Applied Tropical Agriculture
Volume 23, No. 2, 112-123, 2018

ASSESSMENT OF SOME PLANT INSECTICIDES AS CONTROL MEASURES ADOPTED BY GRAIN MERCHANTS IN AKURE METROPOLIS, ONDO STATE, NIGERIA.

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Abstract
This study examined the knowledge and practice of food grain storage and pest management by traders' in markets in Akure metropolis Ondo State, Nigeria between February and May, 2018. Storage facilities, pest problems and the controls adopted by merchants were also investigated. Multi-stage sampling technique was employed in selecting grain merchants in five different markets (Erekesan, Arakale, Isikan, Orita guru and FUTA off campus markets). Descriptive statistics was used to explain the socio-economic characteristics and trading activities of the merchants. The results showed that 16.67%, 3.33%, 5%, 41.67% and 33.33% of the merchant had no formal education, adult literacy, primary, secondary and tertiary education, respectively. Attack by insect pests was mostly on cowpeas and maize. Although the traders generally observed moderate pest infestation in millet, while infestations of cowpea and maize grains were severe. Insect pests found by the traders attacking stored cereal grains and pulses are Callosobruchus maculatus, Sitophiluszeamais, and S.oryzea. 50%of the traders applied pesticides to protect stored food grains and control pest infestation; 41.67% used botanicals like dried pepper, Alligator pepper, neem seeds, cheese wood, Monodora myristica and Pipper guinenese. The study of some of the control measure (botanicals) adopted by the merchants showed some level of potency against all the tested insect pests. The botanicals (P. guineense, M. myristica, Capsicum frutescens, C. annum and A. melegueta) can be utilized as potential substitute to synthetic insecticides for the management of S. zeamais, S. oryzae and C. maculatus infestation on stored products as a result of high mortality of adult insects observed.

Keywords:*Survey; Food Merchant, Callosobruchus maculatus;Sitophiluszeamais; S. oryzae; Piper guineense;Monodoramyristica; Capsicum frutescens; Capsicum annum; Afromomummelegueta*

Introduction
Pest of stored products are referred to as organisms that infest and damage stored foods, documents, goods, and any preserved items that is not used shortly after it is delivered to a location, hence they cause discomfort, destruction, to man, plants or animal and equally bring about deterioration in the quantity and quality of products (Odeyemi and Daramola,2000; Okunade, *et al.,* 2014). Many grain pests preferentially eat out grain embryos, thereby reducing the protein content of feed grain and lowering the percentage of seeds that can germinate (Adedire, 2001; Odeyemi, 2005, Ileke, 2011). Some important stored product (grains) pests include Rhyzoperthadominica, Protesphanus truncatus, Sitophilusoryzae, S. zeamais and Triboliumcastaneum (Adedire, 2001).

The feeding habits of insect pests of stored products have been generally categories into primary and secondary pests. Primary pests are those that are capable of penetrating and infesting intact kernels of grain and have immature stages that can readily develop within the kernel. They infest whole grains giving room for secondary pest. Examples include *S. zeamais, R.dominica, Sitotrogacerealella, C.maculatus* (Adedire, 2001). Secondary invaders cannot infest whole grains but feed on broken kernels, higher moisture weed, seeds, debris, and they however depend on the initial damaged made by primary insect pests. Examples include *Plodiainterpunctella, Lasiodermaserricorne, T.casteneum* (Adedire, 2001). Attack by insect pests may be initiated in the fields prior to harvest, or at various stages of processing and handling (Abate *et al*., 2000; Adedire, 2001). Grain damage results directly from insect feeding and reproducing. Stored products further get contaminated with the presence and buildup of excreta, cast skins and cadavers (Odeyemi, 2005; Ileke, 2011). Insect presence and feeding together may also increase grain temperature and moisture contents to create warm moist spots of increased grain respiration or humidity that stimulate grain deterioration and continual fungal activity within stored commodities (Mills, 1989; Odeyemi, 2005).

Depending on numerous factors such as insect pest density and the length of storage, grain damage can progress in storage resulting in huge losses to farmers, consumers, food or feed millers and other store keepers. Losses can also be as a result of the following situations; improper application of postharvest practices such as harvesting, threshing, drying or transportation; absence or insufficient storage hygiene or poor storage practices; poorly designed storage structures and absence of protective measures. Effective preservation of both food grain quantity and quality in Africa remains greatly limited by post-harvest destruction due to attack by insect pest. Damage and loss of grains in the ranges of 2.9 to 30% and 4.5 to 100% respectively which is due to insect pest infestation have been reported across the continent (Ivbijaro, 1989; Lale and Ofuya, 2001;Ileke, 2011).

Consequently man is faced with the task of developing one control measure or the other against insect pests. These control measures may be single or combination of two or more measures. Although, total eradication of pests may not be achievable, rather control or precautionary measures can be taken to keep their populations to a bearable minimum. The specific objective of this research study is to identify the insect pests associated with different crops at merchant levels; determine the methods the merchants in Akure metropolis have devised in preventing stored grain pests; identify the structural storage facilities used by grain merchants; assess the merchant's chosen methods of preventing stored grain insect pests; and test some plant materials (*Piper guineense*(seed), *Monodoramyristica*(seeds), *Capsicum frutescens* (fruit), *Capsicum annum* (fruit) and *Afromomummelegueta* (seed)) powders used by grain Merchants in Akure metropolis as protectants in the laboratory.

Materials and Methods

Description of Study Area

This study was carried out in Akuremetropolis. Akure is the capital ofOndo State, Southwestern, Nigeria.Data were collected from five different markets (Erekesan, Arakale, Isikan, Oritagun and FUTA off campus market) within the metropolis, between February and June, 2018. These five different markets were selected because of the high concentration of grain merchants in them. Data were collected from 60 randomly selected grain merchants through the use of questionnaire administration and interview schedule.Sixty (60) validly copies of thequestionnaire were retrieved from the 60 respondents.

Insect Culture

Newly emerged adult *C. maculatus, S. zeamais*and *S. oryzae* used for this study were obtained from already existing culture in the Biology Research Laboratory, Department of Biology, Federal University of Technology, Akure, Ondo State, Nigeria. Two hundred pairs of *C. maculatus*, *S. zeamais*and *S. oryzae*were introduced into 2 litres plane glass kilner jar containing 500g of cowpea seeds, maize and rice grains, respectively. The seeds were obtained from Agricultural Development Program, Akure, Ondo State, Nigeria. The cultures was placed in an insect rearing cage at ambient temperature of $28\pm2^{o}C$ and $75\pm5\%$ relative humidity.

Collection of Experimental Seeds

Experimental seeds (maize, rice and cowpea) used for this study were collected from a newly stocked seeds free of insecticides from Agricultural Development Program, Akure, Ondo State, Nigeria. The seeds were sorted, cleaned and disinfested by keeping at $-5^{o}C$ for 7 days to kill all hidden infestations. This is because all the life stages of insect pests, particularly the eggs are very sensitive to cold (Koehler, 2003). The disinfested seeds were then placed inside a Gallenkamp oven (model 250) at $40^{o}C$ for 4 hours (Jambere*et al*., 1995) and later air dried in the laboratory to prevent mouldiness (Adedire*et al*., 2011) before they were stored in plastic containers with tight lids.

Collection and Preparation of Plant Materials

The plant species for protection against insect pest attack evaluated in this work were *Piper guineense*(seed), *Monodoramyristica*(seeds), *Capsicum frutescens* (fruit), *Capsicum annum* (fruit) and *Afromomummelegueta* (seed). They were obtained in fresh form, free of insecticides from Erekesan market, Akure, Ondo State, Nigeria. These plant materials were air dried in a well-ventilated laboratory and ground into very fine powder using an electric blender. The powder was further sieved to pass through $1mm^2$ perforations. The powders were packed in plastic containers with tight lids and stored in a refrigerator at $4^{o}C$ prior to use.

Insect Bioassay

Contact toxicity of plants powders on adult mortality and progeny development of *C. maculatus, Sitophiluszeamais* and *S. oryzae*

The fine powders of the seeds of each of the plant materials was admixed separately at the rates of 0.5g, 1.0g, 2.0g, 3.0g, 4.0g and 5.0g/20g of cowpea seeds in 250ml plastic containers. Ten pairs of adult *C. maculatus*(1 – 3 days old) were introduced into each of the containers and covered. Similarly, fine powders of the seeds of each of the plant materials was admixed separately at the rates of 0.5g, 1.0g, 2.0g, 3.0g, 4.0g and 5.0g/20g of maize grains in 250ml plastic containers. Ten pairs of adult *S. zeamais*(10 to 15 days old) were introduced into each of the containers and covered. Equally, fine powders of the seeds of each of the plant materials was admixed separately at the rates of 0.5g, 1.0g, 2.0g, 3.0g, 4.0g and 5.0g/20g of maize grains in 250ml plastic containers. Ten pairs of adult *S. oryzae*(10 to 15 days old) were introduced into each of the containers and covered. Four replicates of the treated and untreated (controls) were laid out in Complete Randomized Block Design in insect cage. Insect mortality was assessed every 24 hours for five days. Adults were considered dead when probed with sharp objects and made no responses. At the end of day 5, all insects, both dead and alive were removed from each container. Percentage adult mortality was estimated (Abbott, 1925)

$$P_T = \frac{P_o - P_c}{100 - P_o} \times \frac{100}{1}$$

Where P_T = corrected mortality (%)
P_O = observed mortality (%)
P_C = control mortality (%)

Data Analysis

Data collected from the field work were analysed using descriptive statistics that include frequencies and percentages. Data collected from Laboratory test were subjected to analysis of variance (ANOVA) at 5% significant level and treatment means were separated using Tukey's Test.

Results

Socio-Economic Characteristics of Participants

Table 1 shows the socio-economic characteristic of participants and this revealed that 91.67% of them were within the age bracket of 20-60 years while 8.33% indicated those above 60 and none of the respondent were within the age bracket of 0 -19 years. The participants comprises of 36.67% males and 63.33% were females. The majority, 66.67% of the respondents are Christians and 33.33% of the participants Moslems. About 66.67% of them were married having the highest value, 15% were single, 11.67% were widows, while 6.7% were divorced which, represented the least value. Also, 41.67% of the participants had secondary education, 33.33% had their post-secondary education, 16.67% had no formal education, and 5% were holders of primary education and 3.3% attended adult school.

Table 1: Socio-Economic Characteristics of Participants

Parameters	Description	Number	Percentage (%)
Age	<20	0	0.00
	20 – 60	55	91.67
	>60	5	8.33
Gender	Male	22	36.67
	Female	38	63.33
Marital Status	Married	40	66.67
	Single	9	15.00
	Widowed	7	11.67
	Divorced	4	6.70
	Christians	40	66.67
	Muslim	20	33.33
Academic Classification	No Formal	10	16.67
	Adult Literacy	2	3.33
	Primary	3	5.00
	Secondary	25	41.67
	Tertiary	20	33.33

Respondents' Trading Activities and Pattern

The results on the trading activities and pattern of the respondents are presented in Table 2.The Table showed that the majority of the respondents (63.33%) procured their stocks from Northern Nigeria while 36.67% procured their stocks from other five regions of Nigeria. The respondents have specific duration of storage. The three major durations for which they do store their products are less than 3 months (91.67%), between 3 and 6 months (6.67%) and six months (1.66 %). Furthermore, 33.33% of the participants sold their stock in bags and specialized measuring bowls popularly referred to as “congos”. It is a bowl with equivalent of up to ten full milk tins, while 16.67% sold with plastic paint containers and tins. All the respondents marketed their goods by displaying them on shelves, of which majority (71.67%) did interact with their customers and 28.33% claimed that they seldom advertise their goods. About 95% of them were into dealt in grain trading because of the high number of patronage while 5% claimed to be in the business because of the ease of purchase from suppliers of grains and are not necessarily because of easy preservation.

Table 2: Participants Trading Activities and Pattern

Variables	Description	Frequency	%
Place of Purchase	Local Farmers	0	0.00
	Northern States	38	63.33
	Other Regions of Nigeria	22	36.67
Stock Postharvest age	<3 months	55	91.67
	3 – 6 months	4	6.67
	>6 months	1	1.66
Sale size	Milk Tin	10	16.67
	Congo	20	33.33
	Paint Plastic	10	16.67
	Bag	20	33.33
Advertisement	No Advert	17	28.33
	Physical contact	43	71.67
	Self - Display	60	100
Reason for Trading	Easy to get	3	5.00
	Easy and quick market	57	95.00
	Easy to preserve	0	0.00

The Storage Facilities and Problems of Pest

The factors responsible for bulk purchase made by the respondents are presented in Table 3. Those purchasing in bulk (33.33%)were doing so because it is cheaper, 8.33% are into bulk purchasing because of the availability of potential buyers, while 58.33% were not acquiring their stocks in bulk. Concerning the issue of grain preservation, 50% of them preserved their grains with chemical insecticides, 41.67% made use of dry pepper and 8.33% relied on solar disinfestation. About 33.33% of the respondents discovered insect pest on cowpea seeds, 25% of the respondents discovered insect pests on maize, 8.33% of the respondents discovered insect pests on wheat, 21.67% of the respondents discovered insect pests on rice while 11.67% of the respondents discovered insect pests on sorghum grains. This indicates that majority of the participants often found insect pests in cowpea and maize, which implied that cowpea and maize were more susceptible to insect pests of stored grains.

Table 3: Storage Facilities used and Post problems encountered by participants

Parameters	Descriptions	Frequency	%
Factors for bulk purchase	Cheaper to buy	20	33.33
	Presence of other buyers	5	8.33
	No bulk purchase	35	58.33
Preservation of purchase grains	Chemical insecticides	30	50.00
	Solar disinfection	5	8.33
	Stored with dried pepper	25	41.67
	Others	0	0.00
Crops infested with insects	Cowpea	20	33.33
	Maize	15	25.00
	Wheat	5	8.33
	Rice	13	21.67
	Sorghum	7	11.67

Prevalence of Insect Pests in the different Stored Crops

Table 4 shows the prevalence rate of pests on the different stored products. Five (5) insects were identified to infest the grains. While 58.33% found *Sitophiluszeamais* in their maize, 25% found it in their rice and 16.67% found it in their wheat. About 43.33% discovered *S.oryzae*in their rice, 40% found it in the wheat and 16.67% found it in maize. Also, 66.67% found*Callosobruchusmaculatus* to be infesting their cowpea, 21.67% found it in their rice and 11.67% in their wheat. The merchants also discovered *Rhyzoperthadominica* and *Prostephanustruncatus* in their grains though it has the least proportion when compared to the other pests. The percentage those that found in*R. dominica*in their maize was 36.67%, 20% for wheat, 16.67 sorghum and 13.33% for cowpea and also for rice. Finally, 41.67% found *P.truncatus*in their maize, 28.33 found in their wheat, 13.33% discovered the insect in their rice while 10% had it in their sorghum and 6.67% in their cowpea. This is as a result cross infestation in their stores.

Table 4: Prevalence of Insect Pests in different Stored Crops

Parameters	Description	Frequency	%
Crops with *S. zeamais*	Rice	15	25
	Maize	35	58.33
	Wheat	10	16.33
Crops with *S. oryzae*	Rice	26	43.33
	Wheat	24	40.00
	Maize	10	16.67
Crops with *C. maculatus*	Cowpea	40	66.67
	Rice	13	21.67
	Wheat	7	11.67
Crops with *R. dominica*	Cowpea	8	13.33
	Maize	22	36.67
	Wheat	8	13.33
	Rice	12	20.00
	Sorghum	10	16.67
Crops with *P. truncatus*	Maize	25	41.67
	Cowpea	4	6.67
	Rice	8	13.33
	Whea	17	28.33
	Sorghum	6	10

Toxicity of Plant Powder on Adult *Sitophilus zeamais*

Table 5 shows the toxicity of *P. guineense* seed, *M. myristica* seed, *C. frutescens* fruit, *C. annum* fruit and *A. melegueta* powders on the adult of *S. zeamais* at different concentration and exposure time. At 24 hours of exposure, 0.5 g concentration of *P. guinenese* have the highest toxicity of 77.5% mortality of *S. zeamais* and it was significantly different (p <0.05) from the other plant powders. There was no significant difference (p >0.05) in maize treated with *M. myristica* (20.0%), *C. frutescens* (22.5%) and *C. annum* (17.5%) at rate1g/20g of maize grains. At a rate of 4g and 5g/20g of maize grains, there was no significant difference (p >0.05) in *A. melegueta* and *C. annum*. At 48 hours of exposure, *C. annum* had the least toxicity in concentration 0.5g (17.5%), 1g (27.5%), the highest was recorded with *P. guinenese* in all the concentrations. *A. melegueta* (27.5%) was significantly different (p <0.05) from *P. guinenese* (100.0%) in 0.5g. Likewise, *M. myristica* (32.5%), *C. frutescens*(32.5%), and *C. annum* (27.5%) were not significantly different (p >0.05) in 1g plant powder. There was no significant difference between *A. melegueta* (57.5%) and *C. annum* (52.5%) in 2g concentration. At 3g and 4g concentrations, of *A. melegueta*. *C. annum* and *C. frutescens* were not significantly different (p >0.05). At 5g concentration, *P.guinenese* (100.0%), *M. myristica* (100.0%) and *A. melegueta* (92.5%) were not significantly different (p >0.05). Similar observations were observed at 72 and 96 hours of exposure. At 120 hours, *C. frutescens* (60.0%) was not significant different (p >0.05) from *A. melegueta*(42.5%) and *C. annum* (52.50%). There was no survivorship and the toxicity level of *P. guinenese* on *S.zeamais* was the highest in all the concentrations tested. Generally, the mortality of adult weevils increased with increase in length of exposure and concentration.

Table 5: Toxicity of plant powder on % Mortality of *Sitophiluszeamais*

Exposure Time (Hours)	Plant Powder	Concentration (g)					
		0.5	1.0	2.0	3.0	4.0	5.0
24	*P. guinenese*	77.50±2.50^{b}	87.50±2.50^{c}	100.00±0.00^{c}	100.00±0.00^{c}	100.00±0.00^{d}	100.00±0.00^{c}
	M. myristica	12.50±2.50^{a}	20.00±4.08^{a}	47.50 ±2.50^{b}	62.50 ±2.50^{b}	82.50 ±2.50^{c}	100.00±0.00^{c}
	C. frutescens	12.50±2.50^{a}	22.50±2.50^{a}	32.50 ±2.50^{a}	50.00 ±0.00^{a}	67.50 ±2.50^{b}	82.50 ±2.50^{b}
	A. melegueta	20.00±2.50^{a}	40.00±0.00^{b}	47.50±2.50^{b}	50.00 ±0.00^{a}	57.50 ±2.50^{a}	65.00 ±2.89^{a}
	C. annum	12.50±2.50^{a}	17.50±2.50^{a}	32.05 ±2.50^{a}	47.50 ±2.50^{a}	57.50 ±2.50^{a}	70.00 ±0.00^{a}
48	*P. guinenese*	100.00±0.00^{c}	100.00±0.00^{c}	100.00±0.00^{d}	100.00±0.00^{c}	100.00±0.00^{b}	100.00±0.00^{c}
	M. myristica	22.50±2.50^{ab}	32.50 ±4.79^{a}	70.00 ±0.00^{c}	82.50 ±2.50^{b}	100.00±0.00^{b}	100.00±0.00^{c}
	C. frutescens	22.50±2.50^{ab}	32.50 ±2.50^{a}	42.50 ±2.50^{a}	57.50 ±2.50^{a}	77.50 ±2.50^{a}	85.00±2.89^{ab}
	A. melegueta	27.50 ±2.50^{b}	50.00 ±0.00^{b}	57.50 ±2.50^{b}	60.00 ±0.00^{a}	77.50 ±2.50^{a}	92.50±2.50^{bc}
	C. annum	17.50 ±2.50^{a}	27.50 ±2.50^{a}	52.50 ±2.50^{b}	62.50 ±2.50^{a}	72.50 ±2.50^{a}	82.50 ±2.50^{a}
72	*P. guinenese*	100.00±0.00^{c}	100.00±0.00^{c}	100.00±0.00^{c}	100.00±0.00^{b}	100.00±0.00^{b}	100.00±0.00^{a}
	M. myristica	30.00 ±4.08^{a}	47.50±6.29^{ab}	85.00 ±2.89^{b}	100.00±0.00^{b}	100.00±0.00^{b}	100.00±0.00^{a}
	C. frutescens	40.00 ±0.00^{b}	47.50±2.50^{ab}	57.50 ±2.50^{a}	72.50 ±2.50^{a}	80.00 ±0.00^{a}	90.00 ±0.00^{a}
	A. melegueta	40.00 ±0.00^{a}	57.50 ±2.50^{b}	57.50 ±2.50^{a}	75.00 ±2.89^{a}	85.00 ±2.89^{a}	100.00±0.00^{a}
	C. annum	30.00 ±0.00^{a}	42.50 ±2.50^{a}	62.50 ±2.50^{a}	77.50 ±2.50^{a}	85.00 ±2.50^{a}	90.00 ±2.50^{a}
96	*P. guinenese*	100.00±0.00^{c}	100.00±0.00^{c}	100.00±0.00^{c}	100.00±0.00^{d}	100.00±0.00^{a}	100.00±0.00^{a}
	M. myristica	32.50 ±2.50^{a}	57.50±6.29^{ab}	100.00±0.00^{c}	100.00±0.00^{d}	100.00±0.00^{a}	100.00±0.00^{a}
	C. frutescens	47.50 ±2.50^{b}	60.00±0.00^{ab}	67.50 ±2.50^{b}	82.50 ±2.50^{b}	90.00 ±0.00^{a}	100.00±0.00^{a}
	A. melegueta	47.50 ±2.50^{b}	67.50 ±2.50^{b}	60.00 ±0.00^{a}	75.00 ±2.89^{a}	100.00±0.00^{a}	100.00±0.00^{a}
	C. annum	37.50 ±2.50^{a}	52.50 ±2.50^{a}	72.50 ±2.50^{b}	90.00 ±0.00^{b}	100.00±0.00^{a}	100.00±0.00^{a}
120	*P. guinenese*	100.00±0.00^{d}	100.00±0.00^{b}	100.00±0.00^{c}	100.00±0.00^{b}	100.00±0.00^{a}	100.00±0.00^{a}
	M. myristica	42.50 ±2.50^{a}	82.50±10.30^{ab}	100.00±0.00^{c}	100.00±0.00^{b}	100.00±0.00^{a}	100.00±0.00^{a}
	C. frutescens	60.00±0.00^{bc}	72.50 ±2.50^{a}	82.50 ±2.50^{b}	100.00±0.00^{b}	100.00±0.00^{a}	100.00±0.00^{a}
	A. melegueta	62.50 ±2.50^{c}	70.00 ±0.00^{a}	72.50 ±2.50^{a}	82.50 ±2.50^{a}	100.00±0.00^{a}	100.00±0.00^{a}
	C. annum	52.50 ±2.50^{b}	62.50 ±2.50^{a}	87.50 ±2.50^{b}	100.00±0.00^{a}	100.00±0.00^{a}	100.00±0.00^{a}
	Untreated	00.00 ±0.00	00.00 ±0.00	00.00 ±0.00	00.00 ±0.00	00.00 ±0.00	00.00 ±0.00

Mean ±Standard Error represent four replicates. Mean with the same alphabet down the column are not significantly different using Tukey's HSD (Honest Significant Difference) at p>0.05.

Percentage Toxicity of the Plants Powders on *Sitophilusoryzae*

Table 5 presented the toxicity level of the plants at different concentration and exposure time. At 24 hours, there was significant difference ($p < 0.05$) between *P. guinenese* (87.50%) and *A. melegueta* (37.50%), and the two plant powders were significant different ($p < 0.05$) from *M. myristica* seed, *C. frutescens* fruit, *C. annum* powders at concentration 0.5g/20gin rice grains. There was no significant difference between *C. frutescens* (37.5%) and *M. myristica* (37.5%) at the concentration of 1g/20g of rice grains. At the concentration of 2g, percentage mortality of rice weevil ranged from 37.5% (*C. annum*) to 100.0% (*P. guinenese*) while at rate of3g/20g of rice grains, it was from 47.5% (*C. annum*) to 100.0% (*P. guinenese*) and at rate 4g/20g of rice grains, it ranged from 82.5% (*C. annum*) to 100.0% (*P. guinenese*). *A. melegueta* (97.5%) was not significantly different ($p > 0.05$) from *C. frutescens* (92.5%) and *C. annum* (60.0%).Similar observations were observed at 48, 72 and 96 hours of exposure. At 120 hours of exposure, percentage mortality ranged from 57.0% (*C. annum*) to 100.0% (*P. guinenese*), and there was no significant difference between *C. frutescens* (77.5%) and *A. melegueta* (80.0%), and also between *M. myristica* (60.0%) and *C. annum* (57.0%). At the concentration of 1g/20g of rice grains, the percentage mortality ranged from 60.0% (*C. annum*) to 100.0% (*P. guinenese*). At the rate of 2g/20g of rice grains, the percentage mortality of the rice weevil ranged from 77.5% (*C. annum*) to 100.0% (*P. guinenese*). Likewise at 3g/20g of rice grains, the % mortality of the rice weevil ranged from 90.0% (*C. annum*) to 100.0% (*P. guinenese*) and at rate 4g/20g it ranged from 97.5% (*C. annum*) to 100.0% (*P. guinenese*). All the tested botanicals completely kill adult rice weevil at the concentration of 5g/20g of rice grains. Generally, *P. guinenese* has the highest percentage toxicity level on *S. oryzae*. Toxicity increases with increase in length of exposure and concentration.

Table 6: Toxicity of plant powder on % Mortality of *Sitophilusoryzae*

Exposure Time (Hours)	Plant Powder	Concentration (g)					
		0.5	1.0	2.0	3.0	4.0	5.0
24	*P. guinenese*	87.50±2.50^{c}	100.00±0.00^{d}	100.00±0.00^{c}	100.00±0.00^{d}	100.00±0.00^{d}	100.00±0.00^{c}
	M. myristica	17.50±2.50^{a}	37.5 ±2.50^{b}	57.50±2.50^{b}	77.50±2.50^{c}	100.00±0.00^{c}	100.00±0.00^{c}
	C. frutescens	22.50±2.50^{a}	37.50±2.50^{b}	60.00±2.50^{b}	65.00±2.89^{b}	85.00±2.89^{b}	92.50±2.50^{b}
	A. melegueta	37.50±2.50^{b}	50.00±0.00^{c}	57.50±2.50^{b}	72.50±2.50^{ab}	82.50±2.50^{b}	97.50±2.50^{ab}
	C. annum	12.50±2.50^{a}	20.00±0.00^{a}	37.50±2.50^{a}	47.50±2.50^{a}	52.50±2.50^{a}	60.00±2.00^{a}
48	*P. guinenese*	100.00±0.00^{d}	100.00±0.00d	100.00±0.00^{c}	100.00±0.00^{e}	100.00±0.00^{b}	100.00±0.00^{a}
	M. myristica	32.50±2.50^{ab}	47.50±2.50b	70.00±0.00^{b}	90.00±0.00^{d}	100.00±0.00^{b}	100.00±0.00^{a}
	C. frutescens	35.00±2.89^{b}	50.00±0.00b	67.50±2.50^{b}	70.00±0.00^{b}	92.50±2.50^{b}	100.00±0.00^{a}
	A. melegueta	47.50±2.50^{c}	62.50±2.50c	67.50±2.50^{b}	82.50±2.50^{c}	92.50±2.50^{b}	100.00±0.00^{a}
	C. annum	22.50±2.50^{a}	30.00±0.00a	47.50±2.50^{a}	60.00±0.00^{a}	62.50±2.50^{a}	70.00±0.00^{a}
72	*P. guinenese*	100.00±0.00^{d}	100.00 ±0.00^{d}	100.00±0.00^{c}	100.00±0.00^{c}	100.00±0.00^{b}	100.00±0.00^{a}
	M. myristica	42.50±2.50^{b}	65.00±0.00^{b}	82.50±2.50^{b}	100.00±0.00^{c}	100.00±0.00^{b}	100.00±0.00^{a}
	C. frutescens	52.50±2.50^{c}	60.00±0.00^{b}	82.50±2.50^{b}	82.50±2.50^{b}	100.00±0.00^{b}	100.00±0.00^{a}
	A. melegueta	57.50±2.50^{c}	72.50±2.50^{c}	77.50±2.50^{b}	92.50±2.50^{c}	100.00±0.00^{b}	100.00±0.00^{a}
	C. annum	32.50±2.50^{a}	40.00±0.00^{a}	57.50±2.50^{a}	65.00±2.50^{a}	77.50±2.50^{a}	80.00±0.00^{a}
96	*P. guinenese*	100.00±0.00^{c}	100.00±0.00^{d}	100.00±0.00^{c}	100.00±0.00^{b}	100.00±0.00^{b}	100.00±0.00^{a}
	M. myristica	47.50±2.50^{a}	67.50±2.50^{b}	97.50±2.50^{c}	100.00±0.00^{b}	100.00±0.00^{b}	100.00±0.00^{a}
	C. frutescens	60.00±0.00^{b}	67.50±2.50^{b}	92.50±2.50^{bc}	100.00±0.00^{b}	100.00±0.00^{b}	100.00±0.00^{a}
	A. melegueta	67.50±2.50^{b}	82.50±2.50^{c}	87.50±2.50^{b}	100.00±0.00^{b}	100.00±0.00^{b}	100.00±0.00^{a}
	C. annum	42.50±2.50^{a}	50.00±0.00^{a}	67.50±2.50^{a}	75.00±2.89^{a}	87.50±2.50^{a}	100.00±0.00^{a}
120	*P. guinenese*	100.00±0.00^{c}	100.00±0.00^{c}	100.00±0.00^{b}	100.00±0.00^{a}	100.00±0.00^{a}	100.00±0.00^{a}
	M. myristica	60.00±0.00^{a}	82.50±2.50^{b}	100.00±0.00^{b}	100.00±0.00^{a}	100.00±0.00^{a}	100.00±0.00^{a}
	C. frutescens	77.50±2.50^{b}	80.00±0.00^{b}	100.00±0.00^{b}	100.00±0.00^{a}	100.00±0.00^{a}	100.00±0.00^{a}
	A. melegueta	80.00±0.00^{b}	95.00±2.89^{c}	100.00±0.00^{b}	100.00±0.00^{a}	100.00±0.00^{a}	100.00±0.00^{a}
	C. annum	57.50±2.50^{a}	60.00±0.00^{a}	77.50±2.50^{a}	90.00±0.00^{a}	97.50±2.50^{a}	100.00±0.00^{a}
	Untreated	00.00±0.00	00.00±0.00	00.00±0.00	00.00±0.00	00.00±0.00	00.00±0.00

Mean ±Standard Error represent four replicates. Mean with the same alphabet down the column are not significantly different using Tukey's HSD (Honest Significant Difference) at p>0.0

Percentage Toxicity of the Plants Powders on *Callosobruchus maculatus*

Table 7 shows the toxicity level of the selected plantson *C. maculatus* at different concentrations and time of exposure. At 24 hours, there was no significant difference (p >0.05) between *A. melegueta*(47.5%) and *M. myristica* (42.5%) at the rate of 0.5g/20g of cowpea seeds. The percentage mortality rate ranged from 32.5% (*C. annum*) to 92.05% (*P. guinenese*) at rate 1g/20g of cowpea seeds. At the rate of4g/20g of cowpea seeds, it ranged from 72.5% (*C. annum* and C. *frutescens*) to 100.0% (*P. guinenese*). There was no significant difference in seeds treated (p >0.05) with*P. guinenese* (100.0%), *M. myristica* (97.5%) and *A. melegueta* (100.0%).Similar observations were observed at 48, 72, 96 and 120 hours of exposure (Table 7). All the tested botanicals completely killed all the adult rice weevils at the concentrations of3g, 4g and 5g/20g of cowpea seeds. Generally, *P. guinenese* had the highest toxicity level on*C. maculatus*. Toxicity increases with increase in length of exposure and concentration.

Table 6: Toxicity of plant powder on % Mortality of *Callosobruchusmaculatus*

Exposure Time (Hours)	Plant Powder	Concentration (g)					
		0.5	1.0	2.0	3.0	4.0	5.0
24	*P. guinenese*	82.5±2.50^{d}	92.05±0.00^{d}	100.00±0.00^{d}	100.00±0.00^{c}	100.00±0.00^{d}	100.00±0.00^{c}
	M. myristica	42.50±2.50^{c}	52.50±2.50^{bc}	60.00±0.00^{b}	72.50±2.50^{b}	80.00±0.00^{b}	97.50±0.00^{c}
	C. frutescens	32.50±2.50^{b}	42.50±2.50^{ab}	50.00±0.00^{a}	62.50 ±2.50^{a}	72.50±2.50^{a}	80.00±0.00^{a}
	A. melegueta	47.50±2.50^{c}	57.50±2.50^{c}	67.50±2.50^{c}	77.50±2.50^{b}	90.00±0.00^{c}	100.00±0.00^{c}
	C. annum	20.00±0.00^{a}	32.50±2.50^{a}	50.00±0.00^{a}	62.50±2.50^{a}	72.50±2.50^{a}	87.50±2.50^{b}
48	*P. guinenese*	100.00±0.00^{d}	100.00±0.00^{d}	100.00±0.00^{d}	100.00±0.00^{d}	100.00±0.00^{b}	100.00±0.00^{a}
	M. myristica	52.50±2.50^{c}	62.50±2.50^{c}	70.00±0.00^{b}	82.50±2.50^{c}	92.50±2.50^{b}	100.00±0.00^{a}
	C. frutescens	42.50±2.50^{b}	52.50±2.50^{b}	60.00±0.00^{a}	72.50±2.50^{b}	82.50±2.50^{a}	90.00±0.00^{a}
	A. melegueta	57.50±2.50^{c}	67.50±2.50^{c}	77.50±2.50^{c}	87.50±2.50^{c}	100.00±0.00^{b}	100.00±0.00^{a}
	C. annum	30.00±0.00^{a}	42.50±2.50^{a}	62.50±2.50^{a}	62.50±2.50^{a}	82.50±2.50^{a}	100.00±0.00^{a}
72	*P. guinenese*	100.00±0.00^{d}	100.00±0.00^{d}	100.00±0.00^{c}	100.00±0.00^{b}	100.00±0.00^{b}	100.00±0.00^{a}
	M. myristica	62.50±2.50^{c}	72.50±2.50^{c}	80.00±0.00^{b}	92.50±2.50^{b}	100.00±0.00^{b}	100.00±0.00^{a}
	C. frutescens	52.50±2.50^{b}	62.50±2.50^{b}	70.00±0.00^{a}	82.50±2.50^{a}	100.00±0.00^{b}	100.00±0.00^{a}
	A. melegueta	67.50±2.50^{c}	77.50±2.50^{c}	95.00±2.87^{c}	100.00±0.00^{b}	100.00±0.00^{b}	100.00±0.00^{a}
	C. annum	42.50±2.50^{a}	52.50±2.50^{a}	70.00±0.00^{a}	82.50±2.50^{a}	92.50±2.50^{a}	100.00±0.00^{a}
96	*P. guinenese*	100.00±0.00^{c}	100.00±0.00^{c}	100.00±0.00^{b}	100.00±0.00^{b}	100.00±0.00^{a}	100.00±0.00^{a}
	M. myristica	82.50±2.50^{b}	82.50±2.50^{b}	97.00±0.00^{b}	100.00±0.00^{b}	100.00±0.00^{a}	100.00±0.00^{a}
	C. frutescens	60.00±0.00^{a}	72.50±2.50^{a}	82.00±2.50^{a}	92.50±2.50^{a}	100.00±0.00^{a}	100.00±0.00^{a}
	A. melegueta	77.50±2.50^{b}	87.50±2.50^{b}	100.00±0.00^{b}	100.00±0.00^{b}	100.00±0.00^{a}	100.00±0.00^{a}
	C. annum	57.50±2.50^{a}	72.50±2.50^{a}	80.00±0.00^{a}	92.50±2.50^{a}	100.00±0.00^{a}	100.00±0.00^{a}
120	*P. guinenese*	100.00±0.00^{d}	100.00±0.00^{c}	100.00±0.00^{b}	100.00±0.00^{a}	100.00±0.00^{a}	100.00±0.00^{a}
	M. myristica	92.50±2.50^{c}	92.50±2.50^{bc}	100.00±0.00^{b}	100.00±0.00^{a}	100.00±0.00^{a}	100.00±0.00^{a}
	C. frutescens	77.50±2.50^{b}	87.50±2.50^{ab}	92.50±2.50^{a}	100.00±0.00^{a}	100.00±0.00^{a}	100.00±0.00^{a}
	A. melegueta	90.00±0.00^{c}	100.00 0.00^{c}	100.00±0.00^{b}	100.00±0.00^{a}	100.00±0.00^{a}	100.00±0.00^{a}
	C. annum	60.00±0.00^{a}	82.50±2.50^{a}	90.00±0.00^{a}	100.00±0.00^{a}	100.00±0.00^{a}	100.00±0.00^{a}
	Untreated	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00 ±0.00

Mean ±Standard Error represent four replicates. Mean with the same alphabet down the column are not significantly different using Tukey's HSD (Honest Significant Difference) at p>0.05.

Ld$_{50}$ and LD$_{90}$ of Plant Materials on the Selected Seeds at 24 and 48 Hours

Table 8 shows LD$_{50}$ and LD$_{90}$ of the plant materials on the tested insects at 24 and 48 hours of exposure. *Pipper guinenese* had the lowest LD$_{50}$ of 0.29g, followed by *M. myristica* (1.82g) and the highest was *C. annum* (3.07g) at 24 hours of exposure on *S. zeamais*. The LD$_{90}$ of *P. guinenese* was 0.87g, it was 5.35gfor*M. myristica* and the highest was *A. melegueta*(40.31g). At 48 hours of exposure, LD$_{50}$ and LD$_{90}$ of *P. guinenese* were less than the least concentration used. The highest LD$_{50}$ and LD$_{90}$ (1.85 and 9.09g respectively)were recorded in *C. annum*.

On *S. oryzae,* both LD$_{50}$ and LD$_{90}$ of *P. guinenese* had very low (0.33 and 0.53g respectively) but very high with *C. annum* (3.43 and 26.81g respectively) at 24 hours of exposure. *Afromomumm elegueta* also had a low (0.99g) LD$_{50}$but it was 3.61gfor*M. myristica*in LD$_{90}$. At 48 hour, LD$_{50}$ and LD$_{90}$ of *P. guinenese* were lesser than the least concentration used. The highest LD$_{50}$ and LD$_{90}$(2.13 and 19.99g respectively)were recorded in *C. annum*. On *C. maculatus,* LD$_{50}$and LD$_{90}$ of *P. guinenese* were 0.24g and 0.72g respectively at 24 hours. The highest LD$_{50}$ was in *C. annum* (1.72g) and in LD$_{90}$, it was *C. frutescens*(15.8g). At 48 hours, the highest LD$_{50}$ and LD$_{90}$(0.86g and 8.24g respectively) were in *C. frutescens*.

Table 8: LD_{50} and LD_{90} of plant materials on the selected seeds at 24 and 48 hours of Exposure

Test Insects	Plant Powders	Concentration (g)			
		24 hours		48 hours	
		LD_{50} (LL - UP)	LD_{90} (LL - UP)	LD_{50} (LL - UP)	LD_{90} (LL - UP)
S. zeamais	*P. guinenese*	0.29 (0.18 – 0.38)	0.87 (0.73 – 1.06)	-	-
	M. myristica	1.82 (1.13 – 2.68)	5.35 (3.41 – 16.38)	1.17 (0.70 – 1.66)	3.21 (2.18 – 7.19)
	C. frutescens	2.46 (1.75 – 3.6)	10.91 (6.21 – 42.89)	1.79 (1.12 – 2.67)	10.05 (5.44 – 50.65)
	A. melegueta	2.45 (1.96 – 3.17)	40.31 (20.11 – 60.88)	1.25 (0.51 – 2.00)	8.53 (4.31 – 18.72)
	C. annum	3.07 (2.65 – 3.47)	17.09 (11.92 – 28.96)	1.85 (1.61 – 2.11)	9.09 (7.03 – 12.95)
S. oryzae	*P. guinenese*	0.33 (0.01 – 0.41)	0.53 (0.46 – 0.82)	-	-
	M. myristica	1.29 (0.72 – 1.91)	3.61 (2.36 – 10.02)	0.92 (0.50 – 1.33)	2.86 (1.92 – 6.56)
	C. frutescens	1.39 (0.95 – 1.84)	6.12 (4.08 – 13.41)	0.96 (0.29 – 1.58)	4.47 (2.58 – 29.40)
	A. melegueta	0.99 (0.31 – 1.62)	6.28 (3.34 – 55.78)	0.66 (0.13 – 1.12)	3.82 (2.22 - 20.41)
	C. annum	3.43 (2.86 – 4.31)	26.81 (16.42 – 57.91)	2.13 (1.77 – 2.58)	19.99 (12.59 – 41.36)
C.maculatus	*P. guinenese*	0.24 (0.12 – 0.33)	0.72 (0.59 – 0.89)	-	-
	M. myristica	0.87 (0.15 – 1.52)	6.93 (3.41 – 12.87)	0.58 (0.08 – 1.04)	3.79 (2.16 – 24.53)
	C. frutescens	1.41 (1.11 – 1.72)	15.80 (10.05 – 32.70)	0.86 (0.39 – 1.29)	8.24 (4.62 – 24.23)
	A. melegueta	0.70 (0.12 – 1.23)	4.48 (2.47 – 8.02)	0.49 (0.05 – 0.90)	2.57 (1.50 – 12.52)
	C. annum	1.72 (1.49 – 1.98)	8.87 (6.83 – 12.72)	1.20 (0.36 – 2.04)	6.01 (3.14 – 20.16)

Discussion

Bulk buying of food grains without considering the post-harvest age of the products has been an old practice among merchants in the developing countries such as Nigeria. This is because cheaper to buy grains in bulk. This practice is contributing to pest proliferation and leading to high infestation of insect pests during handling and storage (Mailafiya *et al*., 2014a).

The results of this study revealed that the sampled grain merchants were in their active age as most of them in the study area were within the range of 40 years above and were mostly women. The levels of their education were low. So, the high level of illiteracy among the merchants could significantly affect their knowledge about insect pests of stored grains.

Cowpea beetle, *C. maculatus* was the most abundant and easily identified beetle by the merchants, follows by maize weevil, *S. zeamais*. They were the most important primary pests and field-to-store hexapod pests' of major cereals and legumes crops, belonging to the order Coleoptera (Adedire, 2001). These hexapods, cowpea beetle and maize weevils are causing qualitative and quantitative losses through direct feeding, deterioration and contamination of grains. Their bio activity could lead to secondary infestation by fungi (Odeyemi, 2000). If the insect pest populations are left unchecked the consequences are quite detrimental to human and even livestock, as food security is threatened and a possibility of hunger and starvation looms.

Majority of the merchants stored their produce in sack bags and insect pest are most likely to infest crops that have been opened but are also capable of penetrating unopened ones. They may chew their way into packages or crawl in through folds and seams. Insects within an infested package begin multiplying leading to hot spot that could promote secondary infestation by moulds. This could as well lead to aflatoxin contamination (Odeyemi, 2000; Williams *et al*., 2004; Atanda *et al*., 2011; Upadhyay and Ahmad, 2011). Insects can spread to other store and locate an alternative hosts. This accounted for the presence of insects that are not known to be a major insect pest of a particular produce in the study area. In a previous study, Babarinde*et al.,* (2008); Utono*et al.*

(2013); Mailafiya*et al*. (2014a); Mailafiya*et al*. (2014b) reported the incidence of *Sitophiluszeamais, R. dominica, S. oryzae*and *P. truncatus*on some of it non-host crops, and reported that it fed on some but did not reproduce on them. Sighting of store and warehouse far away from maize, rice and legumes fields will prevent problem of cross-infestation. Moreover, grain merchants did not use separate stores or warehouses for each of the crops they dealt in and this contributed to the problem of cross infestation.

In the studied area, merchants did not practice the principle of warehouse management and this affected their storage facilities which led to high losses to insect pest attacked in their produce. Good sanitation in storage facilities including regular cleaning and timely repair of damaged components of stores as well as fumigation should be inculcated (Ofuya and Lale, 2001). Majority of the respondents preserved their grains with synthetic chemicals, while some were also using plant products.

The use of plants as grains and legumes protection is a long practice in the tropics. The problems associated with synthetic chemicals such as environmental pollution and toxic waste hazard to non-target organisms are minimized with the use of plant preservatives (Ileke et al., 2016; 2017; Ileke and Adesina, 2018). Generally, all the plant powders used in this study have adulticidal potential against *S. zeamais*, *S. oryzae* and *C. maculatus.* This is confirmed by previous studies on the toxicity potential of some plant materials against insect pests of stored produce (Adedire, 2003; Fernando and Karunaratne, 2012). Ileke*et al*. (2016) investigated the toxicity of *Myristicafragrans* and *Aframomummelgueta*on the control of *Sitophiluszeamais* and found that these plants have biopesticide ability against the insect pest of maize. The insect mortality may be due to the blockingof spiracles of the insect by dust particles and death causedby asphyxia (Fernando and Karunaratne, 2012). Plant product may also penetrate the insectbody via the respiratory system (Kedia*et al*., 2015). Report of Asawalam*et al*. (2012) on *S. oryzae*isis in agreement with the findings of this study. Asawalam*et al*. (2012) recorded highest percentage of mortality with *P. guineense* among the other plants he used. Adedire and Akinkurolere (2005) also reported the effectiveness of *P. guineense*extract on *C. maculatus.*

The high mortality rate observed in the treatment with *P. guineense*seed powder could be as a result of direct feeding of the insects on the various resins particularly, chavicine and a yellow alkaloid, piperine, which is contained in the seeds(Asawalam and Emosairue, 2006). Duna*et al.* (2014) also observed that *C. annum* powder was effective against *C. maculatus* and suffered less damage from pulse beetles attack, but it was less effective in offering protection against beetle infestation when compare to other plants used in this study. *C. frutescens*wasconsiderably toxic to all the insect pests in this study and this was in line with Ileke*et al*. (2013) who reported on the effectiveness of *C. frutescens* seed and fruit on the survival, oviposition and progeny development of Cowpea bruchid, *C.maculatus*. Generally, adult insect's mortality increased with increase in length of exposure and concentration dependent. *Pipperguineense* completely killed all adult insect (*S. zeamais*, *S. oryzae* and *C. maculatus*) at all tested concentrations after 24 hours of exposure.Fasakin and Aberejo (2002) have reported that pulverized plant material from *P. guineense*inhibited egg hatchability and adult emergence of *Dermestesmaculatus*in smoked catfish *(Clariasgariepipus)* during storage. Similar effects of plant materials as insect protectants have been observed in the treatment of cowpea and maize weevils (Adedire and Ajayi, 1996).

Conclusion

Post-harvest grans are usually infested with pest as a result of poor handling and over age in store. Methods involve in the preservation of crops includes the use of synthetic insecticides, heat treatment/ solar, and the use of other materials like botanicals, bio-pesticides and beneficial organisms or natural enemies. The common insect pests identified by the merchants were beetles weevils from the order Coleoptera. The presence of some insect pests on nearly all produce traded by the merchants explains the adaptability of insect species and the reason why insect population in storage environment should not be allowed to get beyond economic threshold level. Findings from this study indicates the necessity for government and non-governmental agencies to rescue the merchants and sponsor extension packages for pest control in stored products in order to reduce losses and guaranty high quality stored products in our society.

Indiscriminate use of chemicals mustbe discouraged through sensitization and education by extension workers and storage Entomologist. All the botanicals powders (*P. guineense, M. myristica*, *Capsicum frutescens*, *C. annum* and *A. melegueta*) evaluated can be incorporated into the pest management programme for the control of *S. zeamais, S. oryzae* and *C. maculatus.*

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