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Research Paper

Traders' perception of food grain storage and pest management in Dalwa market, Borno State, Nigeria

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Abstract. The knowldege and practice of food grain storage and pest management by traders' in Dalwa market, Borno State, Nigeria was investigated in this study. Data on socio-economic characteristics, grains storage practices, constraints, pest problems and pest control practices were obtained using a structured questionnaire administered randomly to traders'' in the market. In addition to having no formal education, most of the traders'' practiced the storage of three to four different grain types in shared stores. Inadequacy or insufficiency of storage rooms/structures and poor availability or high cost of pesticides were acknowledged to be abiotic factors of serious concern to the traders'. Attack by insect pests, rodents and termites, were found to be more important biotic factors than rotting of crop produce due to infection by micro-organisms. Although the traders' generally observed moderate pest infestation in bambaranut, millet, sorghum, cowpea, groundnut and maize grains, infestation of the latter three grain types was at times severe. Insect pests found attacking stored cereal grains and pulses included *Callosobruchus maculatus* (Fabricius), *Sitophilus zeamais* Motschulsky, *Rhizopertha dominica* (Fabricius), *Trogoderma granarium* (Everts), rodents (*Rattus* spp. and *Mus* spp.), termites (unidentified species), *Tribolium castaneum* Herbst and *Callosobruchus subinnotatus* (Pic.). Of which, only the latter two species were ranked to be the least important pests. Most traders' applied pesticides to protect stored food grains and control pest infestation. Pesticides application was, however, generally practiced with very little or poor technical knowledge. The implications of all the above findings on effective and safe food grain storage are discussed.

Keywords: Traders' knowledge, storage constraints, insect pests, food grain, cereals and pulses, control.

INTRODUCTION

Between 70 and 90% of the food grains harvested annually in sub-Saharan Africa, mainly by resource-poor farmers, get stored for household consumption and/or marketing purposes (Ivbijaro, 1989; Golob et al., 1999). Storage is often over six to twelve months at farm and domestic level in traditional or improved/semi-modern storage structures such as rhombus, cribs, bins, bags etc, that are not insect-proof. Effective preservation of both food grain quality and quantity in Africa, however, remains greatly limited by postharvest destruction due to insect pest attack. Grain damage and loss in the ranges of 4.5 to 100% and 2.9 to 30%, respectively, due to insect infestation have been reported across the continent (Youdoewei and Service, 1986; Ivbijaro, 1989; Lale and Ofuya, 2001; Philips and Throne, 2010). Of the over 1195 insect species associated with stored products in the tropic, 407 are major pests that principally belong to the orders Coleoptera and Lepidoptera (Cornes, 1964; Hill, 1975; Lale and Ofuya, 2001). Examples of important species include *Sitophilus* spp. (Coleoptera: Curculionidae), *Rhyzopertha* sp. (Coleoptera: Bostrichidae), *Trogoderma* sp. (Coleoptera: Dermestidae), *Callosobruchus* spp. (Coleoptera: Bruchidae), *Tribolium* spp. (Coleoptera: Tenebrionidae), *Sitotroga* spp. (Lepidoptera: Gelechiidae), *Corcyra* sp. (Lepidoptera: Pyralidae), *Ephestia* spp. (Lepidoptera: Pyralidae), *Myelois* sp. (Lepidoptera: Pyralidae) and *Plodia* sp. (Lepidoptera: Pyralidae). Attack by insect pests may be initiated in the fields prior to harvest, or at various stages of processing/handling (that is, drying and threshing), transportation and storage (Ayertey and Ohiagu, 1982; Abate et al., 2000). Grain damage results

directly from insect feeding and reproduction. Stored products further get contaminated with the presence and accumulation of excreta, cast skins and cadavers. Insect presence and feeding together may also raise grain temperature and moisture contents to create warm moist spots of increased grain respiration or humidity that stimulate grain deterioration and further fungal activity within stored commodities (Mills, 1989). Alterations or reduction in grain weight, physical appearance or aesthetic value and nutritional or chemical constituents such as sugar, proteins, lipids, minerals, vitamins, etc ultimately leads to qualitative and quantitative losses (Ayertey and Ohiagu, 1982; Abate et al., 2000). Depending on several factors such as inscet pest density and the length of storage, grain damage can progress in storage resulting in huge losses to farmers, traders'/consumers, food/feed millers and other store keepers. Especially, under any or all of the following situations: i) improper application of postharvest practices such as threshing, drying or transportation, ii) absence or insufficient storage hygiene, iii) poorly designed storage structures, and iv) absence of protective measures.

Grains of cereals and pulses including maize (*Zea mays* L.), cowpea (*Vigna unguiculata* (L.) Walp), sorghum (*Sorghum bicolour* (L.) Moench), pearl millet (*Pennisetum glaucum* (L.) R. Br.), rice (*Oryza sativa* L.), groundnut (*Arachis hypogaea* L.), wheat (*Triticum aestivum* L.), bambaranut (*Vigna subterranean* (L.) Verdcourt) and soyabean (*Glycine max* L.) constitute valuable sources of carbohydrates, proteins, fats or some essential nutrients including vitamins and minerals in human food (Wudiri and Fatobi, 1992). The production, processing and marketing of these grains supports the livelihood of millions of people across the northern region of Nigeria where these crops are cultivated. Between 40 and 85% of grains harvested in the Sudan and Guinea Savanna agroecological zones of this region are averagely stored for one year (Ivbijaro, 1989). Grains can however be kept for longer periods of up to ten years (Adejumo and Raji, 2007), as drier environmental conditions farther northwards of the savanna zones allow for longer storage periods than in other parts of the country. Although, low to high rates of insect damage (4 to 88%) (Giles, 1964a; Ivbijaro, 1989; Bamaiyi et al., 2006) and weight loss (1 to 37%) (Giles, 1964a; Caswell, 1979, 1981; Adugna, 2006) have been recorded from grains stored in the savanna region of northern Nigeria, these ranges, as influenced by factors such as storage structures utilized, the length of storage and pest control measures employed, can broadly vary with agroecological zones. Grain losses of even 1% in the various zones can deprive people of constant supply of quality food/adequate nourishment year round and planting materials, and also income generation and their means of livelihood. It is therefore imperative to establish the pest problems and consequent destruction incurred by grain handlers in various areas of the savanna region where agriculture is characterized by little or no resources, as well as the consequent effect on food security at local, regional, national and continental levels. This study therefore attempted investigating the constraints and insect pest problems of cereal and pulse grains storage by traders' in a major market or trading hub in Dalwa, Borno state situated in the Sudano-Sahelian Savanna agroecological zone of Nigeria.

MATERIALS AND METHODS

Dalwa market, within Konduga Local Government Area, is located at the outskirts (15 km) of Maiduguri, the capital of Borno state in Nigeria. The area lies at the edge of two agroecological zones, the Sudan and Sahel Savanna zones; and is characterized by altitudes of less than 410 m above sea level, eight months (October/November to May/June) or more of dry season, and erratic rainfall of 250 to 700 mm per annum lasting from June/July to September/October. Annual mean low and high temperatures are respectively 19.1°C (in January/February) and 34.7°C (in April/May), whilst relative humidity ranges from less than 10% in January/February to over 90% during the peak rainy season in August and with an annual mean value of 45.2% (Kowal and Knabe, 1972; NIMET, 2009). Agriculture is the major occupation of inhabitants of the area, as well as the larger north-eastern region. Amongst others, agricultural commodities traded in this major market include cereals, pulses, vegetables and fruits. Of which, grain cereals including maize, millet, rice, sorghum, wheat and pulses including cowpea, groundnut, bambaranut, soybeans are sold in relatively large quantities almost throughout the year. Grains sold in the market are sourced and transported from the stocks of mainly resource-poor farmers producing crops in various Local Government Areas of Borno state and around the shores of the Lake Chad basin, as well as the entire north-eastern region.

Data collection was through the use of a structured and validated questionnaire, eliciting information on the socio-economic characteristics of the respondents, as well as grain storage practices, constraints, pest problems and pest control practices. The questionnaires were administered to 50 randomly selected respondents, out of the approaximately 113 grain traders'' encountered in the market. The samples of each insect pest species per infested grain type were collected and identified in the Entomology Laboratory, Department of Crop Protection, University of Maiduguri. Data obtained were presented using descriptive statistics that comprised of frequency distributions and percentages.

RESULTS

The majority of respondents encountered were between

Table 1. Socio-economic characteristics of respondents in Dalwa market.

Variables	Frequency	Percentage (%)
Age (years)		
< 25	7	14
25 - 45	41	82
46 and above	2	4
Marital Status		
Single	10	20
Married	40	80
Education Level		
Non-formal	26	52
Primary	6	12
Secondary	18	36
Occupation		
Trader	26	52
Trader and farmer	24	48
Experience (Years)		
< 10	18	36
10 - 19	29	58
20 and above	3	6

the ages of 25 and 45 (82%), and also married (80%) (Table 1). Most of the respondents had no formal education (52%), which was limited to secondary school education (36%) and below (12%) (Table 1). In addition to trading strictly (52%), some respondents combined both trading and farming (48%) (Table 1). About 64% of the respondents have ten years experience and above of grain trade (Table 1). Cereal grains and pulses are mostly stored for a period of less than 12 months (64%), mainly for the purposes of trading (92%), followed by domestic consumption (78%) and seed preservation for planting during subsequent years (24%) (Table 2). A great proportion of traders' store three to four (76%) different cereal grain and pulse types together in store rooms shared alongside other traders' (58%) (Table 2). Many of the respondents stored and traded less than 3000 bags (84%) of cereal grains and pulses annually (Table 2).

Constraints faced by grain traders' in this study include insect pest infestation (86%), insufficient or inadequate store room/structures (62%), poor availability and high cost of pesticides (58%), attack by rodents (42%), transportation difficulty and cost (26%), incidence of termites (38%) and the rotting of crop produce (18%) (Table 3). The respondents indicated *Callosobruchus maculatus* (Fabricius) (82%), *Sitophilus zeamais* Motschulsky (76%) and *Rhizopertha dominica* (Fabricius) (60%) to be very common and major pest species infesting cereal and pulse grains traded in the market (Table 3). Other important pest species included *Trogoderma granarium* (Everts) (42%), rodents (*Rattus* spp. and *Mus* spp.) (38%), termite (unidentified species) (36%), *Tribolium castaneum* Herbst (16%) and *Callosobruchus subinnotatus* (Pic.) (10%). Based on host distribution, *S. zeamais* was recovered from five different grain types. *Rhizopertha dominica*, *T. castaneum* and unidentified termite species were found attacking four different grain types (Table 4). *Callosobruchus subinnotatus*, *C. maculatus* and *T. granarium* were respectively recovered from 1, 2 and 3 different grain types. Pest infestation of millet (36 to 64% respondents) and sorghum (27 to 73% respondents) grains mainly ranged from low to moderate, whilst that for cowpea (58 to 86% respondents), maize (38 to 86% respondents), groundnut (46 to 78% respondents) and bambaranut (22 to 56% respondents) generally ranged from moderate to severe (Table 5).

Sanitation (88%) and pesticide application (94%) were the two protective and control measures applied by the respondents (Table 6). Pesticides used by the respondents to manage insect and termite pests include Permethrin (Rambo (active ingredient (a.i.) = Permethrin 0.60%); manufactured by Gongoni Company Limited, Kano - Nigeria), Dichlovos (a.i. = DDVP 1000 EC; manufactured by Hubei Sanonda Company Limited, China), Aluminium Phosphide (Vee Phos (a.i. = Aluminium

Table 2. Purposes and practices of cereal and pulse grains storage by respondents in Dalwa market.

Variables	Frequency	Percentage (%)
Storage period*		
< 12 months	32	64
1 - 2 years	21	42
2 years and above	14	28
Uses of stored grains *		
Seeds	12	24
Domestic consumption	39	78
Trading	46	92
No. of grain type stored*		
1 - 2	9	18
3 - 4	38	76
5 and above	3	6
Store sharing		
Shared	29	58
Not shared	21	42
Quantity of bags stored and traded		
< 1000	22	44
1000 - 3000	20	40
> 3000	8	16

* Multiple responses obtained

Phosphide 57%); manufactured by Sandhya Organic Chemicals Private Limited, Vapi - India) and Chlorpyrifos (Rocket (a.i. = Chlorpyrifos 20%); manufactured by Red Sun Group Corporation, Nanjing - China). Also, the respondents warded off rodents attack by killing them with Zinc Phosphide (Rodenticide or Commando (a.i. = Zinc Phosphide 80%; manufactured by Excel Crop Care Limited, Gujarat - India). None of the respondents encountered had knowledge of the life cycle, behavior and appropriate control measures against the identified insect pests (Table 6). Most of the respondents acknowledged sourcing information on the pesticides applied primarily from pesticide vendors (86%); and then from other farmers (42%) (Table 6). Pesticides application by most respondents was observed to be moderately (86%) or very effective (72%) against pest infestation. Ineffective (26%) and very ineffective (18%) results have also been observed by some of the respondents. Most of the respondents seek the assistance of Government and Non-Governmental Organizations in providing modern storage structures (78%) and effective/affordable pesticides (70%) for their utilization (Table 7).

DISCUSSION

Results in this study highlight abiotic and biotic factors as major constraints faced by cereal and pulse grain traders'' in Dalwa market. Inadequacy or insufficiency of storage rooms/structures, as well as poor availability and high cost of pesticides have been expressed to be the abiotic factors of great concern to the traders'. Of the four biotic factors acknowledged by the traders', attack by insect pests, rodents and termites tended to be key over rotting of crop produce due to infection by micro-organisms. *Callosobruchus maculatus*, *S. zeamais*, *R. dominica*, *T. granarium*, rodents (*Rattus* spp. and *Mus* spp.), termites (unidentified species), *T. castaneum* and *C. subinnotatus* were particularly observed by the traders'' to be common pest species responsible for mild to severe infestation of stored cowpea, maize, groundnut, millet or sorghum grains. In terms of host range, most of these pests (*S. zeamais*, *R. dominica*, *T. granarium*, *T. castaneum*, rodents and termites (unidentified species)) attacked more number of hosts (three to six different grain types), and therefore, were important pest species in different grain types. *Sitophilus zeamais*, for instance, is a serious pest of maize that is also capable of developing in all other cereal grains and products (Tipping et al., 1987). Previous studies have found *S. zeamais* to be particularly responsible for 30 to 50% grain damage and 8 to 20% weight loss in six months stored maize grains (Taylor, 1971; Obengofori and Amiteye, 2005; Adugna, 2006). In

Table 3. Constraints and pests associated with cereal and pulse grains stored by traders'' in Dalwa market.

Variables	Frequency	Percentage (%)	Rank
Constraints*			
Insect infestation	43	86	1st
Insufficient or inadequate store rooms/facilities	31	62	2nd
Poor availability and high cost of pesticides	29	58	3rd
Attack by rodents	21	42	4th
Incidence of termites	19	38	5th
Transportation difficulty and cost	13	26	6th
Rotting of produce	9	18	7th
Pest species*			
Callosobruchus maculatus (Fabricius)	41	82	1st
Sitophilus zeamais Motschulsky	38	76	2nd
Rhizopertha dominica (Fabricius)	30	60	3rd
Trogoderma granarium (Everts)	21	42	4th
Rodents (*Rattus* spp. and *Mus* spp.)	19	38	5th
Termites (Unidentified spp.)	18	36	6th
Tribolium castaneum Herbst	8	16	7th
Callosobruchus subinnotatus (Pic.)	5	10	8th

* Multiple responses obtained

Table 4: Host distribution of various pest species attacking different grain types sold in Dalwa market.

Pest species	Grain type					
	Maize	Sorghum	Millet	Groundnut	Bambaranut	Cowpea
S. zeamais	√	√	√	√		√
T. castenium	√	√	√	√		
R. dominica	√	√	√	√		
T. granarium	√	√		√		
C. maculatus					√	√
C. subinnotatus					√	
Termites (Unidentified spp.)	√	√	√	√		√
Rodents (*Rattus* spp. and *Mus* spp.)	√	√	√	√	√	√

Table 5. Rating of damage due to insect infestation on cereal and pulse grains sold in Dalwa market.

Extent of infestation*	Maize		Sorghum		Millet		Groundnut		Bambaranut		Cowpea	
	Freq.	Perc.	Freq.	Perc.	Freq.	Perc.	Freq.	Perc.	Freq.	Perc.	Freq.	Perc.
Mild	12	24	9	27	18	36	8	16	3	6	5	10
Moderate	43	86	24	73	32	64	39	78	28	56	43	86
Severe	19	38	2	4	5	10	23	46	11	22	29	58

Freq. = Frequency; Perc. = Percentage; * Multiple responses obtained

addition to occurring throughout the savanna zones of northern Nigeria, *Sitophilus* spp. and *Rhyzopertha* sp. preferred sorghum grains over maize in these areas (Ayertey and Ibitoye, 1987). *Tribolium castaneum* is an important pest of pearl millet, causing annual weight losses of 10% in Nigeria (Schulten, 1989) and 40% throughout the world (Hill and Waller, 1990). A possible reason for the low ranking (7^{th}) of *T. castaneum* in this study, where pest infestation of particularly millet and sorghum grains was generally low to moderate, might be due to low proportion of broken to whole grains in the threshed (usually with a pestle in a mortar) lots sold. This

Table 6. Control measures applied by traders'' aginst pests attacking various grain types sold in Dalwa market.

Variables	Frequency	Percentage (%)
Protective and control measures*		
Sanitation	44	88
Pesticide	47	94
Source of knowledge of the control measures applied*		
Farmers	21	42
Pesticide sellers	43	86
Knowledge of insect biology and control measures*		
Yes	0	0
No	48	100
Results of pesticides application*		
Very effective	36	72
Moderately effective	43	86
Ineffective	13	26
Very ineffective	9	18

* Multiple responses obtained

Table 7. Assistance sought for by traders'' for effective cereal and pulse grains storage in Dalwa market.

Variables	Frequency	Percentage (%)
Assistance sought*		
Effective pesticides	35	70
Free pesticides	9	18
Modern storage structures	39	78
None	2	4

* Multiple responses obtained

because, as a secondary insect pest, *T. castaneum* does not infest whole grains but feeds on those damaged by primary pests or broken ones. *Tribolium castaneum*, with *S. zeamais* and *Sitotroga cerealella* (Oliv.) were reported by Ayertey and Ohiagu (1982) to be very important pests of maize grains in northern Nigeria. As such, with *S. zeamais* (a primary pest) ranked as the second most important pest species in this study, *T. castaneum* was rather expected to be much more important in maize grain. These at least in part explains the generally moderate to severe pest infestation of maize grain compared to the converse observed by traders' in stored sorghum. Although *R. dominica* is an important pest of sorghum, as recovered along with *Sitophilus* spp. and/or *S. cerealella* (together comprised 57 to 84% of all insect pests found) by Halliday (1966), Caswell (1979, 1980) and Ayertey and Ibitoye (1987) on sorghum and maize grains stored in the savanna zones of northern Nigeria, the incidence of all these pests was observed to decrease northwards moving from the Southern-Guinea Savanna and through the Northern-Guinea and Sudan Savanna zones. Alighning with the results of sorghum and millet grain infestation being generally mild to moderate in this study, Bamaiyi et al. (2006) observed the damage by insect pests to both grain types stored in northern Nigeria to be between 4 and 10%. Giles (1964a, b), Caswell (1979, 1980) and Ivbijaro (1989) similarly reported that the annual weight loss of sorghum grain due to insect pests attack in northern Nigeria falls between 1 and 4%. Although high sorghum and maize grain damage (>70%) or weight loss (>20%) levels after six months storage have also been recorded in parts of the northern savanna region (Giles, 1964a; Caswell, 1979, 1980; Adesuyi and Shode, 1977; Ayertey, 1980; Ivbijaro, 1989), these rates were very likely obtained from the more southward areas (that is, the Southern-Guinea Savanna zone) of the region (Ayertey and Ibitoye, 1987). Relatively high moisture availability owing to heavy rainfall in such areas can support rapid development and reproduction of various insect pest species, and in turn,

encourage great extents of grain damage (Ayertey and Ibitoye, 1986, 1987). For example, as stated earlier, the incidence of both *Sitophilus* and *Rhyzopertha* sp. is much more in the Southern-Guinea savanna compared to the Northern-Guinea and Sudan Savanna zones. Though *C. maculatus* was also found attacking bambaranuts in this study, it is a destructive pest of stored cowpea in the tropics. Up to 5% of cowpea pods produced in northern Nigeria have been shown to get infested by *C. maculatus* (Booker, 1967). Resultant grain damage has also been observed to progress from 10% following harvest to 50% after six months storage (Caswell, 1980). Devoid of any protective measure, losses of between 30% and 100% have been reported from three to six months stored cowpea grains (Anonymous, 1996; Singh, 1997). Jackai and Daoust (1986) further estimated that over 30 million U.S. dollars worth of cowpea was lost annually in Nigeria owing to grain infestation by this pest. Inspite of being responsible for damage in the range of 11 to 99% in bambaranuts as observed in the laboratory by Maina et al*.* (2011), *C. subinnotatus* was the least ranked insect pest found attacking stored commodities in this study. This was attributed to the very low host range (limited to only bambaranuts) of *C. subinnotatus*, and perhaps, relatively short storage period(s) of this grain legume. The storage duration of bambaranuts has been observed to positively correlate with the damage caused by *C. subinnotatus* irrespective of the initial population density (Maina et al*.,* 2011). Attack by termites is a major livelihood constraint to inhabitatnts of the semi-arid tropics, destroying crops both in the field and store, as well as wooden materials or storage structures (Nwilene et al., 2008; Yakubu et al., 2012). Termite infestation of crops in the fields was found in 75% of the farms investigated by Obi et al. (2008) in the Guinea Savanna zone of Nigeria. In addition to being higher during the cropping season, termite infestation rates increased with given crop-type combinations which included maize > millet > sorghum > cassava. Details of termite infestation of stored food grains and storage structures across seasons and the different savanna agroecological zones of northern Nigeria are lacking. Scarcity of literature concerning the pest status of *T. granarium*, *Rattus* spp. and *Mus* spp. in the savanna zones of this country, suggests that the moderate importance ranking (4^{th} and 5^{th} species) of the same pests in this study was due to mixed infestation from various grain types stored year round within the same store room(s) either by a single or several traders''. Such storage practice should provide pests with suitable alternate hosts that readily support their reproduction. Especially, where old and new grain stocks are always mixed together or stored under poor sanitary conditions, for instance, in structures that are not rodent proof (Hall, 1980; Gwinner and Harnish, 1996; Abate et al., 2000). Seifelnasr (1992) with results also from the Sudano-Sahelian Savanna zone of another country, Sudan, found *T. granarium* along with *R. dominica* to be important pest species (respectively ranked 1^{st} and 2^{nd} at all sampled sites) over eight other species (*Cryptolestes ferrugineus* (L.), *Oryzaephilus mercator* (Fauvel), *Oryzaephilus surinamensis* (L.), *S. cerealella*, *Sitophilus oryzae* (L.), *T. castaneum*, *Tribolium confusum* (J.V.), and *Tenebriodes mauritanicus* (L.)) recovered using baited traps placed in the main grain production and storage area in the zone.

These results showed that most traders' employed the combination of sanitation and pesticide application to either prevent or manage insect pest infestation, and to these control actions, most traders' expressed obtaining satisfactory results. Although, most traders' had an average of ten years grain trading experience, they generally lacked formal education as well as knowledge of the life cycles of these pests and the appropriate control measures to use against their infestation. In consequence, they mainly sourced information on pest control measures and pesticides application from commercial pesticide vendors. Not suprising, therefore, most traders' were oblivious of the recommended rates, but rather applied pesticides at their discretion and at rates conceived to give the most effective results (that is, 100% kill or protection) for the longest possible period. Permethrin, Dichlovos and Chlorpyrifos were generally applied either to the inside walls/floor of the store or directly on bags containing stored grains at the point of grain stocking or upon noticing insect and termite infestation. Also, upon sighting insect infestation following regular checks and especially in cowpea, the traders' generally placed one to two tablets of Aluminium Phosphide per 50 kg bag of grains instead of that to 100 kg of grains or one to three tablets per ton (de Groot, 2004; Yakubu et al*.*, 2012). Furthermore, fumigation is poorly attempted by some traders'' that use their discretion to place numerous (without measure) tablets of Aluminium Phosphide inbetween the stacked bags of grains in non-airtight conditions or stores. Worsestill, inspite of the carcinogenic concerns of Aluminium Phosphide (Anonymous, 1972; Howe, 1974; Desmarchelier, 1979), traders' also placed the tablets directly onto bagged grains without wrapping securely in a piece of cloth, tissue paper or perforated envelope. As a result, the residues of this insecticide are not removed from the grains and disposed off appropriately, as should be done four days after exposure (Yakubu et al*.,* 2012). Compared to other effective insecticides against many stored product insect pests such as Deltamethrin, Bioresmethrin and Pyrethroid that have a very low toxicity for humans and animals, Dichlorvos is specifically highly toxic to human beings and warm-blooded animals (de Groot, 2004). Moreover, because it vapourises rapidly, it is not suitable to use as a fumigant. These results together clearly indicate the non-awareness, and consequently, non-practice of safe pesticides application or handling by the traders'. This further raises questions on their observation of the recommended safe period between grain treatment and consumption by non-suspecting buyers that may immediately uztilize insecticide

treated agricultural commodities. In conclusion, traders' majorly depend on pestsicides to protect and control pest infestation that ranged from mild to severe in each stored grain type. This is however practiced without adequate understanding and regard for the recommended application rates and safety concerns. Further investigations of questions raised or gaps in knowledge indicated above will be necessary. These results highlight the urgent need for effective extension services by the relevant government agencies to food grain traders' and likewise farmers (the source of these agricultural commodities) so as to educate them on appropriate and effective pesticide choice, application and handling.

REFERENCES

Abate T, van Huis A, Ampofo, JKO (2000). Pest management in traditional agriculture: an African perspective. Ann. Rev. Entomol. 45:631-659.

Adejumo BA, Raji AO (2007). Technical appraisal of grain storage systems in the Nigerian Sudan savanna. Agricultural Engineering International, Int. Commission Agric. Eng. (CIGR) Ej. 9(11). September 2007.

Adesuyi SA, Shode DA (1977). Assessment of losses in two varieties of maize (FARZ 26 and NST) stored in cribs in the humid tropics. Nig. J. Plant Prot. 3:98-101.

Adugna H (2006). On-farm storage studies on Sorghum and Chickpea in Eritrea. Afr. J. Biotech. 5(17):1537-1544.

Anonymous (1972). Pesticide residues in food. World Health Organization. Technical Report Series No. 502. Report of the Joint FAO/WHO Meeting, Geneva.

Anonymous (1996). Lecture presented at PEDUNE Ecological Sustainable Cowpea pest Management Training Workshop held at IITA/IAR Research Station, Kano 27th May to 1st June, 1996. pp. 1-8.

Ayertey JN (1980). Infestation of and damage to preharvest maize in Samaru and Daudawa, northern Nigeria. Paper presented at the 10th Annual Conference, Nigerian Society for Plant Protection, Zaria, Nigeria.

Ayertey JN, Ibitoye JO (1986). The growth of laboratory populations of *Sitophilus*, *Rhyzopertha* and *Sitotroga* on sorghum seeds under ambient and humidity-controlled conditions in northern Nigeria. In: Eds. Donahaye and S. Navarro, Proceedings of the 4th International Working Conference on Stored-Product Protection, Tel Aviv, Israel, September pp. 435-446.

Ayertey JN, Ibitoye JO (1987). Infestation of maize and sorghum seeds by *Sitophilus*, *Rhyzopertha* and *Sitotroga* in three contiguous climatic zones in Nigeria. Insect Sci. Appl. 8:981-987.

Ayertey JN, Ohiagu CE (1982). Entomological problems associated with grain storage in Nigeria. An invited paper at the Symposium on Research for Effective Food Storage in Nigeria. 8th Annual Conference, Biochemical Society of Nigeria, Zaria, March, 1982.

Bamaiyi LJ, Onu I, Amatobi CI, Dike MC (2006). Effect of *Callosobruchus maculatus* Infestation on Nutritional Loss on Stored Cowpea Grains. Arch. Phytopath. Plant Prot. 39(2):119-127.

Booker RH (1967). Observation on three bruchids associated with cowpea in Northern Nigeria. J. Stored Prod. Res. 3:1-15.

Caswell GH (1979). Damage to stored sorghum in the northern part of Nigeria. Institute for Agricultural Research, Samaru, Zaria. p. 22.

Caswell GH (1980). A review of the work done in the Entomology Section of the Institute for Agricultural Research on the pests of stored grain. Samaru Miscellaneous Paper p. 99.

Caswell GH (1981). Damage to stored cowpea in the northern part of Nigeria. Samaru J. Agric. Res. 1:11-19.

Cornes MA (1964). A revised list of the insects associated with stored products in Nigeria. Annual Report: Nigerian Stored Products Research Institute. Technical Report p. 19.

De Groot I (2004). Protection of stored grains and pulses. Agrodok series (No. 31). Digigrafi, Wageningen, the Netherlands. pp. 78.

Desmarchelier JM (1979). Analysis of formulations and residues – Some current considerations. Proceedings of the 2nd International Working Conference on Stored Product Entomology, Ibadan, Nigeria, 1978, pp. 193-195.

Giles PH (1964a). The infestation of sorghum stored in granaries in northern Nigeria. Bull. Entomol. Res. 55:573-588.

Giles PH (1964b). The storage of cereals by farmers in northern Nigeria. Trop. Agric. 41:197-212.

Golob P, Dales M, Fidgen A, Evans J, Gudrups I (1999). The use of spices and medicinals as bioactive protectants for grains. FAO, Rome, Italy.

Gwinner J, Harnish R-M (1996). Manual on the prevention of post-harvest grain losses. GTZ Eschborn, Eschborn, Germany.

Hall DW (1980). Handling and storage of food grains in tropical and subtropical areas. FAO, Rome, Italy.

Halliday D (1966). Insect damage to foods on sale in a Kano market. Report of the Nigerian Stored Product Research Institute. Technical Report. 13:103-107.

Hill D (1975). Agricultural pests in the tropics and their control. Cambridge University Press, London, UK.

Hill DS, Waller JM (1990). Pests and Diseases of Tropical Crops. (Vol.2) Scientific and Technical, Longman, UK p. 432.

Howe RW (1974). Problems in the laboratory investigation of the toxicity of phosphine to stored product insects. J. Stored Prod. Res. 10:167-181.

Ivbijaro MF (1989). Evaluation of existing storage systems for grains and tubers and loss estimates at different points in the distribution and marketing chain. In: A Study of Private Sector Participation in National Food Storage Programme, Federal Department of Agriculture. Peat Marwick Management Consultants, Nigeria pp. 6-8.

Jackai LEN, Daoust RA (1986). Insect pests of cowpea. Ann. Rev. Entomol. 31:95-119.

Kowal LD, Knabe DN (1972). An Agroclimatological Atlas of Northern States of Nigeria. 1st Edn. Samaru Zaria (Nigeria): Ahmadu Bello University Press.

Lale NES, Ofuya TI (2001). Overview of pests problems and control in the tropical storage environment. In: Ofuya T.I. and Lale, N. E. S. (eds) pest of stored cereals and pulses in Nigeria. Dave Collins publications, Nigeria. p. 23.

Maina YT, Degri MM, Sharah HA (2011). Effects of population density and storage duration on the development of *Callosobruchus subinnotatus* in stored bambara groundnut (*Vigna subterranean* (l.) Verdcourt). J. Environ. Issues Agric. Dev. Coun. 3(3):70-75.

Mills J (1989). Spoilage and heating of stored agricultural products. *Prevention, detect on and control*. pp. 101. Agric. Canada Pub.1823E.

NIMET (2009). Weather Report 2003 – 2008. National Meteorological Agency (NIMET), Abuja, Nigeria.

Nwilene FE, Agunbiade TA, Togola MA, Youm O, Ajayi O, Oikeh SO, Ofodile S, Falola OO (2008). Efficacy of traditional practices and botanicas for the control of termites on rice at Ikenne, southwest Nigeria. Int. J. Trop. Insect Sci. 28(1):37-44.

Obi JC, Ogunkunle AO, Meludu NT (2008). Effect of Termite Infestation on the Farming System Characteristics ofan Endemic Area in the Guinea Savanna Region of Nigeria American-Eurasian J. Sci. Res. 3(1):1-6.

Obeng-ofori D, Amiteye S (2005). Efficancy of mixing Vegetable Oils with Pirimiphos-methyl against the maize weevil, *Sitophilus zeamais* Motschulsky in stored maize. J. Stored Prod. Res. 41:57-66.

Philips TW, Throne JE (2010). Biorational approaches to managing stored-product insects. Ann. Rev. Entomol. 55:375-397.

Schulten GGM (1989). FAO's Experience with crop loss assessment. Insect Sci. Applic. 9:763-767.

Seifelnasr YE (1992). Stored grain insects found in sorghum stored in the central production belt of Sudan and losses caused. Trop. Sci. 32:223-230.

Singh SR (1997). Cowpea cultivars resistant to insect pest in world germ-plasm collection. Trop. Grain Legume Bulletin 19:3-7.

Taylor TA (1971). The flight activity of Curculionidae and some other grains infesting beetles in the field and in a store. J. Stored Prod.

Res. 6:295-306.
Tipping PW, Mikalajczak EL, Rudringuez JG, Poneleit CG, Legg DE (1987). Effects of whole corn kernels and extracts on the behaviour of maize weevil (Coleoptera: Curculionidae). Entomol. Soc. Am. 85:1010-1013.
Wudiri BB, Fatobi TO (1992). Cereal in the food economy of Nigeria. In: Lawani, S.M and Babalay, T (Eds), Recent developments in cereal production media forum for Agriculture. International Institute of Tropical Agriculture, Niger. pp. 13-32.
Yakubu, BL, Mbonu OA, Nda AJ (2012). Cowpea (*Vigna unguiculata*) Pest Control Methods in Storage and Recommended Practices for Efficiency: A Review. J. Biol. Agric. Healthcare 2:27-33.
Youdoewei A, Service MW (1986). Pest and vector management in the tropics. English Language Book Society/Longman, Singapore.