the grain, the longer it can be stored without being affected by one of the grain pests, (De Lima, 1979).

2.3.1. Mould as an agent

Many mould species can develop on grains, in the field as well in storage. Among the major field moulds are species of the genera fusarium and Aspergillum. They can develop under high relative humidity conditions (78%), over a wide range of temperatures (10-35^0C), (Jelle, 1990).

Species of Aspergillus and penicillum are among the principal storage moulds of grains, each requires minimum moisture content for growth. Like wise, the development of a species is limited to a certain temperature range.

The major losses caused by fungal growth in grains are decreases in germ inability, discoloration of the seed germ, heating and development of mustiness,

biochemical changes, potential production of toxins and loss in dry matter of particular importance is the potential production of toxins.

Several grain moulds produce toxins, called mycotoxins (Jelle, 1990). They are defined as ''fungal metabolites which when ingested, inhaled or absorbed through the skin cause lowered performances, sickness or death in man or animals. Major mycotoxins are aflotoxins, vomitoxins (DON) and Zearalenane.

2.3.2. Insect as agent

Insect can cause major losses in stored grain not only in tropical and subtropical regions but also in temperate climates. Hundreds of insect species have been found in grain storages.

Losses inflicted by insects to stored grains consists of disappearance of a large portion of the kernels, damage to the germs, heating (followed by moulding) of the grain, and contamination of the grain mass. The development of insect in grain storages can be prevented by controlling the temperature and moisture content of the grain or by modifying the interstitial air. In chilled grain storages, the grain temperature and equilibrium moisture content are kept low.

Stored-grain insects are divided in to internal feeders and external feeders. The internal feeders develop from egg to larva to insect within grain kernels. The external feeders hatch from eggs laid on the surface of grain kernels. Internal feeders are the more destructive insects, major species are the rice and maize weevils, the lesser and larger grain borers and the angoumois grain moth. Among the common destructive external feeders are the Indian meal moth, the red flour and rusty grain beetles, and the saw-toothed grain beetles. Which insects' species occur in a region depends on the

local temperature and humidity conditions and on the type of grains in storage. (Adams and Schulten, 1978).

2.3.3. Rodents as an agent

Rodents are considered a storage pest because they consume and damage grains in the field and in storage, destroy baggage and storage structure, and transmit diseases that are dangerous to human (i.e. through urine and droppings mixed with grain). Cleanliness during grain harvest and handling reduces the risk of rodents. The three common rodents found throughout the world are the house mouse (mus musculus), the brown rat (Rattus norvegicus), and the ship rat (Rattus rattus).

Two forms of rodent control are practiced. Poisons are used only if a rapid reduction in rodent population is required. Trapping is implemented if poisons are two dangerous and rodent odour must be avoided.

Rodent proofing of a storage facility is necessary to curtail the development of rodents. (Boxall 1978)

2.3.4. Birds as an agent

Birds feed mainly on grains, especially when shelled. They cause a lot of damage to unharvested grains. Generally, it is only local methods that have been used to control the birds, such method include tying of topes around the farm to produce noise to drive away the birds, (Boxall, 1978)

2.3.5. Man as an agent

Man is known to cause the greatest damage to grains man is known to cause the greatest damage to grains both on the field and in the warehouse. Such damage ranges from handling during harvest to processing storage.

Though some efforts are being made to prevent some of the man-made damages, one of such effort is mechanization of the various unit processes.

2.3.6. Mites as an agent

Mites are known for their burrowing habit and also consume the embryo of the grain there by rendering the grain uses to both the consumer and the farmer. Pointed out that these parasites, which are found in large groups living in all part of the world, are pests to plant and animals, (Cotterell and Howe, 1952).

2.3.7. Fire as an agent

This mostly occurs due to the carelessness of the handlers. It found to be most common on the field when the grains are drying up. Fire rarely occurs during storage and when it does, it consumes almost every thing in the ware horse.

2.4. Storage Structures

A storage structure is a container that is designed and fabricated to perform the function of safely keeping of crops. It may not involve original designs but mere modification or remodelling of existing structures to perform this act of storage. On a wider note. Storage structures will refer to all those facilities within and some far removed from an agricultural establishment, which are used for the storage of agricultural inputs and produce.

The functional requirement of a crop storage structure is that it should be capable of retaining the quality and quantity of the crop for as long as it is stored. An ideal storage structure should therefore eliminate the destructive effects of weathering, the invasion by pasts and insects, activities of micro-organisms and enzymes, loss of structure through dehydration (wilting and shrivelling), germination of seeds and loss of viability, (Ajisegiri and Igbeka, 1986)

2.4.1. Grain Storage System in Benue State

From the study, it was observed that grains are stored both by traditional rural methods and modern methods.

2.4.2. Grain handling

Adequate precaution should be taken at every stage of handling grain between harvest or picking and storage i.e. during drying, threshing, cleaning and transportation operation in order to prevent lesions. Handling should be kept to a minimum,(Hall ,1970) A survey of the grain storage structure system in Benue state revealed that the following methods are obtainable.

2:4.3. Traditional Rural Storage

From the study in Benue state, almost half of the agricultural output of some peasant farmers is kept at village level for use locally. This storage at farm level in the place where the grain crops are produced has its own advantage. It does away with transport and handling cost and eliminates the losses that occur during these operations. The arrangements and methods currently in use are the results of age-old experience and tradition. They are perfectly suited to local conditions and on the whole give satisfaction. This type of preservation should be continued, subject to making minor improvements to certain systems, in order to give the produce greater protection against pests and damp. The structures employed generally provide many features that are conducive to good preservation, and are inexpensive, as they are made of local, natural materials. Farmers store their crops either outside, suspended, or on platforms or in granaries or even inside their dwellings.

2.4.3.1 Open Structures

(a) **Storage on the ground:** This is a temporary storage method employed by most farmers in Benue, immediately after harvest and lasting only a few days either because of prospecting rain, or may be the farmer has not had time to bring in what he has harvested unfortunately, during this period, no matter how short, there may be appreciable losses for instance, rice may be devoured or carried off by rats.

(b) **Aerial storage:** Unshucked maize is suspended in bunches or sheaves, using rope or plant materials from the branches of trees or the top of poles driven into the ground in the field. The grain can be dry in the air and the sun until it is gradually consumed by the farmer and his family. This simple approach requires no infrastructure, but applies only to small quantities of grain,(Ajisegiri,1991)

2.4:3:2 Enclosed Structures

(a) **Dwellings:** Unthreshed grains are commonly stored under the roof of the dwellings, hanging from the roof timbers or spread out on a grid above the fire, the heat and smoke, ensuring that they keep well. Some farmers in the Makurdi farming environments keep grains seeds in containers inside their houses. This method keeps the grain safe from theft,(Ajisegiri,1991)

(b) **Bags:** Some farms here sometimes store grains in jute sacks that are used commercially and placed inside the houses. This approach is not particularly widespread. Some peasant farmers use bags woven from plant fibric (e.g. palm leaves) with fibric or leather handles,(Salmond,1969)

(c) **Baskets:** Farmers in Benue state also uses basket of various types which may be woven from plant fibrics in which they place their grains. There is a very wide

variety of shapes and sizes. Some may contain 500kg of grain. These baskets are employed for short term storage and placed inside the house. These baskets do not provide particularly good protection against insects and rodents, as they are difficult to clean, and if they are used again, the following crops may be contaminated by insects hidden in the

(d) Jars: jars are used as a storage structure in Benue State, the shape, content or Sizes varying from one farmer to another. They are made of clay with narrow neck and hermetically sealed by means of flat store stucked around the edges. The value of these jars as storage containers depend on the amount of work which has gone into making them, the condition in which they are used and where they are placed. They must not be either porous, Cracked or exposed to the Sun.

(e) Jerry cans (plastic):- In Benue state, use is made of extensively of jerry cans for storing grain crops. From study, they are said to provide a well-managed storage where losses are minimal. The harvested grains are introduced into the jerry cans and they are being protected by the addition of Decis, Coopex or cyber force which are powdery from chemicals and the jerry cans are sealed to ensure that air are not introduce into the cans. This is being practiced in all part of Benue State by the various farmers.

2.4:4: Modern Structures

From the survey study carried out, it was revealed that farmers in Benue State do not really give proper attention to their grains after harvesting. Some even allow the grains get spoilt on the farm before harvesting, and storing such grains posses a lot of damages in the storehouse. This non-Challant attitude can be attributed to the fact that apart from being subsistent farmers, they are not financially updated to afford

materials for storage proper and more so because they handle small quantities of grain.

Particularly traders, Cooperatives, government warehouses and other agricultural organisations or industries, use modern structures for storage system found during the survey.

In Benue State agricultural rural development authority, the kind of storage employed is the hermetically sealed systems, the premises is either being Constructed of concrete or bricks of metal bolted together with these structures, there is obviously A risk of condensation, and a threat of attack by rodent and the opportunities for fumigation are uncertain because the unit are not air tight.

Ventilated systems are also used either to the grain or lower the moisture content.

Use is also made here of hermetically sealed system which consist of lowering the oxygen content of the air present in the storage facility to a very low level to kill off insects and prevent mould development.

In Ollam Nigeria limited in Makurdi, use is made of metal silos, which are corrosion-resistant made of sheets steel welded together, and is suited to prevent dry grains in tropical climate conditions. Storage as carried out by traders in the collection centre, cooperative and government facilitation is subjected to the same imperutions as regards preserving the grain from causes of physical and biological deterioration as village storage, but it differs in the following respects:

- It does not involve small quantities.
- Application of modern structures
- Product are handled a number of time before being offered to the customer.
- Actions are taken against storage pest.
-

2.5 Storage losses estimation.

Various standards were introduced by various parts of the world for the their major grain crops.Thus,providing guidelines for both sellers and purchasers to assist financial transaction and ensuring quality.

Storage losses estimation is determined by the use of the following:

- The count and weigh method.
- Weigh in weigh out method.
- Bulk density method.
- The percentage x damage factor method.
- Others

Count and Weigh Method.

This method makes use of a measure of the mean kernel weight, the principle was proposed, this was because most authors of articles on grain damage reported only the percentage of attacked kernel, he urged that an attempt should always be made to estimate the correct weight loss.

The grain sample was first cleaned over a sieve to remove insect and other fine materials. Some insect frays may also be removed during the cleaning. A small portion is then randomly removed from each cleaned sample. Each kernel is observed and damaged kernels are separated from the sound kernels. The kernel in each fraction are then counted and weighed to allow the calculation of the mean kernel weight of each fractions and the proportion of damage kernels.

Weigh-In-Weigh-Out-Method

This is the standard to which other methods are compared. Weight losses determined by this method are often called "observed" losses.

The moisture content of the grain is taken whenever the grain is weighed into or out of the experimental storage container.

This is done so that the total weight of dry matter placed in the experimental conditions can be compared with the total dry weight of matter removed the dry weight lost during the experiment is then usually expressed as a percentage of the beginning dry weight.

Bulk Density Method.

This is also called the standard volume weight method (SVW) which is the mass of a material for each unit of volume it occupies. The bulk density of grain has been used by most of the grain industry for many years as an indicator of processing yield.

It was proposed that changes in bulk density of grain be used as indicator of weight loss, since the bulk density of a grain is always determined over a range of moisture contents before this method can be used. The samples of the same grains are taken after damage is presumed to have occurred, the bulk density (expressed as dry weight) of the damaged sample is compared to the dry bulk density of sound grain at the same moisture content and the difference is divided by dry bulk density of the sound grain and the result expressed in percentage.

Percentage X Damage Factor Method

This method depends mainly on the difference between the mean weight, damaged kernels and the mean weight of undamaged kernels. When using this method, calculation is based on the percentage of the damaged kernels in a grain sample multiplied by a factor representing the presumed percent weight lost per damaged kernel.

A portion containing from 100 to 1000 grains should be used to determined the percentage damaged.

Others

These are local methods used by farmers to determine the viability of the grain yet to be store.

Odour (Aroma) : most grain types, when fresh, have a distinctive natural odour. This is generally accepted as an indicator of good quality , although some people prefer grain which smells old or even fermented.

2.6 Statement of problems.

The followings are the statement of problems for this study.

(a) Structures:

To ascertain or identify the most suitable storage structure that will suit a particular local government area within the state. Also those that are not applicable to that should be discouraged.

(b) Methods.

The various methods used in storing farm produce were examined though not all methods used are good for the storage of farm produce. Better methods are introduced to farmers through the extension workers.

(c) Losses.

To identify various storage structure losses, quantity of grain loss and identifying the various agent of losses in the study area.

CHAPTER THREE

3.0 MATERIALS AND METHODOLOGY.

For study work Benue State was chosen as a case study and it is made up of twenty-three (23) Local Government areas. For effective coverage of the State, the collection areas which are the local government areas were randomly selected.

The study was based on the following local government areas, in the State. They include Apa, Gboko, Makurdi, Kwande, Agatu, Ado, Guma, Konshisha, Vandekiya, Tarka, Gwer east and Otukpo.

3.1 Research method used.

The method used in gathering information for this study was by the use of questionnaires. The responses were later analysed. Farm visits and personal interviews of some farmers/personnel directly involved in charge of the use of storage structures in the farm were undertaken. Inspection of the structures of each farms visited and also inspection of various grains available for storage were carried out.

Question set were aimed at obtaining some information on the number of hectares Cultivated, type of grain grown, method of handling, storage structures, methods of storage, losses due to agent of storage and quantity lost.

In each district, at least twelve and not more than twenty people were interviewed per district. A grade line was drawn by using block design in selecting collection points in each of the local government areas to ensure an even distribution in the pattern of coverage. Two houses along a street were picked at intervals of the houses. Grain sellers were also considered which was done on market days in the various district. Grain samples were collected from the marketers considering rows of grain sellers with intervals of three [3] rows one after the other.

3.2 Administering the questionnaires.

The questionnaires were distributed to the persons in charge of relevant information needed and they were requested to ask questions on any part of it which seemed ambiguous. Some of the questionnaires given out were not returned due to their misplacement by the respondents. The questionnaires consist basically of multiple choice and descriptive forms.

The districts in each local government area, which gives a total of 60 districts, covered.

Table 3.2. Sample Method and in each Local Government Area.

S/No	L.G.A	No. Of Villages	No. Of houses.
1	Apa	5	12
2	Gboko	5	14
3	Makurdi	5	20
4	Kwande	5	14
5	Agatu	5	12
6	Ado	5	12
7	Guma	5	14
8	Konshisha	5	14
9	Vandekiya	5	18
10	Tarka	5	16
11	Gwer east	5	14
12	Otukpo	5	18

3.3 Methods employed in estimating Storage Losses.

Six methods are available for estimating storage losses, the following methods were chosen out of the six.

i Count and weight method.

ii Weigh in-weigh-out method.

These two methods above were chosen due to their simplicity.

3.3.1 Count and weigh method.

This method involves the collection of samples of grains from the farmers. The samples collected numbered between 1000 Kernels, which were removing Contaminants.

The samples were carefully observed Kernel to Kernel to separate the damage grains from the undamaged ones separating the samples into the damaged and sound Kernels, each of these fractions was weighed and removed. The percentage weight lost was then calculated using the following formulae.

$$\text{Percentage weight lost} = \frac{(Und - Dnu)}{U(Nd + Nu)} \times 100$$

Where; U = weight of sound or undamaged Kernels.

D = weight of damaged Kernels.

Nu = Number of sound Kernels.

Nd = Number of damaged Kernels.

The counting and weighing of samples up to an extent could be correct when carefully carried out, though problem involved is the separation of the sound from the damaged Kernels, also the separation could generate some errors in calculation.

To calculate percentage weight from samples, a total of 1000 sample of grain was collected.

$$\text{Percentage weight loss} = \frac{Und - Dnu}{U(Nd + Nu)} \times \frac{100}{1}$$

U = 1.5kg

Nu = 548

D = 1.10kg

Nd = 452

$$\text{Percentage weight loss} = \frac{1.5(452) - 1.1(548)}{1.5(452 + 548)} \times 100$$

$$= \frac{678 - 602.8}{1.5(1000)} \times 100$$

$$= \frac{75.2}{1500} \times 100$$

$$= \frac{752.0}{1500}$$

$$= 5.013$$

$$= 5\%.$$

3.3.2 Weigh – in – Weigh– out method.

The use of this method was basically on the questionnaires. In the questionnaires, the farmers were asked to give an estimated weight lost during storage.

This weight loss could be as a result of the quantity and quality losses. They were able to do this because of long time handling of grains.

This method was chosen to compare what the farmer felt in weight loss of his grains and what is gotten in the laboratory using other methods.

3.4 Problems encountered during the course of survey.

Some farmers/marketers visited during the survey thought that the study was government sponsored and so they should be given some money before the questions are answered. Because there was no money to meet such requests, when such a problem occurs, author had to plead and explain the rationale behind this until favourable response was obtained from such category of people. In some instances, efforts to get favourable response proved abortive.

This group of people which comprises mainly of those working in establish private farms, believed that questionnaires was a means devised by the government to asses their income for purpose of taxation.

Some respondent will keep this author waiting in the farm on the pretence of coming back and at the end will not return to the farm for the day.

Also bureaucratic policies in government establishment made it difficult to get the necessary information needed from these establishments. These were either on the pretence that the officer in charge of the section where the information were needed was not on seat. Some may say that instruction has been given not to entertain any question from outsiders pertaining to the establishment.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSIONS

4.1 RESULTS.

The sources of information for the weigh-in-weigh-out method was the administration of questionnaire while that of count and weigh method was based on the samples of grain collected from the various farmers and marketers in each local government areas.

The count and weigh method was chosen because of its simplicity weighing the grain twice of different times which involves grains handling this eliminating errors in losses estimation.

For the weigh-in-weigh-out method this does not involves the researcher actually weighing the grains, the farmers were able to give in adequate information of estimated storage losses based on this method which was made possible due to long time experience on handling grains.

4.1:1. Estimation of percentage weight loss.

The main method used to estimation the percentage of grain list was the count and weigh method. This method makes use of the mean kernel weight of the grain. This compares the kernels of the damage and the undamaged grain taken from whose bulk.

The grain was cleaned to remove contaminants. Each grain was then classified as sound and damaged darnels. The kernels from each fraction were counted and weighed to allow for calculation of mean kernels weight of each fraction and the proportion of damage kernel.

Below was the formula used in the estimation of percentage weight lost.

Percentage weight loss $= \frac{(UNd - DNu)}{U(Nd + Nu)} \times \frac{100}{}$

Where U = weight of undamaged kernels

Nu = Number of undamaged kernels

D = Weight of damaged kernels

Nd = Number of damaged kernels

4.1:2. Quantity of grain loss estimation.

Calculation of losses due to insect

All weights of samples are expressed on a 14% moisture content basis.

$$\text{Weight loss} = \left(\frac{\text{Quantity of grain removed}}{100 - \%\text{ loss in samples by count and weigh}} \times 100 \right)$$

- (Quantity of grain removed)

Where % loss in sample by count and weigh = 5%.

Weight loss as percentage $= \frac{\text{weight lost}}{\text{Weight stored}} \times \frac{100}{1}$

Calculations

1. Losses due to insect in Apa L.G.A

Quantity of grain originally stored = 420,968.0kg.

Quantity of grain removed = 370,225.26kg

Loss in sample by count and weigh = 5%

Weight loss $= \frac{370,225.26}{100 - 5} \times \frac{100}{} - 370,225.26\text{kg}$

$= \frac{(370225.26 \times 100)}{(95)} - 370,225.26\text{kg}$

= 389,710.8 - 370,228.26

= 19,485.54 kg

Weight loss as percentage = $\frac{19485.54}{420,968.0} \times \frac{100}{}$

= 4.6 %

The quantity of grain loss due to insect in Apa L.G.A is given to be = 19,485.54 kg

and the percentage weight loss = 4.6%.

2. Losses due to insect in Gboko L.G.A.

Quantity of grain originally stored = 306,133.14 kg

Quantity of grain removed = 257,455.14kg

Loss in sample by count and weigh = 5%

Weight loss = $\frac{257,455.13}{100-5} \times 100 - (257,455.13)$ kg

= $\frac{(275455.13 \times 100)}{95} - (257,455.13)$ kg

= (271005.4 –257,455.13) kg

= 13,550.27kg

Weight loss as percentage = $\frac{13550.27}{306,133.14} \times \frac{100}{1}$

= 4.6%

The quantity of grain loss due to insect in Gboko L.G.A is given to be = 13,550. 27kg

and the percentage weight loss = 4.6%

3 Losses due to insect in Makurdi L.G.A

Quantity of grain originally stored = 291,486.1 kg

Quantity of grain removed = 242, 699kg

Loss in Sample by count and weigh = 5%

$$\text{Weight loss} = \frac{242{,}699.16}{(100-5)} \times 100 - [242{,}699.16]\ \text{kg}$$

$$= \frac{242699.16 \times 100}{95} - [242{,}699.16]\ \text{kg}$$

$$= (255.472.8 - 242{,}699.16)\ \text{kg}$$

$$= 12{,}773.64\text{kg}.$$

$$\text{Weight loss as \%} = \frac{12773.64}{291{,}486.4} \times \frac{100}{1}$$

$$= 4.4\%$$

The quantity of grain lost due to insect in Makurdi L.G. A is given to be =12,773.64 Kg and the percentage weigh loss = 4.4%.

4 Losses due to insect in Kwande L. G. A.

Quantity of grain originally stored =300,376.3 kg

Quantity of grain removed = 255, 029.4 kg

Loss in sample by count and weigh = 5%

$$\text{Weight loss} = \frac{255,\ 029.4}{(100-5)} \times \frac{100}{1} - (255{,}029.4)\ \text{kg}$$

$$= \left(\frac{255{,}029.4}{95} \times 100\right) - (255{,}029.4)\ \text{kg}$$

$$= (268{,}452.0 - 255{,}029.4)\ \text{kg}$$

$$= 13422.6\ \text{kg}$$

$$\text{Weight loss as percentage} = \frac{13422.6}{300{,}376.3} \times \frac{100}{1}$$

$$= 4.5\%.$$

The quantity of grain loss due to insect in Kwande L. G. A is given to be =13,422.6 kg and the weight loss as percentage = 4.5%

5 Losses due to insect in Agatu L.G.A.

Quantity of grain originally stored =292, 786. 25 kg

Quantity of grain removed = 244,149. 05 kg.

Loss in sample by count and weigh = 5%.

$$\text{Weight loss} = \frac{(244{,}149.05 \times 100)}{(100-5)} - (244, 149.05)\ \text{kg}$$

$$= \frac{(244{,}149.05 \times 100)}{95} - (244{,}149.05)\ \text{kg}$$

$$= (256{,}999.0 - 244{,}149.05)\ \text{kg}$$

$$= 12, 849.95\ \text{kg}.$$

$$\text{Weight loss as percentage} = \frac{12849.95}{292{,}786.25} \times \frac{100}{}$$

$$= 4.4\%$$

The quantity of grain loss due to insect in Agatu. L.G.A is given to be = 12,849.95 kg and the weight loss as percentage =4.4%.

6 Losses due to insect in Ado L.G.A.

Quantity of grain originally stored = 293,044.4 kg

Quantity of grain removed = 247,551.95 kg

Loss in sample by count and weigh = 5%

$$\text{Weight loss} = \frac{247{,}551.95}{100-5} \times 100 - (247{,}551.95)\ \text{kg}$$

$$= \frac{247{,}551.95 \times 100}{95} - (247{,}551.95)\ \text{kg}$$

= (260,581.0 – 247, 551. 95) kg

= 13, 029. 05 kg

Weight loss as percentage = $\frac{13{,}029.05\ \text{kg}}{293{,}044.4\ \text{kg}} \times \frac{100}{1}$

= 4.5%.

The quantity of grain loss due to insect in Ado L.G.A is given to be = 13,029.05 and the percentage weight loss = 4.5%

7 Losses due to insect in Guma L.G.A.

Quantity to grain originally stored = 270, 180. 4 kg

Quantity of grain removed = 225,161.4 kg

Loss in sample by count and weigh = 5%.

Weight loss = $\frac{225{,}161.4}{100-5} \times 100 - (225, 161.4)$ kg

= $\frac{(225, 161.4 \times 100)}{95} - (225, 161.4)$ kg

= (237, 012.0 – 225,161.4) kg

= 11, 850.6 kg.

Weight loss as percentage = $\frac{11850.6}{270{,}180.4} \times 100$

= 4.4%

The quantity of grain loss due to insect in Guma L.G.A is given to be = 11,850.6 kg and the percentage weight loss = 4.4%

8 Losses due to insect in Konshisha L.G.A.

Quantity of grain originally stored = 303, 794.3 kg

Quantity of grain removed = 258, 960.5 kg

Loss in sample by count and weigh = 5%

Weight loss = $\frac{258,960.5}{100-5} \times \frac{100}{1}$ – (258,960.5) kg

= $\frac{(258,960.5 \times 100)}{95}$ - (258, 960.5) kg

= (272,590.0 – 258,960.5)kg

= 13,629.5 kg.

Weight loss as percentage = $\frac{13629.5}{303,794.3} \times \frac{100}{1}$

= 4.5%

The quantity of grain loss due to insect in Konshisha L.G.A is given to be = 13,629.5 kg and the weight loss as percentage = 4.5%

9 Losses due to insect in vandekiya L.G.A

Quantity of grain stored originally =293,157.86 kg

Quantity of grain removed = 252,439.7 kg.

Losses in sample by count and weigh = 5%.

Weight Loss = $\frac{252\ 439.7}{100-5} \times \frac{100}{1}$ - (252,439.7) kg

= $\frac{(252\ 439.7 \times 100)}{95}$ – (252,439.7) kg

= (265,726.0 – 252,439.7) kg

= 13,286.3 kg.

Weight loss as percentage = $\frac{13286.3}{293,157.86} \times \frac{100}{1}$

= 4.45%.

The quantity of grain loss due to insect in Vandekiya L.G.A is given to be = 13,286.3 kg and the weight loss on percentage is 4.45%.

10 Losses due to insect in Tarka L.G.A.

Quantity of grain stored originally = 309, 849.4 kg

Quantity of grain removed = 264,288.1 kg

Loss in sample by count and weigh = 5%.

$$\text{Weight loss} = \frac{264,288.1}{(100-5)} \times \frac{100}{1} - (264,288.1)\ \text{kg}$$

$$= \frac{(264,288.1 \times 100)}{95} - (264,288.1)\ \text{kg}$$

$$= (278,198.0 - 264,288.1)\ \text{kg}$$

$$= 13,909.9\ \text{kg}.$$

$$\text{Weight loss as percentage} = \frac{13909.9}{309,8494} \times \frac{100}{1}$$

$$= 4.5\%$$

The quantity of grain loss due to insect in Tarka L.G.A is given to be = 13,909.9 kg and the weight loss as percentage in 4.5%.

11 Losses due to insect in Gwer east L.G.A.

Quantity of grain originally stored = 249,137.6 kg

Quantity of grain removed = 211,547.9 kg

Loss in sample by count and weigh = 5%.

$$\text{Weight loss} = \frac{211,547.9}{100-5} \times \frac{100}{1} - (211,547.9)\ \text{kg}$$

$$= \frac{(211,547.9 \times 100)}{95} - (211,547.9)\ \text{kg}$$

$= (222,682,0 - 211,547.9)\ kg$

$= 11,134.1\ kg.$

$$\text{Weight loss as percentage} = \frac{11,134.1}{249,137.6} \times 100$$

$= 4.43\%.$

The quantity of grain loss due to insect in Gwer east L.G.A is given to be = 11,1 34.1 kg and the weight loss as percentage = 4.43%.

12 Losses due to insect in Otukpo L.G.A.

Quantity of grain originally stored = 265,374.2 kg

Quantity of grain removed = 224, 177.2 kg

Loss in sample by count and weigh = 5%.

$$\text{Weight loss} = \frac{224,177.2}{(100-5)} \times 100 - (224,177.2)\ kg$$

$$= \frac{(224,177.2 \times 100)}{95} - (224,177.2)kg$$

$= (235,976.0 - 224,177.2)\ kg$

$= 11, 798.8\ kg$

$$\text{Weight loss as percentage} = \frac{11798.8}{265374.2} \times 100$$

$= 4.4\%$

The quantity of grain loss due to insect in Otukpo L.G.A is given to be = 11, 798. 8 kg and the weight loss as percentage = 4.4%.

To calculate for the total quantity of grain loss, the quantity of grain removed from the store is deducted from the quantity of grain originally stored. The quantities

are based on 100kg per bag, which the farmer uses as scale for measurement of their produces. Thus,

Quantity of grain originally stored = 3596, 269.95 kg

Quantity of grain removed after some period of time = 3053,669.15kg

= 542,600.80kg

The difference is thus the total quantity that is lost due to various agents, which equals to 542,600.8kg.

From the Cumulative of the losses due to insect, a total of 160,712.25kg was observed. From field Survey, it was observed that Rodent recorded 22.96% of the total losses, Handling recorded 21.22%, Birds recorded 11.7%, Thieves recorded 7.54% and 4.8% was observed for fire accidents.

Quantity loss to other agents are calculated thus below.

Rodent

$$\frac{22.96}{100} \times \frac{542,600.8}{1}$$

= 124,590.2kg

Handling

$$\frac{21.22}{100} \times \frac{542,600.8}{1}$$

= 115,154.02kg

Birds

$$\frac{11.7}{100} \times \frac{542,600.8}{1}$$

= 63,361.88kg

Thieves

$$\frac{7.54}{100} \times \frac{542,600.8}{1}$$

= 40,923.22kg

Fire (hazard)

$$\frac{4.8}{100} \times \frac{542,600.8}{1}$$

= 25,885.16kg

From market study during survey work carried out, prices for various grains were observed and projections were made based on these prices to estimate the monetary cost of losses encountered.

Table 4.1 Showing prices/quantity of grain lost in kg

Grains	Quantity loss in (kg)	₦ Amount/kg	₦ Amount Total
Rice	89,606.9	90	6,409,701
Maize	176,295.6	30	4,731,459
Sorghum	114,730.6	25	2,403,770
Millet	119,270.6	25	2,517,265
Soya bean	44,388.9	50	10,220,177
	542,600.8		#21,500,000.00

Table 4.2 DISTRIBUTION OF CROP CULTIVATED IN EACH L.G.A OF BENUE STATE (%)

S/NO	Grain/LGA	Rice	Maize	Sorghum	Soya bean	Millet
1	Apa	25.04	21.36	21.12	16.41	14.07
2	Gboko	26.20	20.54	22.17	17.58	13.51
3	Makurdi	26.53	21.66	19.91	17.32	14.57
4	Kwande	21.27	22.24	21.36	19.11	16.02
5	Agatu	24.84	20.26	19.33	19.76	15.88
6	Ado	22.64	23.95	21.40	17.91	14.61
7	Guma	22.35	23.14	20.22	17.48	16.86
8	Konshisha	21.54	21.06	21.14	17.77	18.14
9	Vandekiya	22.26	22.44	20.48	17.70	17.18
10	Tarka	21.32	22.88	19.33	18.60	17.80
11	Gwer east	21.04	22.42	20.20	18.80	17.79
12	Otukpo	23.05	22.71	21.02	18.11	16.06
	Average	23.10	22.1	20.7	18.10	16.00

TABLE 4.3 DISTRIBUTIONS OF STORAGE METHODS IN BENUE STATE IN EACH L.G.A

S/NO	Structures/LGA	Pot	Pit	Bags	Basket	Silo	Ware house	Hanging	Jerry cans	Total
1	Apa	70	18	102	38	18	30	52	68	396
2	Gboko	55	27	136	39	25	41	59	87	469
3	Makurdi	49	40	61	31	54	114	58	75	482
4	Kwande	96	17	77	40	86	17	33	36	324
5	Agatu	83	21	59	46	6	13	28	30	298
6	Ado	47	15	98	30	5	10	45	35	284
7	Guma	53	19	65	41	-	4	51	22	256
8	Konshisha	62	20	80	60	-	14	31	21	302
9	Vandekiya	45	35	68	60	7	7	28	32	278
10	Tarka	55	30	65	60	6	11	42	23	295
11	Gwer east	63	14	68	59	12	15	40	62	316
12	Otukpo	70	26	80	64	33	24	53	38	388
	Total	748	282	956	568	252	300	520	529	
	%	18	6.8	23	13.7	6.1	7.2	12.5	12.73	100%

Table 4.4 Percentage Distribution of Storage Structures in Benue State in Each L.G.A

S/NO	Structures/LGA	Pot	Pit	Bags	Basket	Silo	Ware house	Hang ing	Jerry cans
1	**Apa**	17.73	4.6	25.8	9.4	4.6	7.4	13.3	17.1
2	**Gboko**	11.7	5.7	29.0	8.4	5.3	8.6	12.7	18.6
3	**Makurdi**	10.2	8.3	12.7	6.4	11.2	23.7	12.0	15.5
4	**Kwande**	24.6	5.3	23.6	12.4	2.6	5.4	10.0	11.0
5	**Agatu**	28.0	6.9	19.6	15.4	2.1	4.2	9.4	10.0
6	**Ado**	16.4	5.3	34.6	10.4	1.6	3.4	15.9	12.3
7	**Guma**	20.8	7.4	25.4	16.2	-	1.6	20.1	8.6
8	**Konshisha**	20.4	6.7	26.4	19.8	-	4.6	10.3	6.8
9	**Vandekiya**	16.3	12.4	24.5	21.4	2.4	2.4	10.0	11.5
10	**Tarka**	18.6	10.2	22.7	20.3	2.1	3.7	14.3	8.0
11	**Gwer east**	19.6	4.4	21.7	18.7	3.6	4.7	12.7	19.3
12	**Otukpo**	18.1	6.5	20.7	16.4	8.3	6.4	13.6	9.8

Table 4.5 Grain loss in each storage structure method in each L.G.A (%)

	Structures/LGA	Pot	Pit	Bags	Basket	Silo	Ware house	Hang ing	Jerry cans
1	Apa	7.6	14.97	25.8	10.3	5.4	4.4	24.6	6.93
2	Gboko	10.4	12.83	31.43	9.4	4.6	6.5	18.69	6.2
3	Makurdi	6.2	8.34	29.6	20.4	2.4	10.4	17.5	5.2
4	Kwande	9.3	7.4	26.9	18.4	3.8	7.8	23.6	2.7
5	Agatu	6.4	8.3	24.4	25.5	0.5	6.5	24.7	3.9
6	Ado	6.6	9.4	24.6	28.0	0.4	5.9	20.7	4.4
7	Guma	7.8	14.0	26.8	15.3	-	4.3	24.5	6.9
8	Konshisha	8.6	9.3	28.6	21.4	-	9.4	18.5	4.2
9	Vandekiya	6.5	8.2	25.4	24.5	0.5	6.4	23.7	4.9
10	Tarka	8.3	8.4	25.9	19.5	3.7	7.9	22.6	3.7
11	Gwer east	6.5	9.5	24.7	27.9	0.5	5.9	21.7	3.4
12	Otukpo	6.1	8.4	28.6	21.4	2.5	10.3	18.5	4.2

Table 4.6 Quantity of grain lost to each storage structures in each L.G.A (Kg)

S/NO	Structures/LGA	Pot	Pit	Bags	Basket	Silo	Ware house	Hang ing	Jerry cans	Total
1	**Apa**	3856.5	7596.3	13091.8	5226.6	2740.2	2232.7	12,482.9	3516.5	50743.5
2	**Gboko**	5219.4	6438.9	15,773.5	4717.5	2308.6	3262.1	9379.8	3086.5	50186.3
3	**Makurdi**	2999.9	4035.3	14,341.3	9846.4	1161.2	5012.7	8481.9	2506.3	48385
4	**Kwande**	4217.2	3781.9	12,211.9	8366.5	1723.2	4,697.9	7949.3	2348.9	45296.8
5	**Agatu**	3112.8	4036.9	11,848.0	12,378.2	223.7	3,137.1	12003.7	1896.9	48637.3
6	**Ado**	3002.5	4276.3	11,200.3	12,728.8	172.9	2697.7	9,407.9	2006.2	45492.6
7	**Guma**	3511.9	6289.9	12066.7	6888.8	-	1936.1	11631.1	3106.7	45431.2
8	**Konshisha**	3855.7	4187.5	12840.4	9572.0	-	4196.4	8307.7	1874.1	44833.8
9	**Vandekiya**	2646.7	3338.9	10,326.1	9955.6	195.5	2618.2	9642.1	1995.2	40718.3
10	**Tarka**	3781.6	3827.2	11,814.1	8861.7	1685.8	3613.0	10,315.1	1662.9	45561.4
11	**Gwer east**	2443..3	3571.0	9292.2	10480.0	172.9	2206.5	8149.5	1281.8	35797.2
12	**Otukpo**	2513.0	3439.9	11,798.8	8795.6	1029.9	4226.8	7633.8	1722.0	41159.8
	Total	41,160.5	54,820	134,905.1	107,817.7	11,413.9	39837.2	115,384.80	27004	542,600.8

Table 4.7 Quantity of grain lost to each agent in each L.G.A of Benue State (Kg)

S/NO	**Agents/LGA**	Insects	Rodents	Handling	Birds	Thieves	Fire	Total
1	**Apa**	9485.54	14,512.70	12,381.44	4363.90	-	-	50743.6
2	**Gboko**	13,550.27	11,291.90	10,739.85	1605.96	6072.53	5420.10	48,680.61
3	**Makurdi**	12,773.64	11,709.17	10,935.01	3774.03	4935.30	4257.90	48,385.0
4	**Kwande**	13,422.60	10,171.26	9,423.04	3818.19	7391.50	1120.060	45,346.90
5	**Agatu**	12,849.95	11,492.97	10,928.28	5262.55	4,197.39	3905.60	48,637.20
6	**Ado**	13,029.05	11,718.90	9271.40	5149.80	4189.90	2133.60	45,492.50
7	**Guma**	11,850.60	10,855.50	9005.0	6587.20	3363.40	3363.40	45,025.0
8	**Konshisha**	13,629.50	11,791.30	8253.90	5662.50	3183.20	2313.4	44,833.8
9	**Vandekiya**	13,286.30	11,580.20	7455.50	6233.95	2162.10	-	40,718.16
10	**Tarka**	13,9099.	12,046.40	11,258.20	8346.80	-	-	45,561.3
11	**Gwer east**	11,134.10	9,145.6	7002.96	5792.60	2766.60	1747.90	37,589.7
12	**Otukpo**	11,798.8	9854.3	8498.94	6764.40	2661.30	1623.20	41,197.0
	Total	160,712.25	124,590.0	115,154.02	63,361.88	40,923.22	25,885.16	542,600.8
	%	29.6	22.96	21.22	11.7	7.54	4.8	

Table 4.8 percentage grain lost to each agent in each LGA (%).

S/NO	**Agents/LGA**	Insects	Rodents	Handling	Birds	Thieves	Fire
1	**Apa**	38.4	28.6	24.4	8.6	-	-
2	**Gboko**	27	22.5	24.4	3.2	12.1	10.8
3	**Makurdi**	26.4	24.2	22.6	7.8	10.2	8.8
4	**Kwande**	29.6	22.4	20.8	8.4	16.3	2.5
5	**Agatu**	26.4	23.6	22.5	10.8	8.6	8.0
6	**Ado**	28.6	25.8	20.4	11.3	9.21	4.7
7	**Guma**	26.3	24.1	20.0	14.6	7.5	7.5
8	**Konshisha**	30.4	26.3	18.4	12.6	7.1	5.2
9	**Vandekiya**	32.6	28.4	18.3	15.3	5.3	-
10	**Tarka**	30.5	26.4	24.7	18.3	-	-
11	**Gwer east**	29.6	24.3	18.6	15.4	7.4	4.7
12	**Otukpo**	28.6	23.9	20.6	16.4	6.5	3.9

Table 4.9 percentage of quantities of grains lost annually to each L.G.A in Benue State.

S/NO	Grain/LGA	Rice	Maize	Sorghum	Soya bean	Millet
1	**Apa**	19.8	30.6	22.1	7.3	20.2
2	**Gboko**	22.4	29.5	21.3	7.7	22.4
3	**Makurdi**	13.1	34.0	22.0	9.2	22.3
4	**Kwande**	16.4	33.1	20.3	7.5	22.6
5	**Agatu**	16.5	34.8	21.1	7.9	19.8
6	**Ado**	15.2	31.2	21.6	8.1	24.0
7	**Guma**	15.1	29.8	23.1	9.2	23.0
8	**Konshisha**	15.6	31.9	21.9	8.7	21.9
9	**Vandekiya**	18.7	31.7	18.8	7.8	21.9
10	**Tarka**	16.9	35.8	18.6	7.5	21.4
11	**Gwer east**	15.7	32.0	22.0	9.4	20.9
12	**Otukpo**	12.4	36.5	21.3	23.1	23.1

Table 4.10 Quantity of grain lost annually in each L.G.A of Benue State (kgs)

S/NO	Grain/LGA	Rice	Maize	Sorghum	Soya bean	Millet	Total
1	**Apa**	10,054.0	15,540.6	11,204.4	3,704.2	10,240.4	50,743.6
2	**Gboko**	10,930.3	14,312.0	10,330.6	3,710.4	10,902.6	48,680.6
3	**Makurdi**	6,257.6	16,386.4	10,573.1	4,414.8	10,753.4	48,385.0
4	**Kwande**	7,439.4	15,011.8	9,230.1	3,417.2	10,247.0	45,346.7
5	**Agatu**	8,031.4	16,917.6	10,234.3	3,833.2	9,621.1	48,637.2
6	**Ado**	6,950.4	14,206.1	9,779.2	3,674.8	10,880.4	45,492.5
7	**Guma**	6,790.7	13,410.0	10,372.3	4,131.4	10,319.0	45,025.0
8	**Konshisha**	6,997.4	14,289.3	9,829.9	3,882.8	9,831.6	44,833.8
9	**Vandekiya**	7,446.5	12,881.4	7,718.6	3,146.2	9,378.1	40,718.2
10	**Tarka**	7,688.5	16,280.4	8,452.9	3,420.4	9,718.7	45,561.2
11	**Gwer east**	5,901	12,033.4	8,275.4	3,531.6	7,848.7	37,589.7
12	**Otukpo**	5,119.7	15,026.3	8,776.8	3,521.9	9,529.6	41,197.0
	Total	89,606.9	174,556.8	114,777.6	44,388.9	119,270.6	542,600.8
	%	13.1	29.1	17.5	4.7	18.6	100%

Fig 4.1.1 % Distribution of storage structures in Apa L.G.A

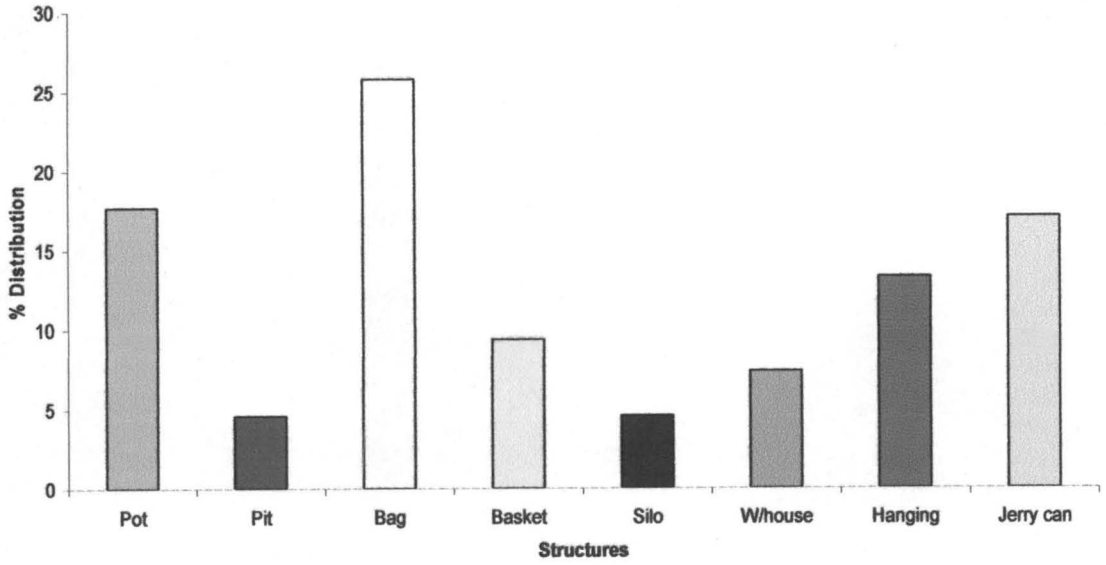


Fig 4.1.2 % Distribution of storage structures in Gboko L.G.A

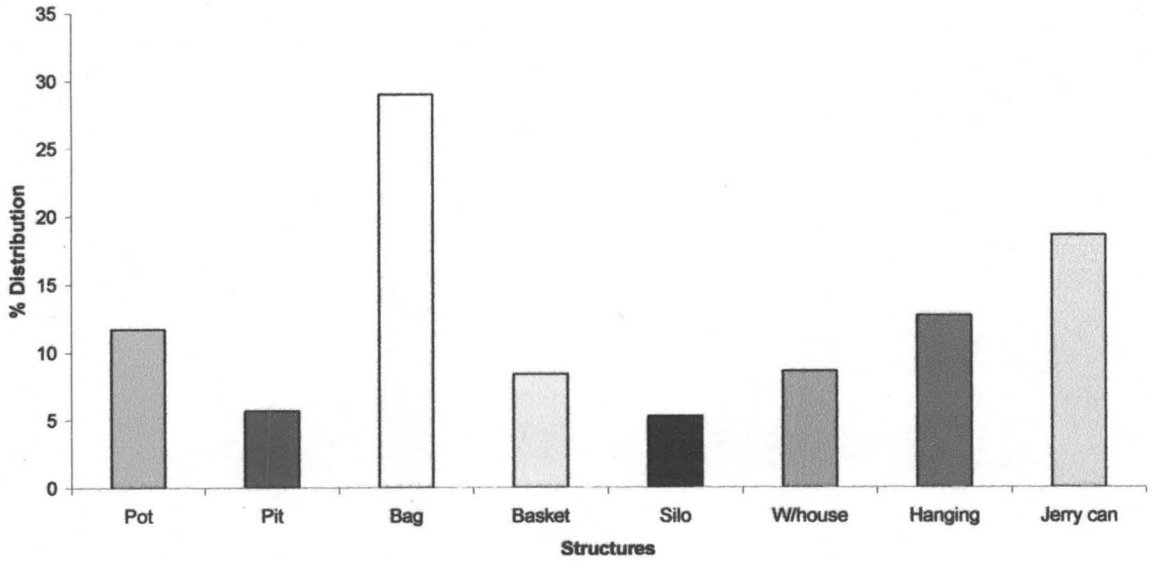


Fig.2.4.3 % Distribution of storage structures in Makurdi L.G.A

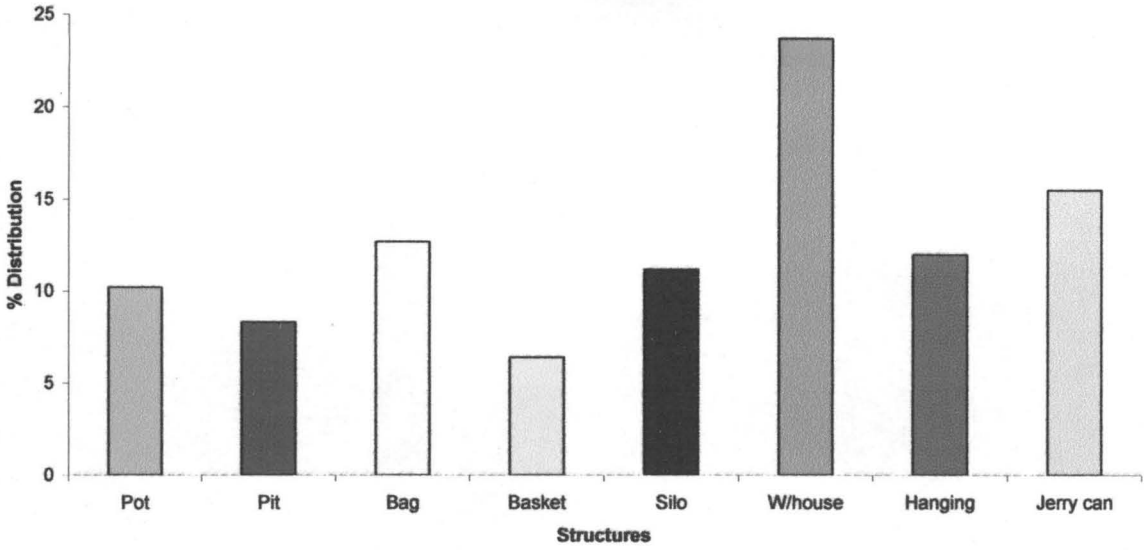


Fig.2.4.4.% Distribution of storage structures in Kwande L.G.A

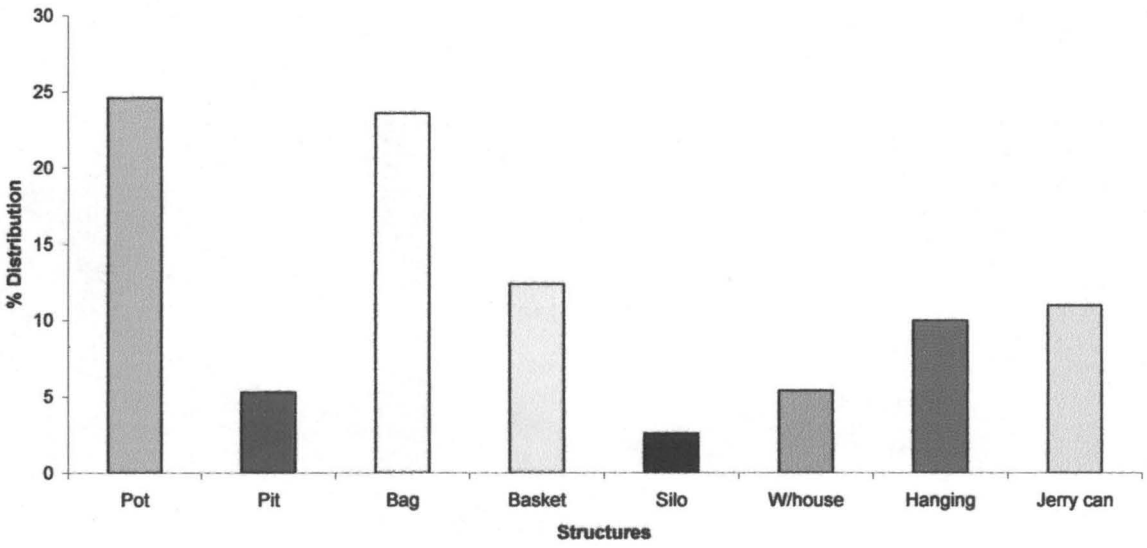


Fig.4.4.5.% Distribution of storage structures in Agatu L.G.A

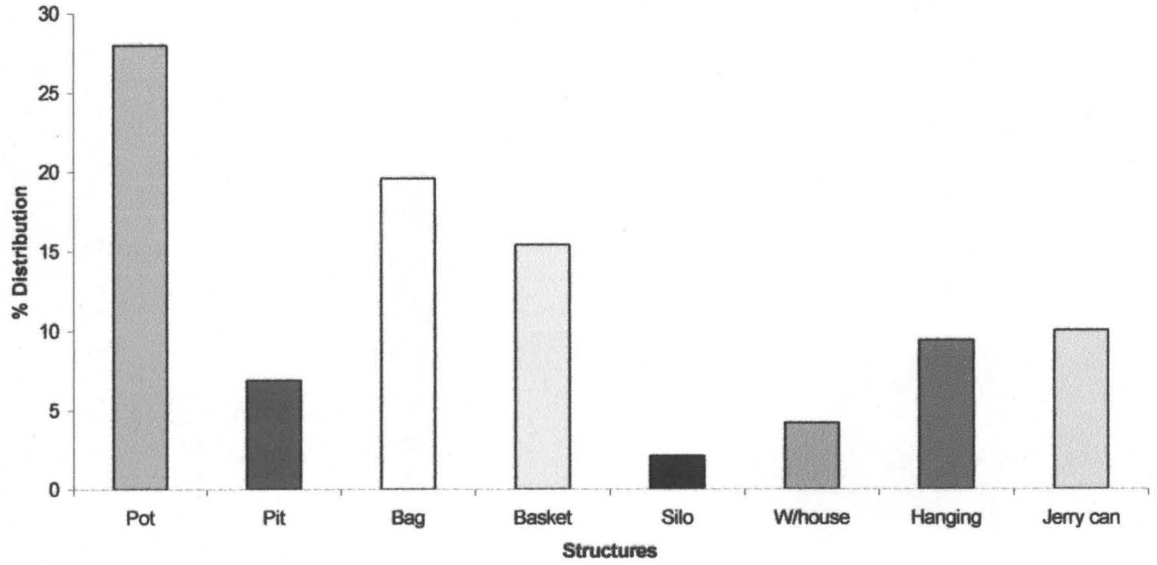


Fig.4.4.6.% Distribution of storage structures in Ado L.G.A

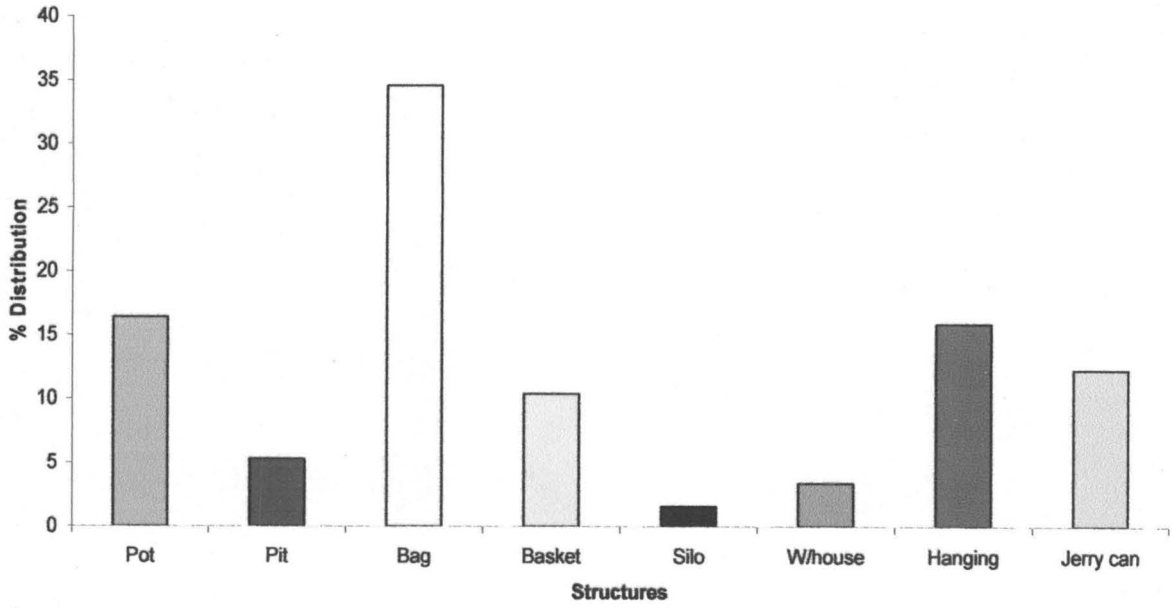


Fig.4.7.% Distribution of storage structures in Guma L.G.A

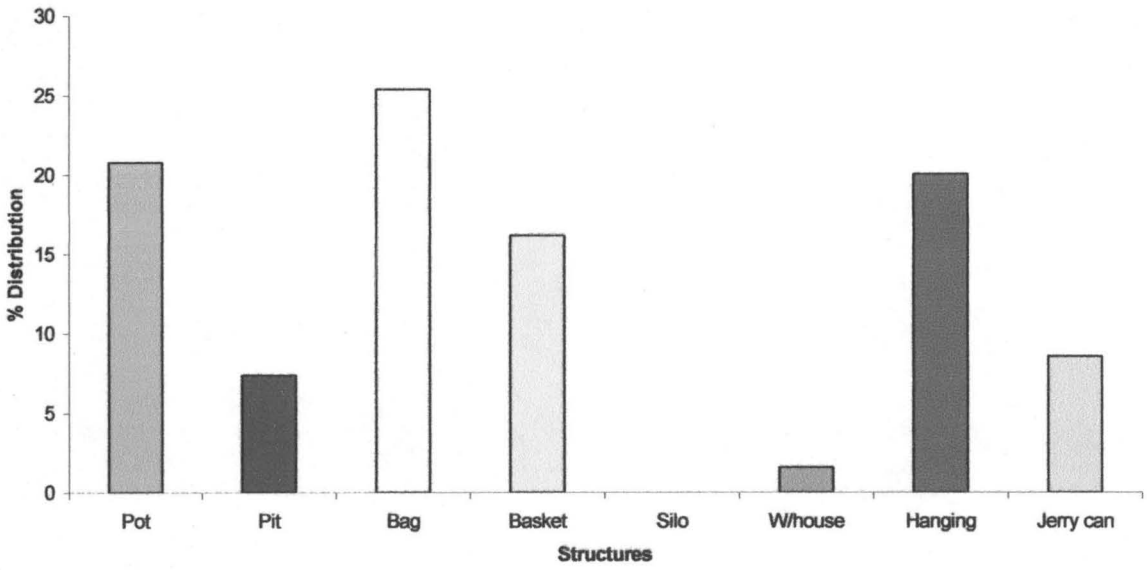


Fig.4.8.% Distribution of storage structures in Konshisha L.G.A

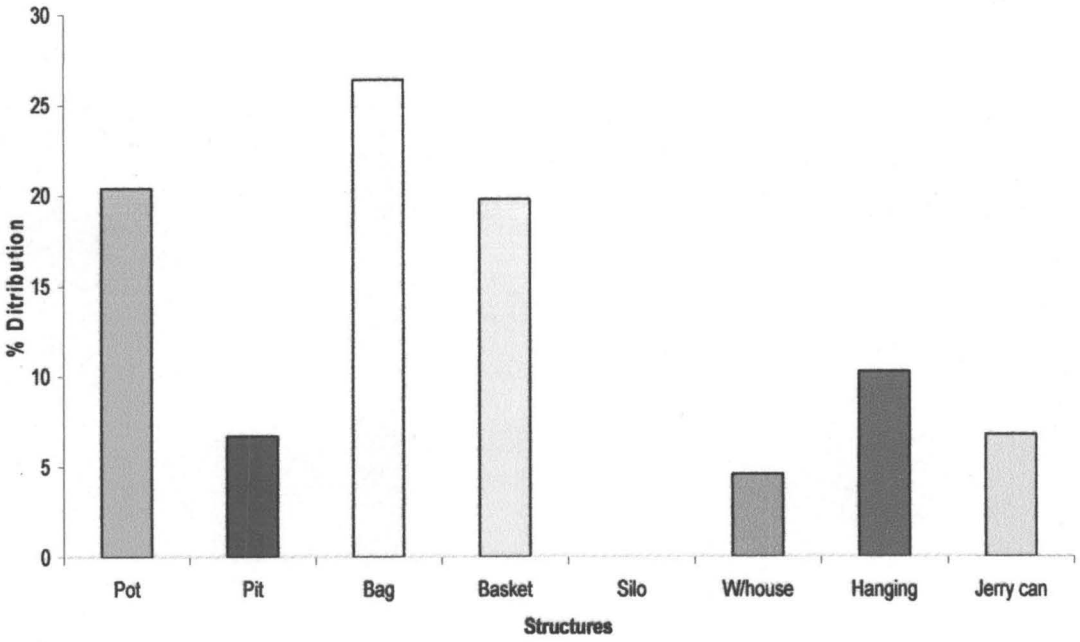


Fig.4.9. % Distribution of storage structures in Vandekiya L.G.A

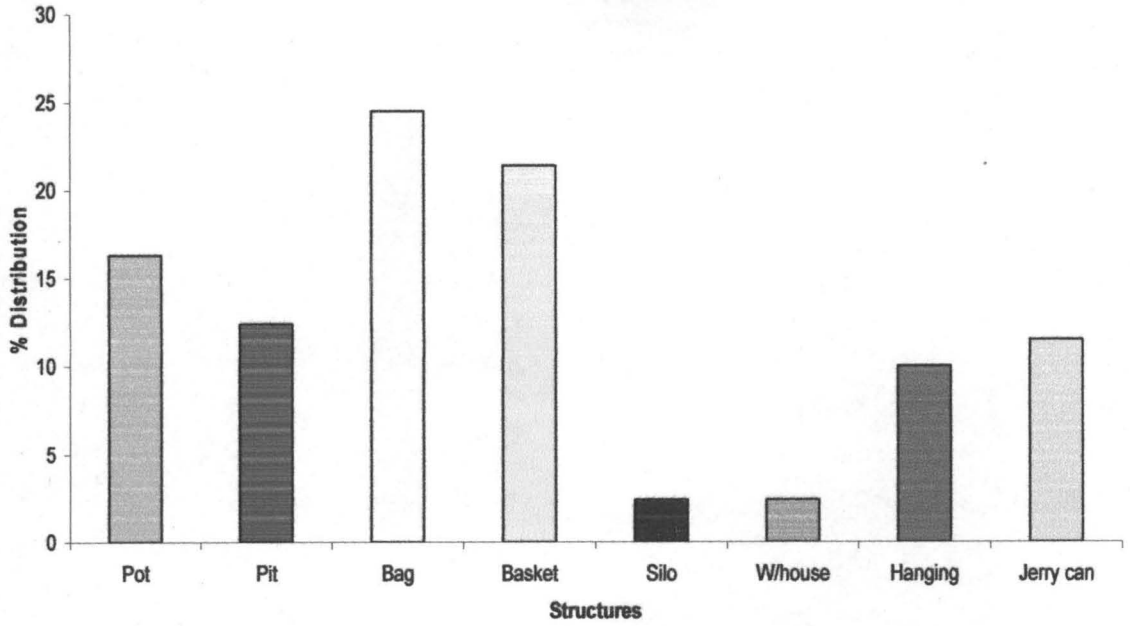


Fig.4.10.% Distribution of storage structures in Tarka L.G.A

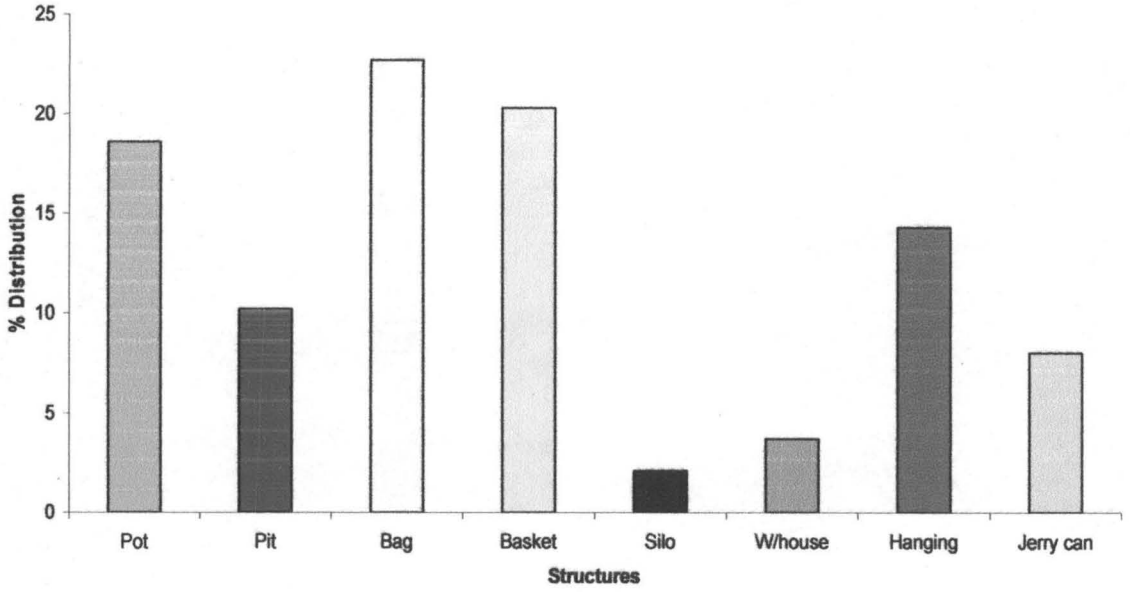


Fig.4.11.% Distribution of storage structures in Gwer east L.G.A

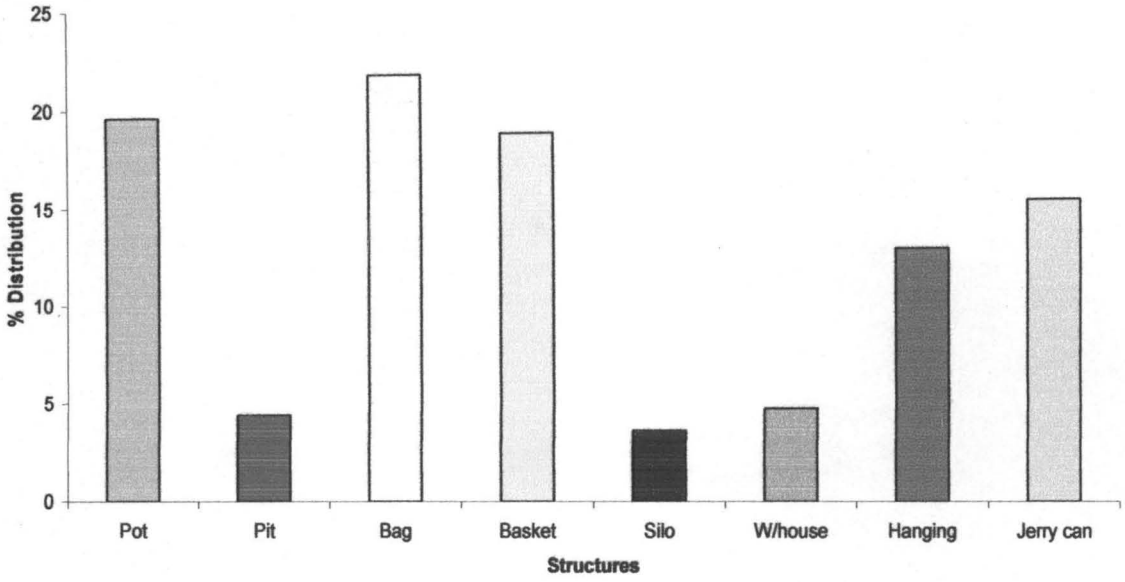


Fig.4.12.% Distribution of storage structures in Otukpo L.G.A

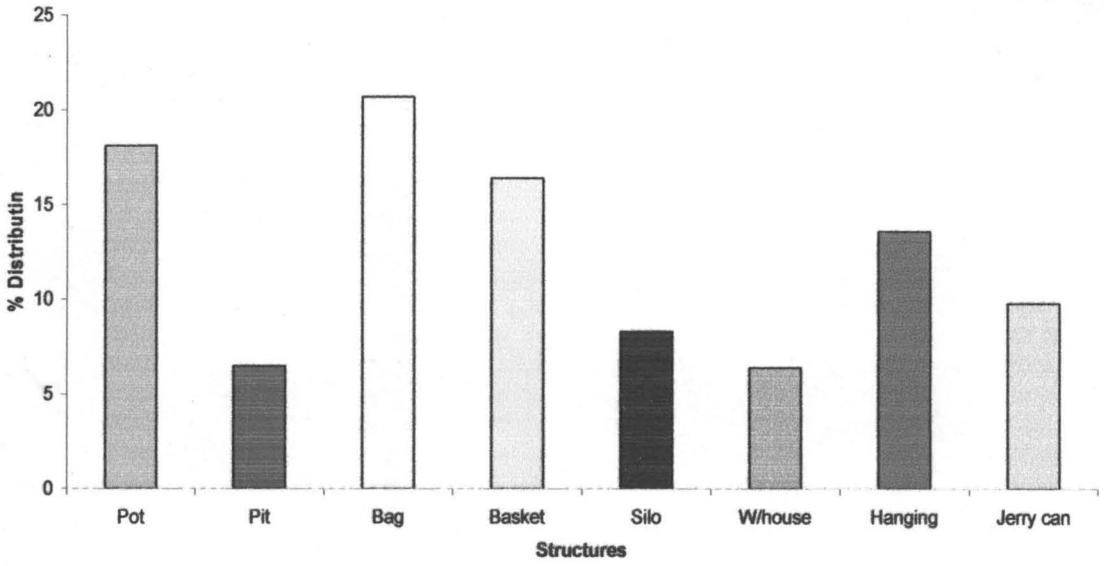


Fig.4.8.1.% Grain lost to each agent in Apa L.G.A

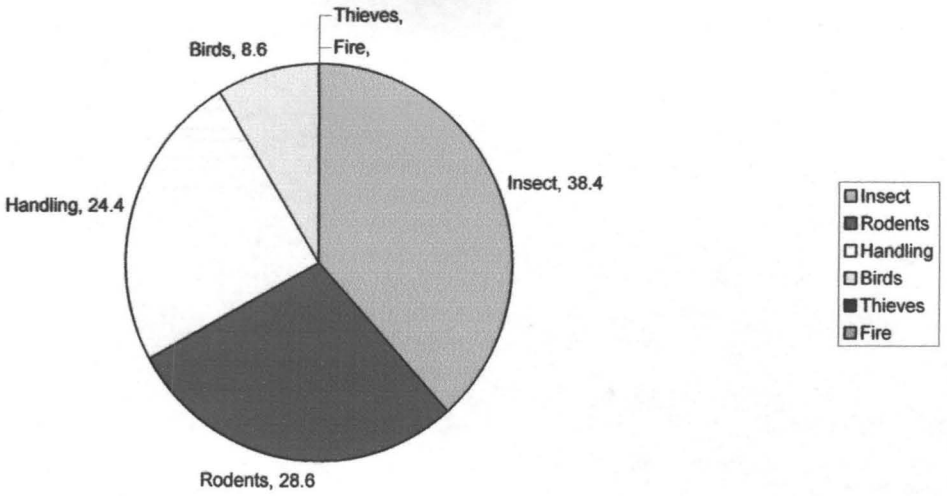


Fig.4.8.2.% Grain lost to each agent in Gboko L.G.A

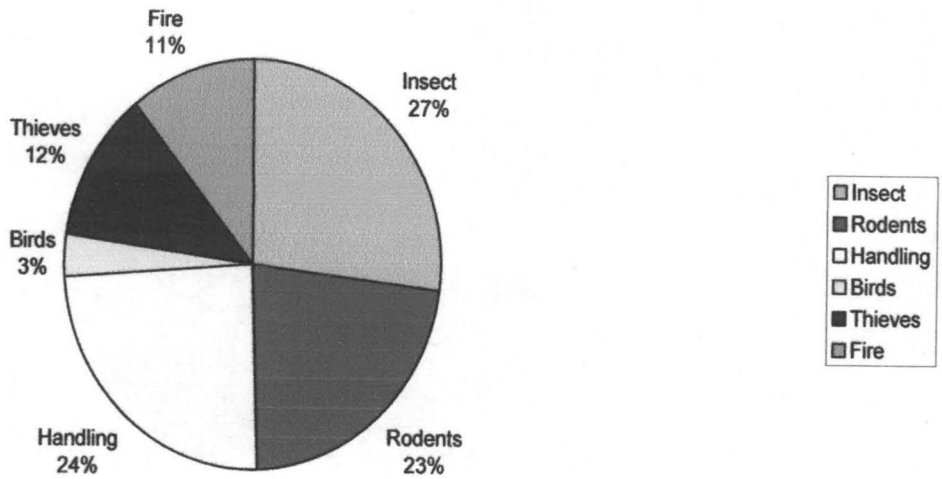


Fig.4.3.3.% Grain lost to each agent in Makurdi L.G.A

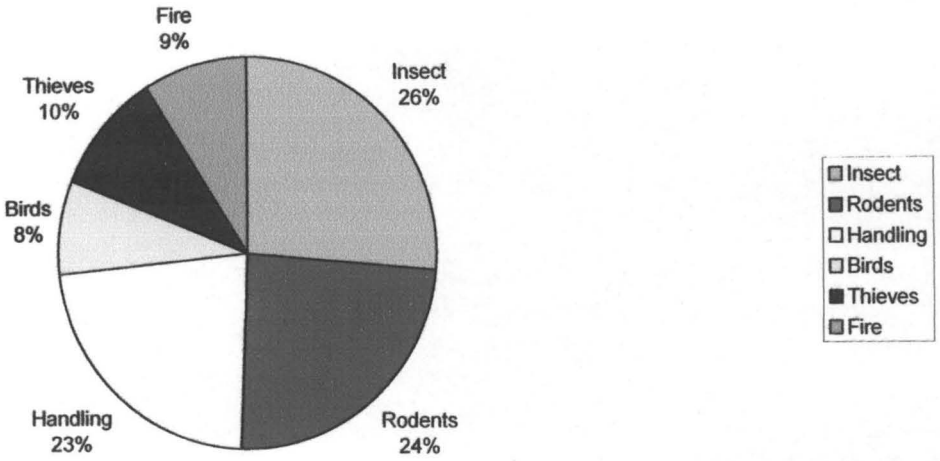


Fig.4.3.4.% Grain lost to each agent in Kwande L.G.A

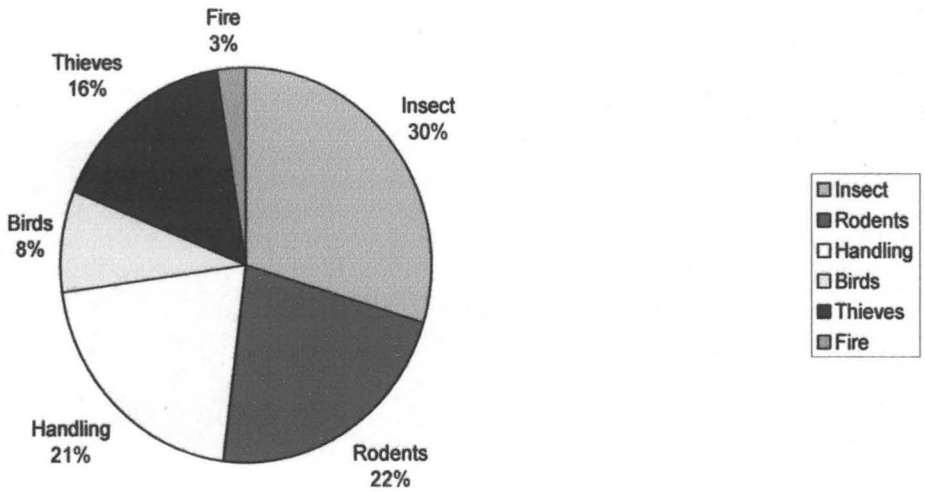


Fig.4.8 5.% Grain lost to each agent in Agatu L.G.A

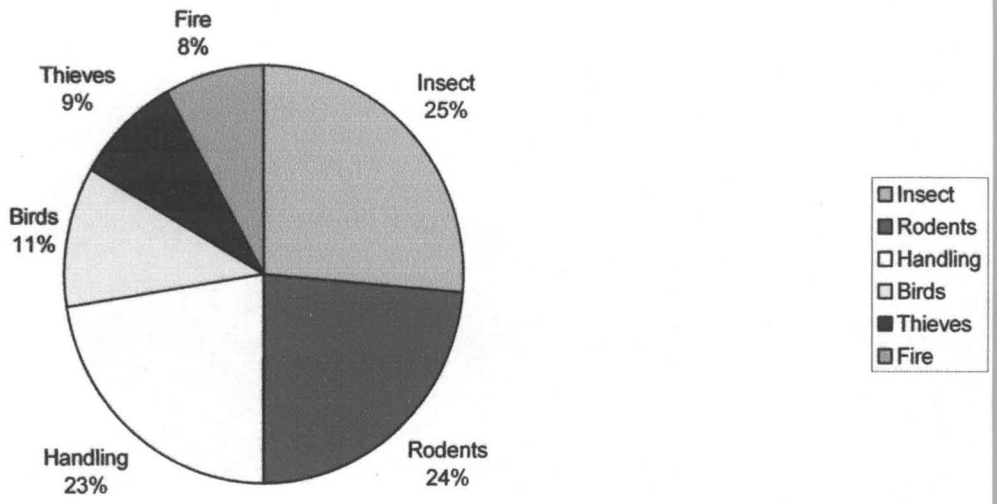


Fig.4.8 6.% Grain lost to each agent in Ado L.G.A

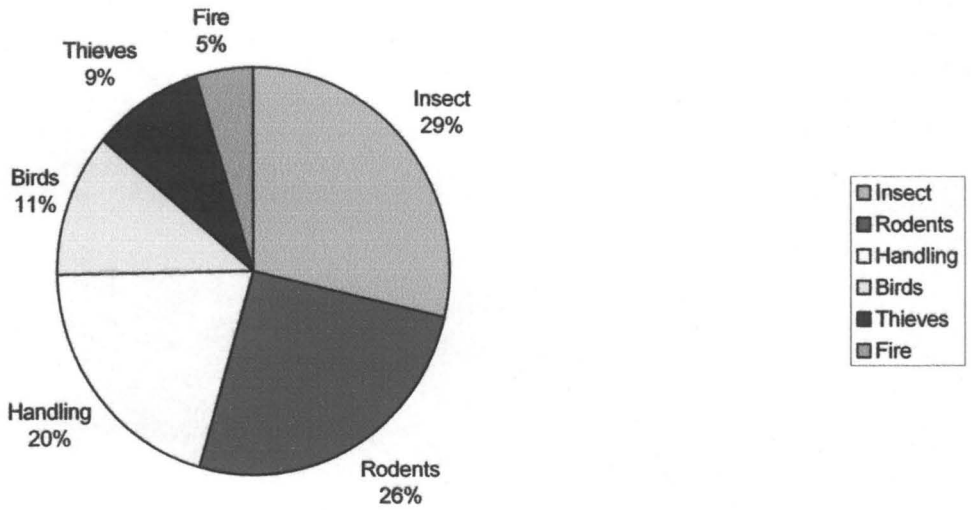


Fig.4.7.% Grain lost to each agent in Guma L.G.A

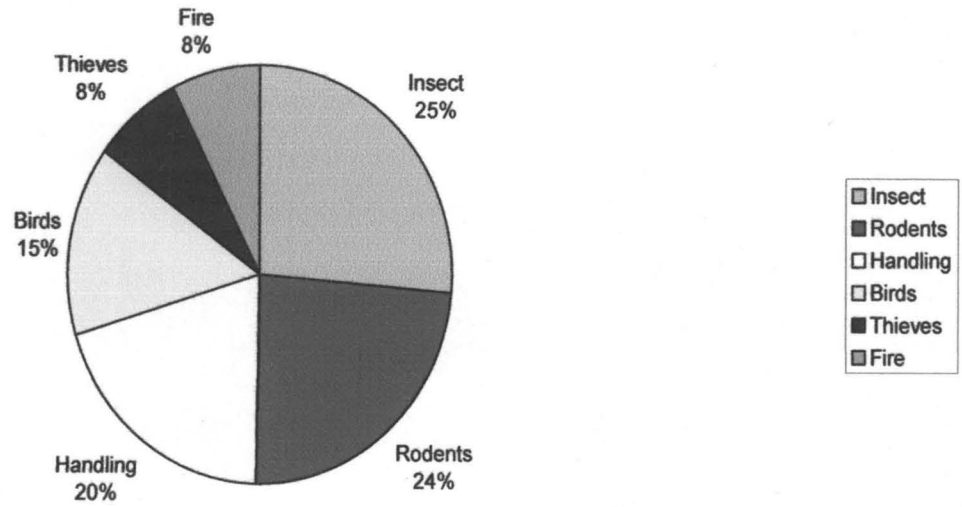


Fig.4.8.% Grain lost to each agent in Konshisha L.G.A

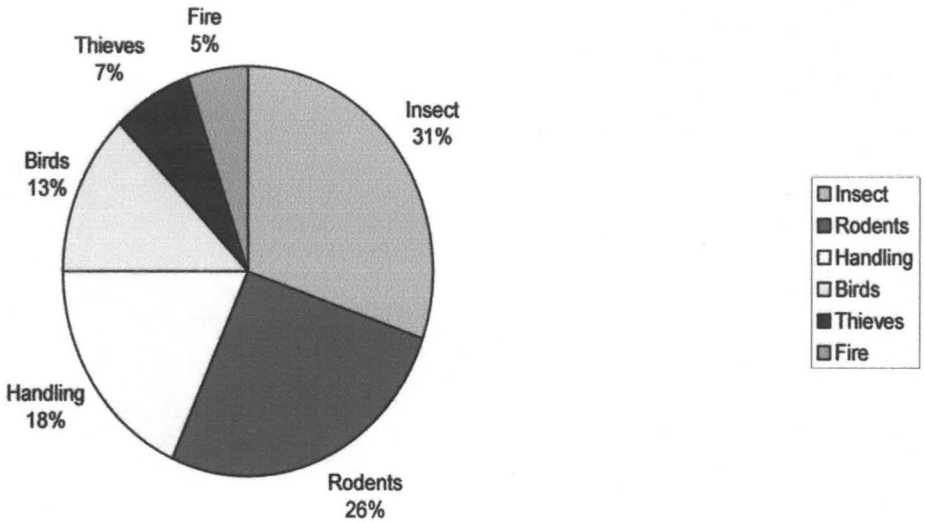


Fig.4.9.% Grain lost to each agent in Vandekiya L.G.A

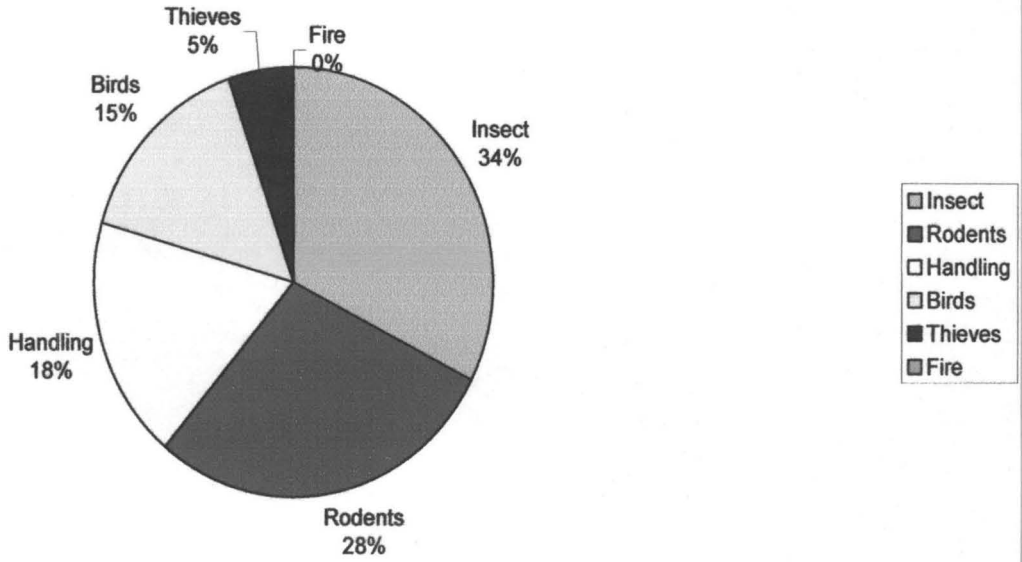


Fig.4.10.% Grain lost to each agent in Tarka L.G.A

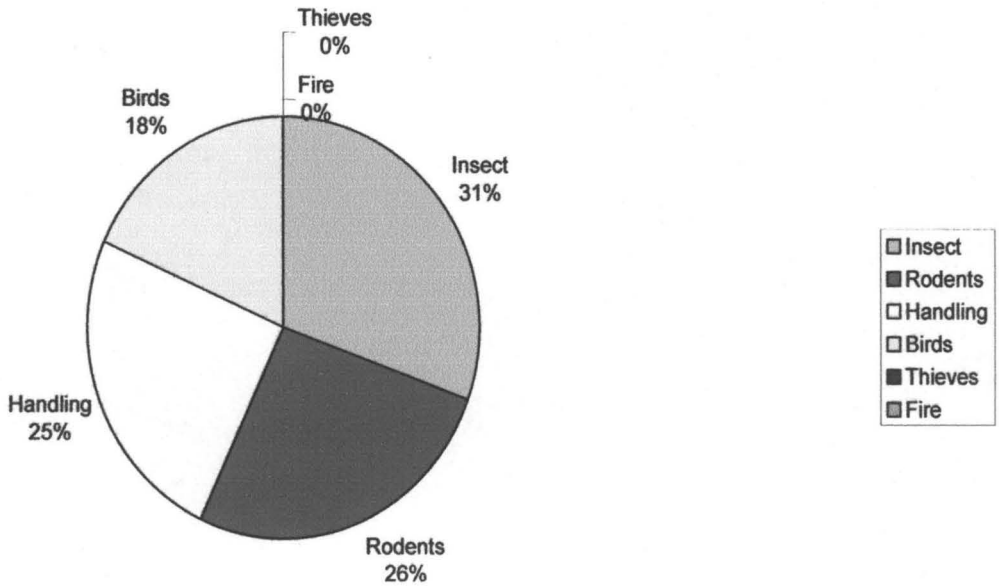


Fig.4.3.11.% Grain lost to each agent in Gewr east L.G.A

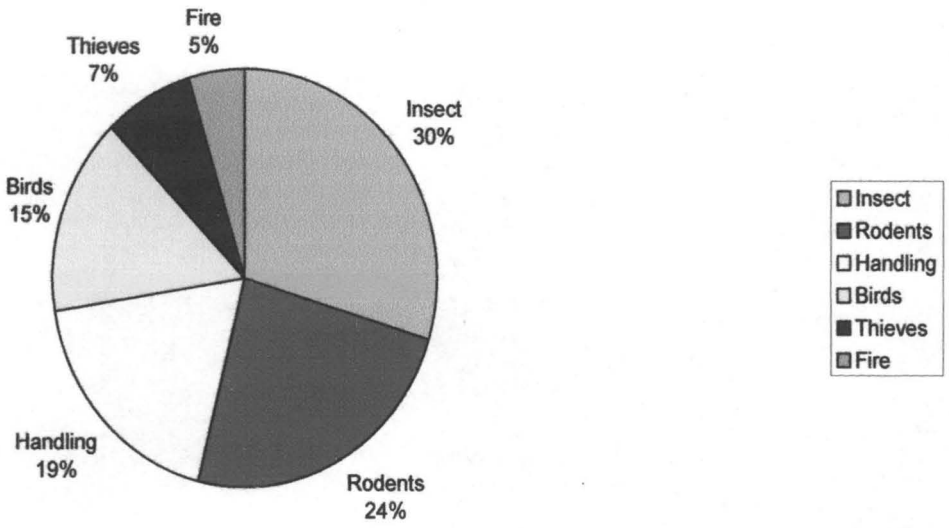
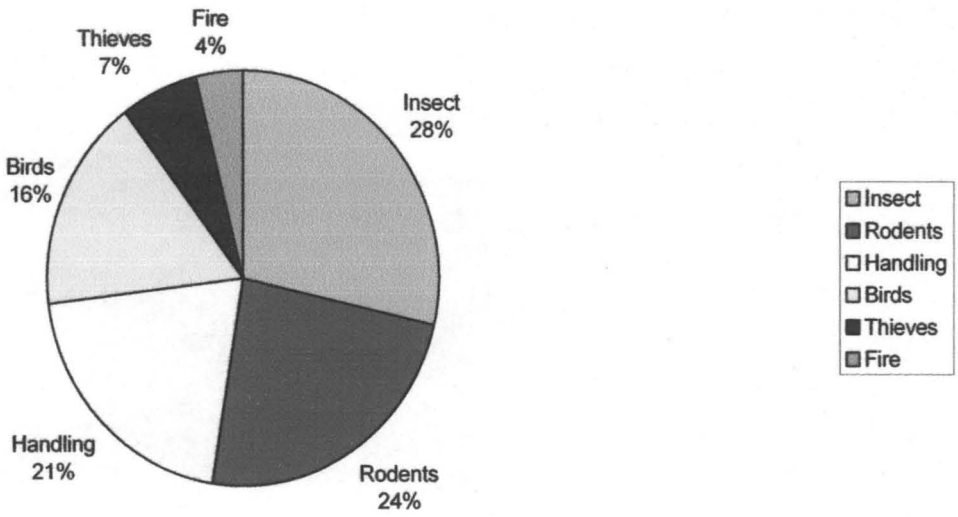


Fig.4.3.12.% Grain lost to each agent in Otukpo L.G.A



4.2 DISCUSSIONS.

From the study, it was observed that almost all the farmers cultivated more than one grain throughout the Local Government areas Visited. The commonly cultivated grain Crops in Benue State are Rice, maize, sorghum, Soya-bean and millet. From Table 4.2, it shows that rice and maize are most commonly cultivated grain crops in all the LGA's surveyed followed by sorghum, Soya bean and millet . Soya bean are the least cultivated crop in the local government areas. Also from Table 4.4, showing the percentage distribution of storage structures it is seen that bag storage is the most dominant storage structure in all the local government areas followed by pot storage. Other prominent storage method is basket and jerry cans storage, which is commonly used for subsistence level grain storage. Warehouses are commonly used in large farms and for commercial storage. Pit/underground and Silo storage is the least dominant method of storage in all the areas surveyed.

Table 4.5 Shows grain loss to each storage methods used. From the table it could be seen that Pit storage suffered more grain loss than any other form of storage. The reason was due to excessive moisture content, as a result of high water table experienced in some parts of Benue State. Caking and moulding are also pronounced in grain as a result of high moisture content. Occasionally, some burrowing animals and insects discover these pit storage and heavy losses are incurred. Basket storage and Bag storage also suffers high losses due to rodent attack and insect proliferation. Pot storage also suffers losses but not as much as in pit and basket. The observed losses were due to moulding because the pots are more rapidly. In hanging which is done mainly for sorghum and maize, the unreliability of weather condition leads to wastage in form of sprouting. In addition, losses as a result of fire, thieves, rodents, insects and birds are high. The bag storage, which is the most common form of

storage in Benue State is shown to have insects and handling as source of grain loss. The reason is due to bursting of bags during handling. The silo and warehouse are limited in number and loss in this storage structure are few or negligible due to how well protected they are from agent of losses. From the survey, it was observed that the main agents of storage loss are insects, birds, Rodents, fire hazards, thieves and improper handling. Table 4.8. Shows percentage of grain lost to each local government area. From the table, insect attack and Rodents shows the highest percentage loss in all local government areas. It was closely followed by improper handling, thieves and hazards (fire). From the table, Kwande local government areas show high percentage of incidents of thieves while Apa and Taraka shows no incident of stealing. Tarka shows the highest incident of birds as agent of lost among the local government areas. Fire incident is generally low except Gboko, Makurdi and Agatu local government areas where fire incident causes more than 8% of the total loss.

Table 4.10 shows the estimated quantity of grain lost and usually in each local government area. This is calculated predominantly in Benue State (table 1) and also, because of its susceptibility to insect and rodent attacks. This is followed by sorghum, millet, groundnuts and rice. The main cause of loss on rice is improper handling. Soya beans have the least grain loss except in Makurdi local government area. This is because; Soya bean is not predominantly cultivated in all the local government areas on survey. High loss in maize is observed in Agatu, Tarka and Makurdi local government areas, while other local government areas shows low storage loss.

The interview conducted also showed that over 60% of the people encountered quality losses in terms of changes in colour, smell, taste and mould growth.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATION

5.1 CONCLUSIONS

Crop storage i.e. grains has been identified, as a major aspect of increasing food production, and any effort that is aimed at increasing agricultural production must be matched with equal if not greater efforts at providing adequate and efficient storage facilities. Buyers will want to know how much of the weight in any grain is comprised of water in order to establish a fair price.

I have tried in this write up to present my points in such a way that they fall within the limits of my under standing of the topic, and care was taken not to go beyond what is expected of me. The survey of the storage in Benue State revealed both traditional and modern methods. The loss of grain in the local communities can be to lack of finance to erect structures that will store their grains better.

From the study, it was observed that government has been assisting local farmers over the years in areas of cultivation, harvesting, but little or no storage facilities are provided for this peasant farmers which poses great danger and loss of seeds after harvest, and this is why during planting seasons, farmers have to buy seeds at very exorbitant prices, which directly influences the prices of their product.

The cordial factor of storage is that the crop must be protected against pest, and weather. It is therefore necessary to ensure that only clean, well dried grains enter a rot proof, weather proof and clean store. All cracks or broken floor surfaces should be repaired and the floors swept thoroughly. Prune trees that are to close. Ensure that the doors, windows and openings both inside and outside the structure should be protected.

5.2 RECOMMENDATION

Recommendations are made in such a way that existing storage facilities can be improved upon, but on the whole, the traditional methods of village storage are satisfactory, at least in dry regions, they are nevertheless capable of being improved. The refinements to be made will be difficult for peasant farmers to accept if they are totally at odds with entrenched habits, for farmers to agree to, and adapt them, they must be able to afford them and have seen for themselves the positive effects

Recommendation for improved storage may include:

- Reinforced concrete silos can be used for storage as concrete is a very useful materials for making storage structure, provided that a cement manufactured locally are used to reduced cost. It is durable, corrosion resistant and maintenance free. This type of silo is heavy, so the foundation must be constructed accordingly. It is also porous and must be painted with damp-proofing agent. These structures are easy to employ and clean out.
- Plastic sheeting in rural area in the protection of grains against dump and pest.
- Hermetically sealed system which consist of lowering the oxygen content of the air present in the storage facility.
- Hermetically sealed system may be in a confined environment like metal silos, non-rigid units, and underground units' trench silos.
- Bag storage structures can also be recommended, as in this case bags are piled one on top the other in the open protected by movable covers, or inside stores or warehouses, which is the most widespread system.
- Corrugated iron silos used particularly for centralized storage and there are some very large units. At rural level it should be small units of about 2m in diameters

and heights, which are proposed usually, made of covered sheets of steel bolted together, the joints between the sections being sealed to ensure water tightness.

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Appendix A

Questionnaire

TITLE OF RESEARCH: STUDY OF GRAIN STORAGE STRUCTURES, METHODS AND LOSSES IN BENUE STATE

RESEARCHER: ZUBAIR ABDULGANIYU
DEPARTMENT OF AGRICULTURAL ENGINEERING,
FEDERAL UNIVERSITY UNIVERSITERY OF TECHNOLOGY, MINNA NIGER STATE

Dear Respondents,

As a final year student of the above department, I am executing a project which seeks to find out the study of the grain storage losses, structures and method of storage in Benue state.

Agriculture is a major source of food supply for the survival of man an animals. But all effort of man to improve the rate of food production has been hindered due to the problems of storage structures and methods. Various agricultural sectors in the country have tried to remove this particular problem but not much impact has been made. In order to create more impact this questionnaire was produce to be able to asses the major area of problems within Benue state.

You are being kindly requested to assist in completing this questionnaire as accurately as possible. Please be assure that your response will be treated in confident

QUESTIONNAIRE

A. Basic Information

(i) Name……..

(ii) Sex……

(iii) Age……

(iv) L.G.A where farm is located……

(v) Marital Status Married ☐1 Single ☐2 Tick √

(vi) No. of children <4 ☐1 5 ☐2 6 ☐3 7 ☐4 8 ☐5 >8 ☐6

(vii) No. of dependent <4 ☐1 5 ☐2 6 ☐3 7 ☐4 8 ☐5 9 ☐6

(viii) Educational qualification None ☐1 Primary ☐2 Second ☐3 Polytechn ☐4 University ☐5 Others (please specify) ☐6

(ix) Major occupation_____

(x) Residential address_____

B Farm Cultivation

(i) No of hectare cultivated <2ha ☐1 3-5 ☐2 5-7 ☐3 7-9 ☐4 >9ha ☐5

(ii) Method of farming Manual ☐1 Use of tractor ☐2 Both ☐3

(iii) Major grains predominantly cultivated your area Maize ☐1 Millet ☐2 G/corn ☐3 Rice ☐4 G/Not ☐5 Beans ☐6 Others (pls. sp ☐7

(iv) Quantity of grains which you produced

S/No	Name of grain	Quantity (100ug/Bags)

1	Maize	.....
2	Millet	.....
3.	G/Corn	.....
4.	Rice	.....
5.	C/Nut	.....
6.	Beans	.....
7.	Others (please specify)	.....
8.	.....	

(v) Major grains which you Market

Maize ☐1 Millet ☐2 G/corn ☐3 Rice ☐4 G/Not ☐5 Beans ☐6 Others (pls. specify) ☐7

(vi) Quantity marketed (100kg/Bags)

S/Nos	Grains/100kg/Bags
1	Maize
2	Millet
3	G/Corn
4	Rice
5	G/Nut
6	Beans
7	Other (please specify

C. Processing.

(i) Method of processing grains

(ii) In what form do you store your grains Machines ☐1 Local ☐2

Names of grain/crop	Processed	Unprocessed
Maize	☐1	☐2
Millet	☐1	☐2
	☐1	☐2

G/Corn

Rice ☐1 ☐2

G/Nut ☐1 ☐2

Beans ☐1 ☐2

Others (please specify) ☐1 ☐2

(iii) Which of the following operations do you carry out before storage

Threshing ☐1 Shellin ☐2 Sorting ☐3 Drying ☐4 Packaging ☐5

(iv) Effect of the following on the viability of the grains produced by you

Factors	High > 60%	Medium 40-59%	Low <40%
Moisture Content	☐1	☐2	☐3
Temperature	☐1	☐2	☐3
Pest	☐1	☐2	☐3
Fungal	☐1	☐2	☐3
Humidity	☐1	☐2	☐3

(v) Uses of these grains (please indicate with percentage)

Uses		Qty(100/Bags)	(Percentage)
Human Consumption	☐	_____	_____
Animal Consumption	☐	_____	_____
Marketing	☐	_____	_____
Seedlings	☐	_____	_____
Exportation	☐	_____	_____
Industrial usage	☐	_____	_____

Please state type _____

_____

D. Storage Methods and Structures

(i) What type of storage method do you practice

Small scale ☐1 Medium scale ☐2 Large scale ☐3

(ii) If you practice small-scale storage method please indicate which of the following

Methods		Capacity (100kg/Bag)
Calabash	☐1	_____
Clay pots	☐2	_____
Polythene bags	☐3	_____
Air tight container	☐4	_____
Drums	☐5	_____
Others (please specify)	☐6	_____
	☐7	

_____

(iii) If you practice medium scale storage method please indicate which of the following

Storage method		Capacity (100kg/Bag)
Sacks	☐1	_____
Drums	☐2	_____
Cribs	☐3	_____
Granary	☐4	_____
Rhumbu	☐5	_____
Room	☐6	_____
Basket	☐7	_____

(iv) If you practice large scale storage method please indicate

☐1 Commercial silo ☐2 Warehouse

(v) What type of silo, if silo is used

Concrete ☐1 Metal ☐2 Wood ☐3 Composite ☐4 ☐5

Capacity (please specify) ☐1 ☐2 ☐3 ☐4 ☐5

(vi) What is the quantity of grains stored by you

Name of grain	Quantity (100kg/Bags)
Maize	_____
Millet	_____
G/Corn	_____
Rice	_____
G/Nut	_____

_____

_____

(vii) Duration of storage

3-6mmths ☐1 6-12mmths ☐2 12-24mmths ☐3 Others (please specify) ☐4

(viii) Changes noticed storage

Name of grains	Change in colour	Change in odour	Change in taste	Mould and rot
Maize	☐1	☐2	☐3	☐4
G/corn	☐1	☐2	☐3	☐4
Rice	☐1	☐2	☐3	☐4
G/Nut	☐1	☐2	☐3	☐4

(ix) Quantity of grains damaged due to agents of storage losses

S/Nos Name of grain	(100kg/bags stored)	Use of	Bags Damaged Due to			
	Rodents	Insects	Mould	Fore	Thieves	Others (pls specify)
1 Maize						
2 Millet						
3 G/Corn						
4 Rice						
5 G/Nut						
6 Beans						

Which of the following methods of storage system do you use.

Name of grain	Rhumbu	Bags	Hanging	Pit	Basket	silo	W.H
Maize	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Millet	☐1	☐2	☐3	☐4	☐5	☐6	☐7
G/Corn	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Rice	☐1	☐2	☐3	☐4	☐5	☐6	☐7
G/Nut	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Beans	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Others (Pls Specify)	☐1	☐2	☐3	☐4	☐5	☐6	☐7

(xi) Quantity of grain lost/damaged per method of storage

S/Nos	Name of grain	No of Bags stored (100kg)	No of bags damaged/lost							Quantity Lost (total 100kg/bag)
			Rhumbu	Bags	Hanging	Pit	Basket	Silo	W.H	
1	Maize									
2	Millet									
3	G/Corn									
4	Rice									
5	G/Nut									
6	Beans									
7	Others (Please Specify)									
8	.....									

(xii) Do you maintain the existing storage structure

Yes ☐1 No ☐2

(xiii) Specify if yes the cost ₦.....

(xiv) Do you build new structure every season for different grains to be stored Yes ☐1 No ☐2 Use of old ones ☐3

(xv) If No, how often do you build

Annually ☐1 Bi-annually ☐2 Triannually ☐3 Others (pls specify) ☐4

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