Technical Appraisal of Grain
Storage Systems in the Nigerian Sudan Savanna

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ABSTRACT

A technical survey of the village level grain storage structures existing in the Sudan Savanna climatic zone of Nigeria was undertaken. Preliminary investigation result shows that the common grain storage structures existing in this zone are the mud rhombus, thatched rhombus, underground pit, and earthen pot and warehouse storage. The grain usually stored in unthreshed forms includes millet, sorghum, maize and cowpea. Most of these structures are not moisture proof, rodent proof and are not airtight. Structural defects occur mainly in the roof, walls and columns of the storage structures. The common types of physical defects are cracks, leakage, termite infestation and structural failure of parts. The causes of defects among others include poor strength of material, inadequate columns, low elevation and pest infestation.

The result however, shows that it might be more profitable for subsistent farmers to continue the storage of unthreshed cereal grain and possible unshelled pulsed in rhombus and underground pits since these have relatively low storage cost per kilogram of grain. However there is need for some technical improvement on the construction materials, nature of columns, elevation and the loading/unloading facilities. The farmers' shows willingness in adopting new storage techniques provided such structures are cheap and affordable.

Keywords: Physical defects, causes of defects, grain loss, mud rhombus, thatched Rhombus, underground pit.

1. INTRODUCTION

The Federal Republic of Nigeria with an area of 941,849km^2 has its greatest East – West length of over 1,127km, the greatest North – South length of 1,046km and a coastline of 960km, bordering the Atlantic Ocean. The country's broad latitudinal range incorporates diverse bio-physiographic features (FMAWRRD, 1978).

The vegetation zoning is largely a reflection of the climatic zoning; hence three broad vegetation zones are delineated. First is the Tropical rain forest of the south with its luxuriant tree growth frequently intertwined with lianes and epiphytes Second is Guinea savannah of the middle belt which is a belt of deciduous trees mixed with grasses. Third is the Northern Sudan savannah with tall grass and acacia trees. The country has a comparatively high average year round temperature of about 28^0c that poses no limitation to the growth of tropical agricultural crops. The major grain crops cultivated in Nigeria are maize, rice, millet, guinea corn, cowpea and soya beans.

The Nigerian government in recent years has provided incentives to the rural farmers, which has tremendously increased the grain production output per hectare in the rural area. A large proportion of the population continues to remain dependent on agriculture, with production patterns being governed by food requirements for home consumption. Since the large majority of the population is dependent on agriculture, only a small proportion of the total food production finds its way out into the market. The large parts of the food grains produced are being retained on the farm for home consumption (Olumeko, 1991). The increase in yield through improved cropping systems and the introduction of high yielding varieties has re-emphasized the need for more resources to prevent post harvest losses.

Storage is an important activity, which enhances marketing efficiency by providing utility. Storage is particularly important in agriculture because agricultural production is seasonal while the demands for agricultural commodities are more evenly spread throughout the year. In this circumstance, there is need to meet average demand by storing excess supply during the harvesting season for gradual release to the market during off-season periods. In the process, seasonal prices are stabilized. Post harvest facilities or appropriate storage technology has been the major problem of Nigerian agriculture for a long time. This has resulted in considerable waste of agricultural output and hence considerable loss to the economy. Nigeria is losing about 2.4 billion tonnes of food yearly to poor harvest and storage facilities (Olumeko, 1999). The losses were mainly in maize, rice, sorghum, millet, cowpea, groundnut, soya beans, yam, cassava, plantain and fruits. In monetary term, the country is losing a total of ₦48billion annually on post harvest losses. It has been observed that different localities in Nigeria have peculiar storage methods depending on the types of crop grown (Adesida, 1988). It has been noted that farmers achieve varying degree of success in applying the basic principles involved in the safe storage of food (Birewar, 1989).

In Nigeria the average proportion of food production retained by the farmers for their own (non sale) is usually assumed to be 70% (Talabi, 1989). However, there is a high degree of variation reflecting among other factors the size of operational holding, the interaction of consumption pattern with cropping patterns, level of indebtedness and the form of labour payment. Grains kept in farmer's structures are mainly for household consumption; any surplus grain to consumption requirement may be sold within two or three months of harvest. After harvest, grains may be stored temporarily in bulk or in bags for a month or two before being transferred to a structure.

The traditional grain storage structures in different part of Nigeria are made of varying locally available materials. Usually, the type of locally available materials indicates the type of

structures. The structures are made of paddy straw, split or whole bamboo poles, planks, reeds, robes, mud brick e. t. c. Most of the structures are constructed at the beginning of harvesting season. The time of harvesting varies slightly throughout the agroclimatological zones usually between the months August and January. The grains are stored either in threshed or unthreshed forms. The different types of on-farm storage structure found in the three different climatic zones of Nigeria had been appraised. (Igbeka and Olumeko, 1996; Olumeko, 1991). The prominent structure found in the Sudan savannah includes mud rhombus, thatched rhombus and underground pit. The structure found in the guinea savannah zone includes mud and thatched rhombus, platforms, cribs and earthen pots; while in the southern rain forest zones, the structures includes mud rhombus, maize crib, platforms, domestic or indoor storage such as plastic containers, gourds, earthen pots and metal container. Other storage structures includes bags, could be made of jute, Hessian, polyethylene or plant fiber. The bag storage has been found to be convenient for bulk storage of shelled or threshed grains as the bags is very convenient in transporting the grains.

The problems of grain storage differ widely throughout Nigeria and depend largely on the climatic conditions of the area. The main objectives of grain storage are to maintain quality of the produce for a long period of time. The basic requirements of every grain storage structure or systems are to protect the grains from insects, rodents and prevent deterioration of the grains by the activities of micro-organisms (Hall, 1970). It is also essential to keep the grains cool and dry during storage. Deterioration of stored grains results from the interactions among the physical, chemical and biological variables existing in the system. Therefore it is important to understand the inter-relations and interactions of these variables in other to design an effective control and management of these factors for safe storage.

This study is undertaken to technically appraise the existing grain storage systems in the Nigerian sudan savannah with the view to analyse their efficiencies. The merits and demerits of each of the systems were ascertained and possible solution proffered to reduce losses of grains during storage.

2. MATERIAL AND METHODS

2.1 Study Area

The states in the sudan savannah climatic zone of Nigeria includes Sokoto, Bauchi, Kano kaduna, Kastina Yobe, Zamfara, Jigawa, Kebbi, Taraba, Gombe, Borno and Adamawa state. The zone is characterized by tall grasses and acacia trees with an annual rainfall of less than 1000mm and as low as 500mm in the upper region. The rainy season could be as short as 3 months, while the relative humidity is generally low. These areas support the production of large quantities of cereal and pulses annually, of which the major ones include millet, sorghum, cowpea, maize and groundnuts. Millet and sorghum constitutes the staple diet and main energy sources for the inhabitant of the area. Harvesting is usually done manually using sickle and other simple tools between the months of September, and January

2.2   Methodology

Preliminary investigations were carried out on the types of grain storage structures existing in the sudan savannah climatic zone of Nigeria. The structures were technically surveyed with the aid of a questionnaire and personal interviews with the farmers; Visual observation and measurement were also undertaken. Ten villages in ten local government areas of Kano, Kaduna, Bauchi, and Borno states were randomly selected for the survey. The questionnaire assisted in determining the following.

1. The efficiencies of the construction materials with particular reference to the types of construction materials, strength of the materials used, shape, size, types, causes and location of defects annual maintenance methods and the age of structure.
2. An estimation of the percentage grain losses and losses in economic value with reference to the types of grains stored, form which grains are stored, types of grain damage, causes of damages and percentage loss in market value.
3. The cost efficiency of the various types of structure with reference to the capacity cost of construction, duration of storage, loss in economic value and annual maintenance cost.
4. The willingness of adopting other storage techniques will also be investigated.

3. RESULTS AND DISCUSSIONS

3.1   Types of Grains Storage Structures

The prominent types of grain storage structures found in the zone include mud rhombus, thatched rhombus, in-hut storage such as earthen pot and warehouse storage. A database was created to analyze the collected data.

3.1.1   Mud rhombus

A mud rhombus is a specially built structure made from a mixture of dry grass and clay. It consists of a bin resting on large stones and covered with a thatched roof plate 1.
A mud rhombus consists basically the following
a. Foundation – floor assembly
b. Shell or wall
c. Roof

Plate 1: Mud Rhombus with stone grillage foundation floor
assembly and thatched roof

The shape and sizes of the mud rhombus depend on the tradition of the area and the availability of the materials. The shape could be cylindrical, spherical, or circular shaped. The height ranges from 7 – 10 meters while the diameter ranges between 3 and 7 meters. The capacity of mud rhombus ranges from 1000kg – 8,000kg of unthreshed cereals and legumes. They are generally not moisture proof, rodent proof or airtight. The cost of construction ranges between N6000 – N10, 000, and it basically depends on the capacity, location and availability of materials. 4 or 8 men manually load grains into the storage structure through the roof. Mud rhombus generally does not have any external support or reinforcement.

(i).Types of physical defects

The physical defects of mud rhombus are usually on the roof and wall of the structure. The physical defect includes leakages of roof, cracks on the wall. The defects are usually as a result of poor strength of materials, change in climate condition and structural failure. The maintenance methods include the repair and replacement of structural parts. Annual maintenance cost depends on the extent of defects, locality, age and regularity of maintenance. The average annual maintenance cost ranges between N2, 000 – N6, 000

(ii) Storage practices

Loading of grains into mud rhombus is done by the removal of the roof, since no appropriate design for loading and unloading is included. The major crops found to be stored in the areas investigated are unthreshed millet and sorghum. It was learnt that the crop is stored for a minimum of two years and maximum of between seven and 10 years. The unthreshed crops are brought from the farm in bundles tied with ropes. The bundles are of same size with four bundles giving approximately 100kg of threshed grain, where the millet is to be stored for a duration of

one year or less, the bundles are not loosened, but stacked in the rhombus where however, the storage is to be for a longer duration, the bundles are loosened and put into the bin by special arrangement carried out by 4 to 8 people depending on the size and the height of the rhombus. The first person stays on the ground, looses the bundles and passes it to the 2nd person who is on top of the bin or on the ladder. The 3rd person who is inside the rhombus or on another ladder inside the rhombus collects the millet heads and together with the 4th person known as the 'good hand' arranges the millet heads in the structure. The man referred to as the good hand is a person believed to be naturally disposed to storage, such that when he stores a product, minimum deterioration occurs compared to other people. In arranging the millet heads, the 'good hand arrange them in a concentrically over locking pattern, such that the millet are self-supporting in a way. After about 30 to 40cm depth of storage 3 to 5 other men climb into the structure and together with the 2 men already inside, the stored product is compressed. This procedure is continued until the bin is filled to the brim; the roof is then lifted and put in place. After about 3 to 4 weeks, the rhombus bin is inspected for settlement. Settlement is the settling of the stored millet mass by virtue of its self weight resulting in both the reduction of depth of storage height and width. When about 5cm reduction in depth with a corresponding gap of about one to two centimeter between stored millet and rhombus shell is observed, the storage is considered good, the mouth of the bin is then sealed with a mud disc and the roof put in place.

Unloading of the stored crop could sometimes become difficult and cumbersome because of the above loading procedure. In large capacity rhombus bin part of the shell may have to be broken to create an opening for easy off – loading, the created opening is later sealed after complete evaluation of stored products.

(iii).Storage losses/damage

The types of grain damage/losses in crops stored in mud rhumbu include change in taste, colour and odors, pest infestation. The damage often results from pest/insect infestation, structural failure, variation in climatic conditions, micro – organisms among others. The losses in grain and economic values are between 10 – 20% during a storage period of 6 months to 3 years the end use of the stored grains are for home consumption and sales.

3.1.2   Thatched Rhombus

The thatched rhombus is made of woven grass stems resting on irregular stores and or tree stems. They are usually cylindrical or circular in share with various capacities. The capacity ranges from 500kg – 8,000kgs depending on the size. The grains are usually stored in unthreshed forms. They are generally not airtight, moisture and rodent proof. Construction cost is between N2, 000 and N 8,000. They usually have external support ranging from 6 – 16 units depending on the size of the rhombus.

(i).Foundation Floor Assembly

The foundation – floor assembly is usually made of irregular stones and tree stems or tree poles stems penetrating the ground, and crossed with other tree stems. The elevation is generally low. It ranges between 100mm and 600mm, no rodent guard provided only very few rhombus has thorn used as rodent guard

(ii).Wall

The wall of the thatched rhombus made of woven grass stems has two layers, being reinforced with two or three tension rings. Some villages in Kano States, uses cow/animal dung in between the two layers to prevent farm animals from eating – up the wall of the rhombus. 6 – 16 tree stems depending on the size of the rhombus support the walls externally. The support usually does not penetrate the ground

(iii).Roof

The roof of the thatched rhombus is usually conical in shape. The materials usually used for the roofs are straw/thatched, tree stem, polyethylene sheets, and robes. They are usually of 2 – 3 layers to prevent water seepage.

Plate 2: Thatched Rhombus with tree stem columns, showing
tree stem external support

Plate 3: Failed Thatched Rhombus after 8 years of use

(iv).Types of Defects

The physical defects are usually on the wall, foundation and roof. The defects includes inadequate support, low elevation, termite infestation which are as a result of poor strength of material structural failure, inadequate design, of the foundation and age of the structures maintenance is usually done by the repair and or replacement of structural parts and cleaning. The maintenance cost range between N500 and N3, 000 depending on the locality, capacity availability of materials and extent of damage.

(v).Storage Losses or Damage in Thatched Rhombus

The loading is usually done through the roof and is the same as that of the loading of the mud rhombus. Grains are usually stored in unthreshed form and they include millet, sorghum and maize. Fumigants are usually applied, but are usually not effective because the structure is not airtight. The type of grain loss includes change taste, colour, and odour, pest infestation. The extent of loss depends on the duration of storage. The main causes of losses include pest infestation, poor strength of material, and structural failure among others. The percentage loss in quantity and economic value ranges between 10 % and 20% and above respectively, which depends on the duration of storage and other factors of deterioration.

3.1.2   Thatched/Sorghum Stalk Rhombus

This type of rhombus has the stone – grillage foundation – floor assembly, the wall has 2 layers of woven grass stem and a wall of well arranged sorghum stalk held in place by local robes.

3.1.3 Underground Pit

This is commonly found in Borno and Yobe states where the water table is low. The pit, which may be round or square in cross section, is 1 – 3m deep and 1 – 3 m in diameter or square. The underground pit is usually lined with straw. The pit and the straw mat are padded with 40 – 60cm of corn husk. Also a layer of husk padding or insulation is provided at the bottom of the pit. The common types of grain stored are millet, sorghum and cowpea; they are stored in threshed form. The capacity ranges from 1000kg – 6000kg and above. After loading the grains into the pit, tree stems are placed across the pit then covered with polyethylene or metal sheet.
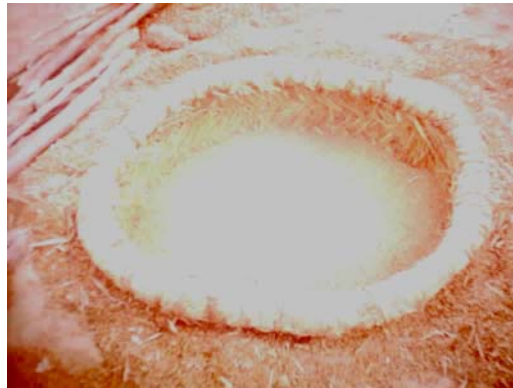

Plate 5: Underground pit, showing woven grass stem lining used for storing millet in Borno state.

Then a layer of husk before finally layers of sand or laterite is used to cover it. The duration of storage could be between 1 and 5 years without opening and usually, once opened; all the content must be emptied. The same site can be used for up to 12 years with annual re-digging. The location of the defect is usually in the wall lining, which may be eaten up by termite, and the structure is not rodent proof. Maintenance is usually done by cleaning and replacement of the wall lining. Maintenance cost is dependent on the locality and availability of material.

Plate 6: Underground pit, showing tree stems across the pit for covering

The damages or loses in stored grains includes charge in colour, odour and taste. It is believed that these grains have low viability. Grains stored in this structure are protected against insect attack because of reduced oxygen level. Causes of grain damage/loss include microbial organisms, structural failure and changes in the chemical composition of grains. Approximate percentage loss of quantity and economic values are 10 – 20% and 5 – 10 % respectively. The underground pit is easy and cheap to construct and requires minimum materials, but however great difficulty is experienced in emptying and cleaning the structure.

3.1.4   Earthen Pot
The earthen pot storage is found in very few villages in Kaduna and Kano States. It is made of burnt clay. The shape and sizes differ with the locality. They have capacity of between 5 – 20kg of threshed or shelled cereals. The grains stored in this pot are used mainly for seedlings. The grain crops stored includes cowpea, maize and sorghum. The main defects are that, it is fragile, small in capacity and absorbs moisture from the ground where it is place. Damages on seed include mould growth, and spouting, change in colour, odour and taste.

3.1.5   Local Warehouse Storage
The store is constructed using clay brick with aluminum roofing sheet. The grains usually in unthreshed or unshelled forms are tied in bundles and placed on the bare ground of the storehouse. There is a small entrance into the store with no window. The grain stored in this form, is usually attacked by insect pest e.g. weevils and termite and, rodent from the ground. The

crops also absorb moisture from the ground. The loss in these types of storage method is usually above 20% during a period of 2 years of storage plate showing local warehouse storage.

4.   RECOMMENDATIONS

1.   The thatched rhombuses were found to be infested with termites, and farm animals usually eat up walls; the elevations are low and external support inadequate. The use of chemical to prevent termite infestation by the farmers, apart from the cost had been ineffective probably due to improper applications or fake or adulterated chemicals; hence the use of thatched rhombus should be discouraged.

2.   The mud rhombus has columns made of irregular stones, the floor foundation assembly is made of clay and tree stems. These were discovered to be infested by termites, and are not water resistant. The loading and unloading is usually done through the roof, which is inadequate. It should be redesigned, in terms of foundation floor assembly and should be made of concrete and water resistant materials.

3.   The underground pit is observed to be infested with termite, and water seeps into the pit due to inappropriate cover. An improvement on the wall lining by the use of water and pest resistant material are suggested; the cover or roof should be made more secured.

4.   The earthen pot is discovered to be of small capacity, fragile and it absorbs water from the floor where it is placed. Small containers of plastic or metals placed on wooden floor should be used instead.

5.   The local warehouse is observed to be open to pilfering, it is neither moisture proof nor rodent proof and the grains are stacked on the bare floor. An improved cheap warehouse that is rodent proof and more secured should be adopted.

6.   More grain reserves should be established whereby farmers would be able to bring their grains for storage. A standard quality control unit for grading grains should be established to assist in checking the grain quality before storage.

5. CONCLUSION

The use of silos and modern technologies for processing and storing food grains will go a long way to aid food security at the village level. But the cost of procurement, operational know how, maintenance and availability of spare parts are usually the limitation of such modern methods. Therefore this process should take into consideration the technologies of the people. The farmers will readily accept a concept or technology that builds up on or improves that which they are used to rather than one which imposes a totally new idea.

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