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Factors Militating Against Full Adoption of Hermetic Storage Structures At All Levels Of Cereal Grain/Pulses Storage in a Developing Economy

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Abstract: *This paper evaluates the prospects and factors militating against the full adoption of hermetic storage structures at all levels of cereal grain/pulses storage in Minna, Nigeria. This is aimed at encouraging the use of hermetic storage structures in the developing countries, and to ensure the reduction of enormous storage losses still recorded in this sector hitherto. To carry out this purported evaluation the protocol entailed, a pre- data survey, carried out to identify the factors militating against the adoption of hermetic storage structures. A multi-stage non-proportional stratified sampling was carried out on 300 respondents in 50 communities in Minna and its surrounding towns, with elevator factor 10 and sampling factor 0.1. The result revealed that the most predominant grain storage structure used presently for threshed form of grain storage is poly propylene bags at 71.1% which are non-hermetic in nature, traditional mud rhombus storage structure at 28.8% and hermetic storage structures at 1.3%. It also revealed that the factors militating against full adoption of hermetic storage structures are non-availability at 88.18%, the fear of farmers to experiment with their crops and lack of adequate and proper introduction of the technology/ storage structures to farmers are at 5.7% and 3.04% respectively. There is no significant relationship between farmer's age, income and the use of recommended technology ($p<0.05$). There is a significant relationship between non-avaliabity and cost of the hermetic storage structures, farmer's fear of experimenting with their crops and lack of adequate Government extension agents in introducing this technology/structures ($p>0.05$). An adequate, efficient, effective, participatory methodology by independent and Government Agricultural extension agents to drive home this technology and enable farmers get the full reward of their labour.*

Keywords: *Farmers, full adoptability, hermetic storage structures, storage losses,*

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I. Introduction

Food security as defined by [1] is the access by all people, at all times, and to safe and nutritious food needed to maintain a healthy and active life. This concept stands on a tripod namely accessibility of food, by all people, and at all times, and will not be achieved, without effective and efficient storage component and mechanism. Food Crop storage is an important aspect of agriculture development, which is considered the main catalyst to attaining agricultural independence and food security. Over the years, cereal grains/pulses storage has proven to be the weak link and the most difficult aspect, of the integrated cereal grains/pulses generic value chain, in the developing countries especially in the tropics. However, effective and efficient grain storage technologies remain the only solution. Since crop storage is inevitable, and the obvious ways of getting the best out of farming, as a business, taking advantage of the economics of lean period and harvest/abundant period in relation to grain prizes is vital.

In Nigeria, crop storage has evolved from the use of completely primordial traditional storage structures such as rhombus and cribs to improved traditional storage structures, and presently modern storage structures, such as metallic silos, warehouse storage, and hermetic storage structures. The change from the traditional storage structures to the modern storage structures by farmers has been greeted with different challenges, which hitherto made some farmers adamant to the change. The issues of cost, availability, culture, and farmer's fear of experimenting with their crops are some of the key factors identified. In the tropics, relative favourable climatic conditions, and agricultural practices encourages the morbidity of causative agent of grain deterioration during storage. This has made storage more challenging than in other climates. The storage losses are of quality and quality which culminates to major source of loss of investment as far as cereal grains/pulses farming/storage are concerned [2]. The losses along the value chain can also be classified under domestic, middle level, and large or commercial scale collectively is estimated from 5% to 46% [3]. Hitherto,

the most popular methods of storage for cereal grains/pulses in Minna, and other states within Northern Guinea Savannah agro-ecological zone of Nigeria (grain belt of Nigeria) still remains the traditional system of storage either on-farm or domestic operated by peasant farmers. It includes the use of traditional storage structures like the different kinds of rhombus, local grain stores, platform, open field, earthen pots, jars, bags and underground pits storage in areas with low water table. The length of storage is mainly between 3 to 12 months. Other storage structures available include very few hermetic storage structures, silos and storage warehouses operated by individuals, organized private sectors or the Nigerian Government. The length of storage can be well above 12 months depending on the prevailing circumstances and the economics of cereal grain storage within the period. However, most of the grains stored by peasant farmers who produce bulk of the grains, are in an unthreshed form, while most of the threshed form of storage is done by middlemen grain merchants, organized private sectors or the Nigerian Government [4].

Due to the perennial colossal storage losses associated with cereal grain storage in Nigeria, farmers are often forced to sell their grains immediately after harvest at their disadvantage of low market prices. Amidst these problems, the peasant farmers and grain dealers resorted to the use of pesticides and fumigants, as a way of solving the most critical problem which is insect/pests infestation. This practice has been counterproductive, due to lack of knowledge on how this fumigants and pesticides are to be used for optimum and effective performance; rather it has left available stored grains with huge amount of pesticide residue above recommended levels [5]. This is affirmed in the inherent high storage losses still being recorded till date, and consequent incidence of food poisons due to consumption of high insecticide/pesticide residual, by human and animals. The zeal to move away from this kind of chemical-based cereal grain storage issues worldwide, and associated problems motivated the re-birth of one of the oldest forms of food preservation in the world known as hermetic storage system (HSS).

1.1 Hermetic storage Technology

Hermetic storage system is an evolution of organic bio-generated or inorganic, modified atmosphere for control of insect/pest, and preservation of quality in stored grains. Its basic principles are the depletion of oxygen and the enrichment of carbon dioxide or nitrogen in the grain bulk through insect/micro-organism respiration or by artificial means in an airtight storage structure, asphyxiating all organisms and insects in a matter of days [6]. Its ability to accommodate different categories of farmers in terms of varieties and capacities of storage structure is one of its unique characteristics, thus a boost to non-chemical based storage worldwide [7] [9]. Three major different types of hermetic storage systems include organic hermetic storage (OHS), vacuum hermetic fumigation (VHF), and gas hermetic fumigation (GHF) [10].

Organic hermetic storage (OHS) often referred to as “hermetic storage” is a storage system which relies on the natural metabolic activities of living organisms (stored crops, insects and or moulds) present in the commodities to generate a low oxygen modified atmosphere, which will lead to asphyxiation of living organisms in the bulk [7]. VHF is the act of creating a low or partial pressure in a vacuum or an air tight storage structure with the aid of a vacuum pump or any other medium, to accelerate asphyxiation of organisms or disinfestations. GHS is the use of an equipment generated external gas source (usually carbon dioxide or nitrogen) to generate a controlled atmosphere in an air tight storage structure, allowing for accelerated asphyxiation or disinfestations of food commodities [8].

Hermetic storage structures are air tight or sealed storage structures. Some are naturally not airtight in nature, but are built or made to be air tight by man. Apart from being air tight, the functional requirements of an efficient crop storage structure must also be fulfilled to enhance its primordial functions. An ideal storage structure should be able to eliminate or reduce the destructive effect of weather, invasion of pests such as birds, rodents and insects; eliminate or reduce activities of microorganisms and should have an integrity in terms of structural strength [11]. Hermetic storage structures could be made from materials such as plastic, concrete, metal (Ferro-cement) and metallic alloys, glass and flexible high density (HD) materials provided they can be adapted to a convenient radius of curvature either during construction or moulding. All levels of storage have unique and peculiar hermetic structures easily adaptable to it. In domestic various types of air tight metallic containers, hermetic envelopes, hermetic bags, plastic jerry cans, gallons/containers, sealable coolers, and buckets are very efficient. At middle level storage, medium metallic containers, mini hermetic storage cocoons, and hermetic/hessian bags could be used, while in large scale storage, mega storage cocoons, and sealed bunker storage could be used.

All the hermetic storage structural materials are characterized by individual intrinsic behaviours, advantages and disadvantages, but must be air tight in nature with reasonable oxygen impermeability. Metallic materials are synonymous with moisture problems such as condensation and migration especially in hot humid climates, but can guarantee high capacity smooth walls and near 100% impermeability, durability. It does well in the prevention of rodents, birds and human pilferage. Concrete materials are also efficient in protecting the grains against rodents and human pilferage, moisture migration, but it is expensive, but most often seepage

challenges and sticking of grains on the walls are always issue of concern. The greatest problems of flexible hermetic structures include high gas permeability problems, very low space maximization, termite/rodent attack, durability, human pilferage and fire outbreak. However, it has high efficiency in flexibility, ease of installation, and re-installation in another location, affordability and easily adapted to new technology. Other types of materials such as glass and plastic containers have high gas impermeability efficiency, but capacity is its greatest undoing. They are durable but exorbitant. However, according to research, no material is absolutely satisfactory as a hermetic storage construction material/structure over all others. They all have their advantages and disadvantages [11]. The choice of material is largely dependent on individual preferences, available resources, available material capacity of storage and the type of crop to be stored and the duration of storage. [12]. Hermetic storage structures can be classified as flexible or rigid structures depending on their structural rigidity [13].

II. Materials And Methods.

Problems militating against the full adoption, proper integration of hermetic storage structures in all levels of storage activities in Minna, were analysed by the use of questionnaires, designed and administered to local farmers within Minna and its surrounding towns as shown in Figure 1. Ad-hoc workers who understand the direction of the research, and can speak the local languages, were recruited to administer, assist in the filling, collect and collate the questionnaires for the purpose of statistical analysis. The questionnaire focused on identified factors such as cost, availability, farmers not willing to experiment with their crops, culture, illiteracy, and lack of efficient/effective agricultural extension methodology/framework to drive home the technology.

Non-proportional or random stratified sampling technique was used. This is due to lack of data on farmers' populations/ registration, based on communities [14] , as indicated by the Federal Ministry of Agriculture, Growth Enhancement Support Scheme (GESS) registration data base. Since the respondent does not need to reflect the diversity of the population, in terms of sex, tribe and religion, the first sampling consideration was coming from the identified communities, secondly being registered under (GESS) and thirdly being a cereal grains farmer. The elevation factor for this research is 10, while the sampling factor is 0.1. 10% of the total numbers of farmers were sampled in this research work.

According to (GESS) registration data of 2013 updated, the population of cereal grains and cereal related farmers in Minna and its surrounded towns within (Bosso and Chanchaga) Local Government Area were estimated at 3000. Based on that, the area was divided into 50 internally homogenous and externally heterogeneous units aligned with the existing communities within the area for sampling. The questionnaires were administered to 6 farmers each from the 50 villages randomly selected, within Minna surroundings where the research work was carried out. A total of 300 questionnaires were administered to 300 respondents. The questionnaires were successfully filled collected and collated.

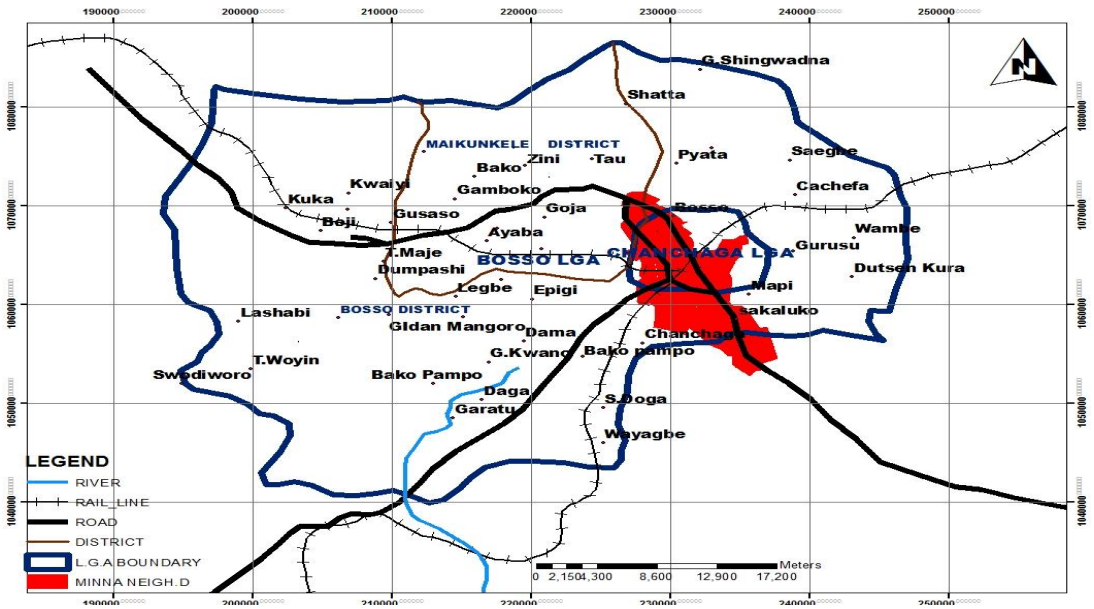

Figure 1: Minna and surrounding towns in Bosso/Chanchaga Local Government Areas.
Source: [20] Urban and Regional Planning Department, Federal University of Technology (FUT) Minna, 2015.

III. Results And Discussion.

3.1. Storage Structures Used For Threshed and Unthreshed Cereal Grain Storage in Minna

The result of the statistical analysis revealed that the most predominant form of threshed cereal grain storage system and structure used in Minna is ordinary polypropylene bags at 71.8%, which are neither treated nor hermetic in nature. Others include traditional system of storage in mud rhombus at 26.8%, and modern system of storage using hermetic storage structures at 1.34% as presented in Figure 2. However, the storage of unthreshed grain is still predominantly done using a traditional storage structure mud rhombus at 51%, followed by another form of traditional storage called open air storage at 35% and thirdly with the use of a modern storage structure, polypropylene bags 14% as presented in Figure 3. This result is in agreement [3] and thus buttresses the fact that there is the need to sensitize our local farmers on the numerous gains of hermetic storage technology.

Cereal grain storage in Minna is normally for a period of 9 months or less with the average capacity of 1-15 metric tonnes (MT) per individual farmer. More than 80 % of the farmers are illiterates and are 40 years and above in age. According to the results of the descriptive statistics 90.60% of the respondents store their crops using inorganic chemicals (insecticide/pesticides) such as Dicholovos organophorous (DDVP) and different brands of fumigants (phosphine). This result is in agreement with [15] and [5] who also reported excessive use of storage chemicals for cereal grain storage in Nigeria. European Union ban of imported food items from Nigeria in 2015 also justifies these findings. The two identified major challenges as far as cereal grain storage is concerned in Minna, are insect infestation and rodent attack. The result also revealed that the most planted cereal grains in Minna are maize, sorghum and rarely millet and rice. Other popular crops are legumes such as cowpea and soya bean

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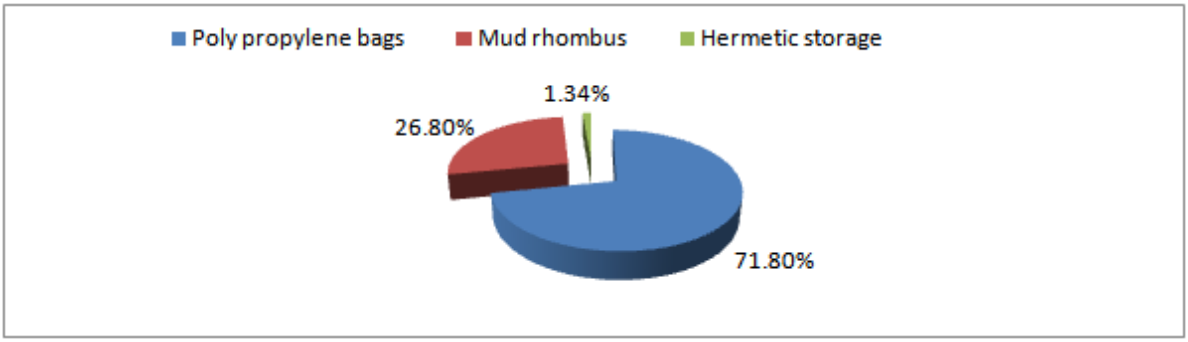

Figure 2. Storage Structures used for Threshed Cereal Grain Storage in Minna.

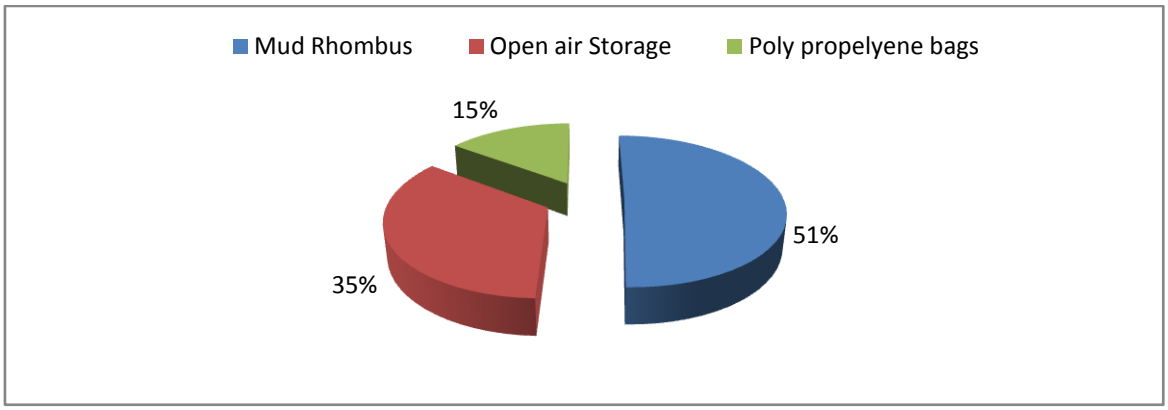

Figure 3. Storage structures used for unthreshed cereal grain storage in Minna.

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3.2. Problems militating against full adoption of hermetic storage structures at all levels of cereal grain storage in Minna

According to the statistical result presented in Figure 4, the major problems militating against the full adoption, of hermetic storage structures at all levels of cereal grain storage in Minna, is the non-availability of hermetic storage structures, which 88.18% of the respondents accented to. Others are farmers fear to experiment the new technology with their crops, and lack of proper introduction of the hermetic storage technology/structures to farmers, by agricultural extension workers at 5.74% and 3.04%, respectively. Cost, availability, cultural factors, illiteracy, farmer demographic factors such as sex, age, marital status, farm size, farming experience, and credit access do not significantly influence the adoption of hermetic storage structures

in Minna, Nigeria. This issue of non-availability of the hermetic storage structures, as the major problem militating against the full adoption of hermetic storage structures at all levels of cereal gain storage is in agreement with [16] who carried out a similar research in ten countries each in West and Central Africa. [17] and [18] also upheld lack of familiarity and awareness creation as the major factors which influences the farmer decision on whether or not to use hermetic storage technology/structures for the storage of grains. This largely agrees with the result of this research. Correlation analysis showed that the last two factors show that they are inter-related. It could be inferred that lack of proper introduction of these hermetic structures was responsible for the farmer's fear of experimenting with their crops. [19] also reported a similar result in a research conducted in Sierra Lone in 2001. However, the leading role required of the Government agricultural extension agents through public demonstrations, promotion and awareness of this technology was seriously lacking according to the statistical analysis. Even at the lowest level of storage where common hermetic structures such as metal drums, plastic gallons and other airtight containers could be used, to store a wide range of cereals, pulses, and many other household perishables, the awareness is lacking.

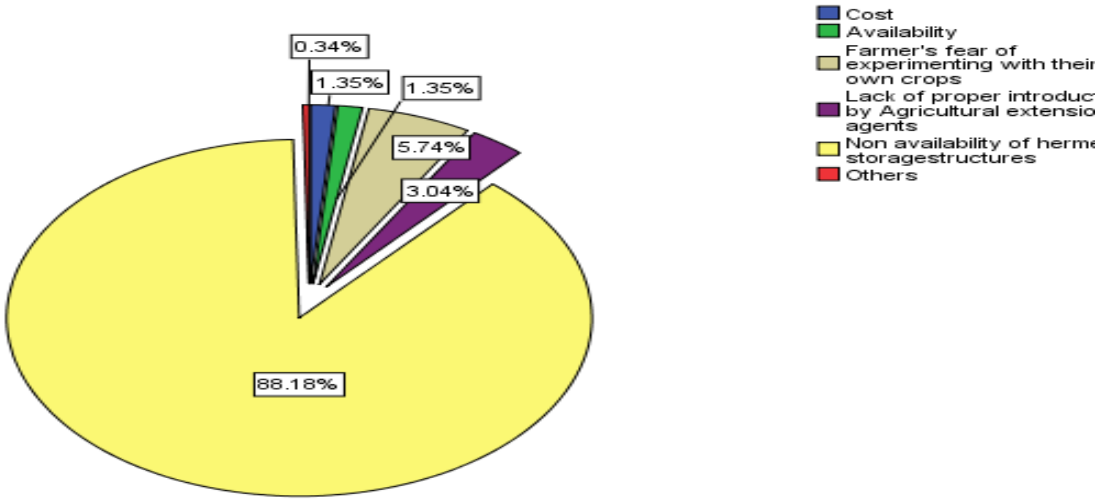

Figure 4: Problems militating against the full Adoption of Hermetic Storage Structures in Minna.

This is evident in the fact that more than 80% of the sampled farmers Minna, Nigeria have never met with an agricultural extension agent. The result of this research, is not in agreement with the incidence of indifference and wrongful use of hermetic storage structures by farmers in Minna in 2009, whereby majority of farmers shunned collection of free metallic silos given to farmers by FAO, and some who collected converted them to water tanks and other numerous uses they deemed fit. The incidence rather agrees with the second and third reasons furnished by this research. Most surprisingly, none of the respondents sampled agreed to be a recipient of the metallic hermetic storage structures given to farmers free by FAO in 2009. This result may have been affected by respondent's bias, and anticipation that they may be given another hermetic storage structure free, if they had not received earlier. However the conversion of hermetic metallic storage structure to water tank would have been caused by lack of trust in the technology or ignorance, which supposedly would have been tackled earlier than its introduction by Government Agricultural Extension workers. The doubt of its workability could have also been tackled through public demonstration. It is evident that apart from non-availability, there is only a single problem among others, this research work identified, that if it were solved would have taken care of all other problems, and that is lack of efficient and effective agricultural extension services through farmer groups, co-operatives and local market town hall meetings/demonstrations in introduction of this technology.

Logit regression and correlation analysis was also used to establish the relationship between the three major factors to further justify or otherwise this claim. The Logit regression model for analyzing the major factor militating against the adoption of hermetic storage structures is as presented below

The logistic regression model could be expressed as:

Logit (πi)= $\log \frac{(\pi i)}{1-(\pi i)} = \beta 0 + \beta 1x1 + \beta 2x2 + \beta 3x3 \ldots . \beta nxn$ or $\pi i = \frac{exp\,(\beta 0+\beta 1xi)}{1+exp\,(\beta 0+\beta 1xi}(1+x)^n = 1 + \frac{nx}{1!} + \frac{n(n-1)x^2}{2!}$ (1)

1= the tendency to use hermetic structures for cereal grain storage.

0= non-tendency to use hermetic structures for cereal grain storage.

πi = probability of farmers to store or not to store grains using hermetic storage structures.

$\beta nxn =$ Independent variables 1, 2...n.

The summary of the relationship between the three major factors namely, non availability of hermetic storage structures, farmer's fear of experimenting with their crops, and lack of effective and efficient agricultural extension services as established using correlation analysis . The correlation result shows that the three major identified problems are inter-related and dependent on each other. Non-availability of the hermetic storage structures and the farmer's fear of experimenting with their crops have the strongest correlation of 0.970%. The lack of proper introduction by agricultural extension agent has the second strongest correlation of 0.947% with non availability of hermetic storage structures, and 0.922% correlation factor for farmer's fear of experimenting with their crops and lack of proper introduction by agricultural extension agents. From this result, apart from non availability of hermetic storage structures, the lack of proper introduction by agricultural extension workers has the second highest correlation factor amongst others, and thus the next most important factor.

IV. Conclusion And Recommendations

4.1 Conclusion

1. The result revealed that the problem militating against full adoption of hermetic storage structure at all level of cereal grain storage in Minna are the non- availability hermetic storage structures at 88.18%, farmers fear of experimenting with their crops at 5.7 and lack of efficient and effective Government Agricultural extension services to drive home this technology.
2. Since presently, Nigeria is diversifying her economy, and agriculture is one of the identified areas of intervention, with cereal grain production one of the countries areas of comparative advantage, there can be no better time than now, to re-position cereal grains storage in Nigeria using hermetic storage technology. This will enable farmers to use the best practices in storage, reduce enormous storage losses, ensure food security and enable cereal grains produced/stored in Nigeria be proudly exported to any part of the globe to earn foreign exchange.
3. Hence, despite the huge repository of on/off-farm agro-technologies available today, efficient promotion methods for greater adoptions remain limited. Improvement in this direction could not only boost farmers' income, but also ensure food security for the underfed populations of the developing world

4.2. Recommendations

1. Government and should encourage more research, to evolve more hermetic storage structures that will be adaptable to Nigeria's agro-climatic environment. Private organizations such as plastic and metal/ foundry companies should be encouraged, to go into the production of hermetic storage structures that will be primarily designed for grain storage, at a reduced cost that will be affordable by the local farmers.
2. The Nigerian Government and non-Governmental Organizations should do more in the area agricultural extension services and public awareness. This will enhance the introduction, publicizing and promotion of hermetic storage technology for use at all levels of grain storage in the country. It will consequently bridge this gap between research finding and the farmers who needs this information, as so many quality research findings has only ended in book shelves.
.3. The Government should expedite effort/awareness geared towards the use of hermetic storage structures for storage of consumable grain, pulses and other dry perishables for family use, where plastic gallons and other hermetic storage containers could be very efficient. The awareness should involve public demonstrations and exhibition, where grains could be stocked in front of farmers using different types and capacities of hermetic storage structures without the use of insecticide or pesticides, and opened in due course at an agreed time, in their presence, so that they can see practically how effective hermetic storage technology is.
4. There is also the need for participatory research that emphasizes collaboration among consumers (end users), farmers (producers), extensions agents (technology disseminators), researchers (technology developers) and decision-makers (research funders). New technologies developed as a result of such collaboration could be more suitable to local communities and acceptable by relevant stakeholders. Agro-technologies that address key concerns of consumers/farmers could further enhance food production, self sufficiency and security at local, regional and global scales.

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