Storage Systems For Bambara Groundnut (Vigna Subterranean) And Their Implications For Bruchid Pest Management In Talensi-Nabdam District, Upper East Region, Ghana.

Ayamdoo A. J., Demuyakor B., Badii K.B., Sowley E.N.K

Abstract: - Bamabara groundnut, Vigna subterranea (L.) Verdc, is an important grain legume that plays a significant role in sustainable agriculture, food and nutritional security in sub-Saharan Africa. In northern Ghana one major constraint to the save preservation of bambara groundnut seeds after harvest is infestation by bruchid insects. A survey was conducted to obtain information on the existing storage systems and their implications for bruchid pest management in the Talensi-Nabdam district of Upper East region of Ghana. Six farming communities and five marketing centers were surveyed between January and March, 2012 by administering structured and semi structured questionnaires to respondents drawn by purposive sampling method. The study revealed that the major storage pests infesting bambara groundnuts in the surveyed areas were insects of the bruchid group which were dominated by three species of Callosobruhus and one species of Zabrotes. Storage structures used by farmers and traders included earthenware pots, gourds, mud silos, jute sacks, metal drums and plastic containers but jute sacks and clay pots were rampant in terms of use. Though not all the structures are effective many were used owing to their hermetic conditions against the pests, coupled with their durability, economic and ease of integration with indigenous grain protectants such as admixture with vegetable oils, fine ash and extracts from a local plant scientifically known as Hyptis spicigera. The extract from Hyptis spicigera was more (50 %) in use to preserve Bambara groundnuts because its work better in warding off the bruchid pest. The rampant postharvest losses to bambara groundnut grains in the area could be minimized if these existing storage structures and grain preservation techniques were improved.

Index Terms: - Bambara groundnuts, bruchids, Ghana, storage systems, Talensi-Nabdam.

1 INTRODUCTION

Bambara groundnut, *Vigna subterranea* (L) Verdcourt, is an indigenous African legume grown primarily for it seeds (Swanevelder, 1998). It is one of the major grain legumes consumed in Ghana: ranking third to cowpea and groundnut (Sellschop, 1962). In the northern sector of Ghana, bambara groundnut has become a food security crop, being a cheap source of proteins and carbohydrates in the diets of many rural and urban households (Anchirinah *et al*., 2001). The seeds are highly nutritious and contain more lysine and methionine than either cowpea or groundnuts (Ezedinma and Maneke, 1985). Dried seeds are boiled and eaten, or the cooked seeds mixed with cassava, maize or rice and consumed. The seeds may also be ground into floor and used to enrich several traditional preparations (Brink and Belay, 2006). Berchie *et al*. (2010) reported that the demand for bambara groundnut in Sub-Saharan Africa exceeds the present supply. Seed yield in Africa average 650-850 kg/ha with significant variations among countries (Stanton *et al*., 1966; Ayayi and Lale, 2001).

- Ayamdoo A J Post-graduate Student,Department of Biotechnology, Faculty of Agriculture, UDS, Box TL 1882, Tamale, Ghana
  Emails: jayamdooabugre@yahoo.com
- Demuyakor B Lecturer Department of Biotechnology, Faculty of Agriculture, UDS, Box TL 1882, Tamale, Ghana Email; Bawainghana2@yahoo.co.jp
- Badii K.B Lecturer, Department of Agronomy,Faculty of Agriculture, UDS, Box TL 1882,Tamale,Ghana
- Email: benbadii@yahoo.com
- Sowley ENK Senior Lecturer, Department of Agronomy, Faculty of Agriculture, UDS, Box TL 1882,Tamale, Ghana. Email: esowley@gmail.com

A major constraint to the increased and sustainable production of bambara groundnut in Ghana is the high grain losses incurred during storage of the harvested grains. In the Talensi-Nabdan District of the Upper East Region, in particular, the grains are the most susceptible to insect infestation and destruction. The destruction may start from the field, but serious insect damage occurs during storage (Amuti and Larbi, 1981; Warui, 1984; FAO, 1985; Golob *et al*., 1996). Average grain losses of about 10% per month are common (Golob *et al*., 1996). According to Obeng-Ofori and Danquah (2004), bruchid beetles are the major storage insect pests of bambara groundnuts. Grain damage and losses (both quantitative and qualitative) are usually caused by larvae which develop within the grain, consuming the seed and rendering it unsalable or inconsumable (Haines, 1991; Allotey and Oyewo, 1993). Previous survey in northern Ghana revealed that average weight losses in bambara groundnut during on-farm storage are of significant proportions and the damage incurred is of serious concern as damaged beans command much reduced market prices (Golob *et al*., 1996; Golop *et al*., 1998). Grain deterioration in bambara groundnuts is not only a problem faced by producers. Traders (sellers) as well, because all levels within the grain value chain, suffer storage losses as a result of bruchid pest infestations. This has also become a major problem for food aid agencies such as the school feeding programme and World Food Programme operating in the district. The economic importance of bambara groundnut in Ghana dictates that promoting its cultivation would be enhanced if effective storage systems and more sustainable grain treatment or preservation methods are developed. This would help increase incomes of producers and traders and ensure food security, particularly among the rural poor. This present survey seeks to obtain baseline information on the existing storage systems for bambara groundnut grains, and the extend to which these systems aid

in brucid pest management in the Talensi-Nabdam District of the Upper East Region of Ghana. The information would be helpful in designing safe storage methods and sustainable management strategies against storage pests of bambara groundnut in Ghana.

2 MATERIALS AND METHODS

2.1 Study Area

The survey was conducted in the Talensi-Nabdam district in the Upper East region of Ghana. The district is located on the north eastern corner of the region between latitude 100° 30' N and longitude 00° 10' west of the equator. The district has a total land area of 912 km^2 and boarded by the Bolgatanga Municipality and Bongo district to the north, West and East Mamprusi districts to the south, Kassena Nankana district to the West and Bawku West district to the East (TNDA, 2005). The rainfall pattern is unimodal with a mean annual rainfall of 950 mm. The rainy period is relatively short, lasting averagely from June to September, and dry season span from October to May. Maximum and minimum daily temperatures could be as high as 45 ^oC in March and as low as 12 ^oC in December, respectively (TNDA, 2005). Farming is the major occupation of the people though at peasant level. Major staples produced are millet, sorghum, maize, peanuts, bambara groundnuts, rice, cowpea and soya beans. The major trading centers for marketing agricultural produce within the district include Kongo market, Tongo market, Pelungu market, Pwalugu market and Tindongo market.

2.2 Questionnaire Survey

The survey was conducted between the months of January and March, 2012 to investigate the storage systems for bambara groundnuts and their implications for bruchid pest management in the district. Both structured and semi structured questions were administered to two hundred and twenty (220) bambara groundnut producers and traders drawn from six (6) farming communities and five (5) market sites across the district. The communities included Balungu, Baare, Duusi, Datuku, Sheaga and Yameriga. These communities were selected based on their popularity for bambara groundnut production in the area. The target market centres were Kongo, Tongo, Pelungu, Pwalugu and Tindongo markets. Twenty (20) respondents were interviewed at each farming community or market site. Purposive sampling procedures were applied to select the targets respondents. Questionnaires were administered by interviewing respondents and writing down the response appropriately. Respondents were allowed to infer, inquire or seek clarifications from family members since crop storage is a household affair. Major aspects covered in the questionnaire included the background of respondents (producers and traders), diversity of bruchid pests encountered in stored bambara groundnuts, storage structures and methods used for preserving bambara groundnut grains, and the implications of these systems for managing the major bruchid pests in storage. Samples of bambara groundnut grains were taken from each producing community or market for laboratory examination to determine the different bruchid species and their population densities.

2.3 Statistical Analysis

Data obtained were analyzed using the Statistical Package for Social Sciences (SPSS) software. Descriptive statistical values, mainly percentages were used to determine and illustrate the differences among the various parameters investigated in the study.

3.0 RESULTS

3.1 Background of Respondents

Table 1 presents the sex and age distribution of the bambara groundnut producers and sellers in the Talensi-Nabdam District. A total of 128 (58.1%) of the respondents interviewed were females while 92 (41.8%) were males. All the bambara groundnut sellers were females (100 females: 0 males) while majority of producers were males (92 males: 28 females). No female producer was recorded in Yameriga and Duusi communities. The age distribution showed that 54 (24.5%) of the respondents were between the age of 15 and 30 years, while 154 (70.0%) fell within the age bracket of 31 and 51. Only 12 (5.4%) respondents were above the age of 50 years as in the case of Yameriga, Sheaga, Duusi and Tongo. Baare, Datuko, Balungu, Pwalugu, Pelungu, Kongo and Tindongo did not have any producer or seller age above 50 years (Table 1). In all, majority of the producers and sellers fell within the age bracket of 31 and 50 years.

Table 1: Sex and age range of bambara groundnut producers and sellers in Talensi-Nabdam

Community/ Market	Sex		Age Range		
	Male	Female	15-30	31-50	Above 50
Baare	16 (80)	4 (20)	4 (20)	16 (80)	-
Yameriga	20 (100)		4 (20)	12 (60)	4 (20)
Sheaga	12 (60)	8 (40)	6 (30)	12 (60)	2 (10)
Duusi	20 (100)		12 (60)	6 (30)	2 (10)
Datuko	8 (40)	12 (60)	8 (40)	12 (60)	-
Balungu	16 (80)	4 (20)	-	20 (100)	-
Pwalugu market	-	20 (100)	-	20 (100)	-
Kongo market	-	20 (100)	4 (20)	16 (80)	-
Pelungu market	-	20 (100)	4 (20)	16 (80)	-
Tongo market	-	20 (100)	8 (40)	8 (40)	4 (20)
Tindongo market	-	20 (100)	4 (20)	16 (80)	-
Total	**92 (41.8)**	**128 (58.1)**	**55 (24.5)**	**154 (70)**	**12 (5.4)**

Values outside parenthesis are actual numbers while those in parenthesis are percentages.

Concerning education, the results revealed that formal educational background of producers and sellers in the district were low. About 146 respondents representing 66.4% of producers and sellers in the district did not have formal education at all. A total of 54 (24.5%) respondents had basic education while 16 (7.3%) had secondary education (Table 2). Apart from Sheaga that had only 4 (1.8%) tertiary

respondents, no producer or seller again had tertiary education among the target population. Duusi had the highest number of respondents (8) representing 40% with secondary educational background. Meanwhile, no respondent in any of the market centers had secondary education (Table 2).

Table 2: Educational status of bambara groundnut producers and sellers in Talensi-Nabdam

Community/ Market	Educational Statue			
	Non Formal	Basic	Secondary	Tertiary
Baare	12 (60)	4 (20)	**4 (20)**	**-**
Yameriga	16 (80)	4 (20)	-	-
Sheaga	8 (40)	48(40)	-	4 (20)
Duusi	12 (60)	-	8 (40)	-
Datuku	8 (40)	8 (40)	4 (20)	-
Balungu	16 (80)	4 (20)	-	-
Pwalugu Market	10 (50)	10 (50)	-	-
Kongo Mkt	4 (20)	16 (80)	-	-
Pelungu Mkt	20 (100)	-	-	-
Tongo Mkt	20 (100)	-	-	-
Tindongo Mkt	20 (100)	-	-	-
Total	**146 (66.4)**	**54 (24.5)**	**16 (7.3)**	**4 (1.8)**

Values outside parenthesis are actual numbers while those in parenthesis are percentages.

3.1 Diversity of Bruchid Pests in Stored Grains

Table 3 represents the population densities of the different bruchid pest species recorded in bambara groundnut samples taken from storage in the various communities and market centers. The major bruchid species identified in grain samples included *Callosobruchus maculatus, Callosobruchus subinotatus, Callosobruchus chinensis and Zabrotes subfasciatus.* All these insects locally are called "wura" meaning beetles. The different sub-species of the bruchids were designated locally as "wura biibis" or "wura kara" meaning small beetles or big beetles. The results showed that *C. maculatus* was the most abundant bruchid species infesting bambara groundnut grains in the district. This was followed by *C. subinotatus*, and *C. chinensis* while *Z. subfasciatus* was the least abundant bruchid pest. No *C. subinotatus* was recorded in grain samples from Duusi community (Table 3). Neither did grain samples taken from Baare or Balungu communities did record *C. chinensis. Also Z. subfasciatus* was not recorded in samples from Baare, Sheaga and Pwalugu market. Overall, grain samples taken from all producing communities and market centers were found to contain high population of *C. maculates* than other bruchids species.

Table 3: Diversity of bruchid pest species infesting bambara groundnut grains

Community/ Market	Population densities of bruchid species recorded per kg of grain sample			
	C. maculatus	C. subinotatus	C. chinensis	Z. subfasciatus
Baare	20.6	7.5	**-**	**-**
Yameriga	26.4	10.3	2.0	3.5
Sheaga	28.5	2.6	3.5	-
Duusi	19.5	-	4.0	4.8
Datuku	30.3	8.4	5.2	3.6
Balungu	24.9	10.6	-	2.1
Pwalugu Market	33.6	14.2	6.5	-
Kongo Mkt	30.5	14.8	7.0	1.5
Pelungu Mkt	25.3	11.5	5.3	2.5
Tongo Mkt	19.2	18.5	8.4	4.2
Tindongo Mkt	31.5	17.9	7.4	1.0
Total	**280.3**	**116.3**	**49.3**	**23.2**

3.2 Storage Structures and their Pest Management Implications

The different types of structures used for storing harvested bambara groundnut grains within the various producing communities and market centers are shown in Table 4. The results showed that clay pots, gourds, mud silos, jute sacks, plastic bags, plastic drums and glass bottles were the major storage structures for bambara groundnut grains in the district. Jute/fertilizer sacks and Clay pots were the most widely used storage structures in all communities and marketing centers. A total of 60 representing 27.3% and 54 (24.5%) of the respondents store their grains in Jute/fertilizer sacks and clay pots respectively. Clay pots were claimed to have high storage capacities, insect resistant and durable though they are more expensive and less portable. Jute/fertilizer sacks were found to be more portable with high storage capacities. They are also used as standard of measurements when it comes to marketing. Jute/fertilizer sacks however increase bruchid pest incidence as they are not insect-proof or moisture resistant materials.

Table 4: Structures used by producers and sellers for storing bambara groundnut grains.

Storage Structure	Frequency	Major Reasons for Choice	Major Limitations
Clay pot	54 (24.5)	High storage capacity, insect resistant, durable	Expensive,not portable, moisture absorbent
Gourds	32 (14.5)	Portable, low maintenance cost, insect resistant	Moisture absorbent, low storage capacity.
Mud silos	22 (10)	High storage capacity, durable, insect resistant	Not portable, moisture absorbent
Jute/Fert sacks	60 (27.3)	Portable,high storage capacity, low maintenance cost	Moisture absorbent, high pest incidence
Plastic bags	31 (14.1)	Portable, airtight, moisture resistant=	Low storage capacity
Plastic containers	14 (6.4)	Portable, airtight, moisture resistan	Expensive,not accessible
Glass bottles	7 (3.2)	Airtight, insect proof, moisture resistant	Expensive, low storage capacity

Values outside parenthesis are actual numbers while those in parenthesis are percentages.

About 32 representing 14.5% of the respondents use gourds to store their grains. Gourds were preferred for their portability and low cost despite their low storage capacities and moisture absorbent nature. Next was 22 (10.0%) of respondents who used mud silos to store bambara grains owing to their high storage capacities and durability. A total of 31 (14.1%) and 14 (6.4%) respondent used plastic bags (polyethyelene sheets) and plastic containers, respectively with the reason that these structures provide airtight conditions against pests, prevent moisture entry, and are relatively more portable. Glass bottles recorded the least usage with only 7 respondents (3.2%) even though bottles are claimed to provide airtight conditions against insects, and are much more portable. Their low storage capacities and fragile nature limited their usage according to respondents.

3.3 Methods of Preserving Grains in Stores

Various chemical grain protectants were used to preserve the grains in storage with the view of keeping them free from bruchid infestations. Plant-derived insecticides such as groundnut oil, shea butter, fine ash and aqueous extracts from seeds of neem (*Azadirachta indica*) and extracts of a local plant called “Dunkpowg” commonly known as black beni-seed or black sesame (*Hyptis spicigera*) were commonly explored for bambara groundnut grain protection in storage. A total of 111 (50.6%) respondents used the local weed “Dunkpowg” *(Hyptis spicigera)* extracts while 39 (17.6%) used neem seed extracts for grain protection. Many respondents explained that the black sesame plant (*Hyptis spicigera*) is effective against bruchids and that they were readily available locally and nontoxic to consumers. Respondents using shea butter and groundnut oil for grain protection were 17 (7.7%) and 14 (6.4%), respectively, reasons being that these are easy to apply and low mammalian toxicity. Major limitations of the used of the various botanicals were their relatively low efficacy, tedious extraction methods and no recommended dosages. Fine ash was explored by over 18 (8.2%) respondents as it was economical, readily available and nontoxic to consumers. Synthetic chemical grain protectants recorded the least usage (Actellic) - 2.3% and (Pyrimiphos) -1.8%) according to the survey. Though these products were said to be effective against the pests, their high costs and mammalian toxicity was a major limitation to their usage (Table 5).

Table 5: Insecticidal products used by producers and sellers for storing bambara groundnut grains.

Grain protectant	Average number using protectant	Major Reasons for Choice	Major Limitations
Actellic dust	5 (2.3)	High efficacy	Expensive, toxic
Pyrimiphos	4 (1.8)	High efficacy	Expensive, toxic
Phosphide	12 (5.5)	Effective, easy to apply	Not in local markets
Fine ash	18 (8.2)	Readily available, cheap, nontoxic	Low efficacy, no recommended dosage
Groundnut oil	14 (6.4)	Easy to apply, repel pests, nontoxic	Low efficacy, no recommended dosage
Shea butter	17 (7.7)	Easy to apply, repel pests, nontoxic	Tedious extraction process, no recommended dosage
Neem extract	39. (17.7)	Effective, readily available, nontoxic	Tedious extraction process, no recommended dosage
***H.spicigera* extract**	111 (50.5)	Effective, readily available, nontoxic	-

Values outside parenthesis are actual numbers while those in parenthesis are percentages.

4.0 DISCUSSION

This survey revealed that more males were involved in bambara groundnut production than females, but only females were involved in the sale of the crop which contradict Adu-Dappah *et al*. (2006) who, reported in their work that there are more female bambara groundnut producers than males in northern Ghana. This may have implication for gender considerations for any technology aimed at improving bambara groundnut production and marketing in the District. Also, majority of the producers and sellers were within the

youthful age indicating that the production and marketing of the crop has a brighter future, except for the low educational background of the majority, which may be a hindrance to technological advancement. The survey has shown that bruchid pests have been a problem to sustainable production, marketing and utilization of the crop in the Talensi-Nabdam District of Ghana. Alan *et al*. (2009) reported that beetles of the family bruchidae have been a postharvest problem to bambara groundnut in sub-Saharan Africa. Bruchids of the genera *Callosobruchus* and *Zabrotes* are worrysome storage pest to bamabra groundnut handlers in the district. Previous research suggests that bruchid damages to pulse crops are substantial although figures presented in literature are often unsubstantiated (Golob *et al*., 1996). Effective loss assessment methods are required to document the scale of the postharvest pest problem of bambara groundnut, and cost/benefit analysis of interventions designed to reduce losses. Protection of pulses from insects by placing them in insect-proof or airtight containers has been known and practiced for a long time (Hall and Hyde, 1954). However, these improved storage techniques such as are not practiced by producers and sellers in the studied areas. Airtight (hermetic) containers have added advantage that with time oxygen levels decrease and carbondioxide levels rises resulting in death of insects and declining populations. For better results, the triple plastic bag technology needs to be adopted by the small scale farmers and traders in the district as an effective hermetic storage method (Kitch and Ntourkam, 1991). Moreover, clay pots and mud silos (granaries) should have polythene liners; the nuts should be placed in sacks with inner liner of cotton material to protect it from insect penetration. The polythene bags and cotton liners should be firmly shut with strings and placed in the pot or mud silo (O'Dowd, 1971). Plastic drums filled with nuts should be fitted with their caps and the caps greased before tightening to ensure that they are airtight. All sealed storage options offer best cost efficiency when the storage period is at least 2-3 months since the containers are expensive, and opening the container, even very briefly, will allow entry of oxygen and resumption of insect activity (Alan *et al*., 2009). Admixture of fine ash with nuts may not actually prevent bruchid damage but hinders activity of newly hatched adults (Giga *et al*., 1992). For ash to be effective requires an admixture rate of over 5% for wood ash to ensure that all the inter-granular spaces are filled (Kitch and Giga, 2000). A wide range of plant materials as well as vegetable oils have been used with some successes in bruchid control. The efficacy of the plant material may vary depending on the plant species and part of the plant used (Alan *et al*., 2009). The products may act as natural insecticides, anti-feedants or repellents. In most cases, their safety to consumers has not been established even though some are known to be non toxic but in most cases, they may taints the nuts and thus, limiting their market value. Particular cases is the use of seed extracts from neem and extract from the black sesame plant (*H. spicigera*) which are used for the treatment of bambara groundnuts by most producers and sellers in the Talensi-Nabdam District of Ghana. Essential oils from groundnut and shea nuts may also be repellent or even kill bruchids in confined spaces with a 'fumigant' effect though the efficacy of the treatment may be lost after 3 months (Baier and Webster, 1992). Although cooking oils are relatively expensive, the cost of treating small quantities of nuts may be well justified? Jute sacks impregnated with plant extracts have been shown to offer about 80% nut protection and also avoid taint and any potential toxic hazards. Synthetic insecticides especially organ phosphorus compounds have been used for the protection of stored pulses usually by admixture of the dilute dust formulation. However, access to these is usually restricted due either to the limited availability or the inability or reluctance of farmers to pay for them.

5.0 CONCLUSION AND RECOMMENDATIONS

The results of this survey have demonstrated that both male and female farmers were involved in bambara groundnut business in the Talensi-Nabdam district of Ghana, with majority being illiterate. Most of these bambara groundnut producers and sellers are in the youthful age which gives assurance that the crop may not be extinguished any time soon in the district. Three species of bruchid insects dominated by two species of *Callosobruchus* and one species of *Zabrotes* were the major insect pests infesting the grains in storage. Producers and sellers use simple traditional structures for storing their harvested grains. Majority of them prefer jute sacks not because of safe grain protection but several factors taken into consideration. Different types of insecticidal products were also explored for grain protection. The most common among them was extract from black sesame (*H. spicigera*) a weed locally called "Dunkpowg" that was found to be quite effective and nontoxic. Synthetic chemical grain protectants were mainly organophosphates but recorded limited usage owing to their high cost, unavailability in local markets and toxicity. There is the need to improve hermetic conditions in the traditional storage structures for better grain protection. The local available plant-base insecticides such as neem and black sesame (*H.spicigera*) should be promoted by establishing more cost effective extraction methods and appropriate dosages and application rates. The integrated control strategy should be adopted by combining the above methods with good store hygiene, solarization, and selection of healthy grains for storage. Research need to investigate more opportunities for integrated control of buchid pests for increased and sustainable production and utilization of bambara groundnut in the District.

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