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Comparative Efficacy of Three Botanicals against *Callosobruchus maculatus* Fabricius (Coleoptera: Chrysomelidae: Bruchinae) in Stored Cowpea Seeds

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ABSTRACT

The pulverized roots of three indigenous plants; *Zanthoxylum zanthoxyloides*, *Petiveria alliaceae* and *Gliricidia sepium* were used as biopesticides against *Callosobruchus maculatus* infesting stored cowpea as an alternative to synthetic insecticides. The laboratory bioassays were conducted at six levels of concentrations (0.0, 0.2, 0.4, 0.6, 0.8 and 1.0g of the plant powder/25g cowpea seed) and the chemical insecticide Actellic Super™ (2%) dust as standard check, for ovipostion deterrence and toxicity to adult *C. maculatus* at the temperature of 28±2˚C, R.H. (68±5%) and 12 h photoperiod. Results showed the efficacy of test botanicals were dose-dependents. *Z. zanthoxyloides* and *P alliaceae* were more toxic than *G. sepium*. They caused (77%) mortality 7 days after application which was insignificantly different than (100%) mortality caused by Actellic Super™. *Z. zanthoxyloides* and *P alliaceae* inhibited reproduction between (70-99%), and seed weight loss between (0.8–1.7%) compared to (10.4%) loss in untreated control within 35 days of storage. Oviposition, F1 progeny emergence, seed damage and weight loss were highly reduced by increasing the dosage level of the tested plant powder. However, *Z. zanthoxyloides* and *P. alliaceae* were the most effective plant-derived insecticides in this study, their inclusion in integrated pest management could reduce the use of hazardous synthetic insecticides.

Key words: Bioactivity, *Callosobruchus maculatus*, Cowpea, Mortality, Plant powder, Toxicity.

INTRODUCTION

Cowpea (*Vigna unguiculata* L. Walp) is one of the most important grain legumes which provide a low cost source of protein. As a result of its nitrogen replenish ability, cowpea can be grown on relatively poor cultivated soil (Langyintou *et al.*, 2004). Its production is greatly affected by both field and storage pests, causing quantitative and qualitative damage to the grains. The cowpea weevil, *Callosobruchus maculatus* Fabricius (Coleoptera: Chrysomelidae: Bruchinae) is a cosmopolitan field to store pest of grain legume in tropical and sub-tropical regions. Its infestation starts from the field when the eggs are laid on the pods or partially broken pods and transferred to the store. The damage is caused by both adults and larvae, as larvae eat and develop inside the seeds, leading to grain perforation, reduced seed weight, poor viability and poor market value, these losses constitute a major threat to food security and availability (Ojo *et al.*, 2013).

Control methods like chemical, physical and biological control are employed to combat cowpea beetle populations. Although the use of synthetic insecticides such as phosphine fumigants, dimethoate, methyl bromide and pirimiphos methyl (Velki *et al.*, 2014) have been effective to control several insect pests, their use have significant adverse effects on ecosystem such as environmental pollution, pest resistance to insecticide and hazards to farmers (Ileke and Oni, 2011). Consequently, there is a need to use a more sustainable alternative. Non-chemical control proffers solution to the aforementioned problems. Such methods include physical, biological and use of plant materials/botanicals (Ewete *et al.*, 1996; Odeyemi and Daramola, 2000 and Akob and Ewete, 2007). Plants with insecticidal properties like *Azadirachta indica*, *Piper guineense*, *Moringa oleifera*, *Alstonia boonei*, *Anhomane difformis*, *Senna species*, *Allium sativum* (Ewete *et al.*, 1996; Ojo *et al.*, 2013 and Nwachukwu and Asawalam, 2014) among others, have been found to be efficient against several storage pests. Due to the fact that stored cowpea is vulnerable to cowpea weevil attack which causes economic damage, and with the negative impact synthetic insecticide has on ecosystem, this study seeks to test roots of three cheap, readily available and environmentally friendly plant materials (*Z. zanthoxyloides* – candle wood; *P. alliaceae* – anamu and *G. sepium* – gliricidia).

Therefore, the main objective of this study was to determine the efficacy of root powder of three plant products in comparison with actellic dust as post-harvest grain protectants against cowpea weevil, *C. maculatus*.

MATERIALS AND METHODS

Insect culture

The initial population of *C. maculatus* was collected from pure cultured samples maintained on cowpea seeds at Agricultural Research Laboratory of College of Agriculture, Kwara State University, Malete, Ilorin, Nigeria at temperature of 28±2˚C, R.H. 68±3% and 12 h photoperiod. Samples (250g) of clean un-infested cowpea seeds were weighed and kept in 2.3 kg capacity kilner jars, five pairs of newly emerged adult of cowpea beetle from infested cowpea seeds was introduced into each of the kilner jars. They

were allowed to remain for 7days for feeding and oviposition. The infested seeds were left undisturbed for new offsprings to emerge and to be used as a source of *C. maculatus* colony.

Plant powder preparation

Powder of roots of the three plants; *Z. zanthoxyloides, P. alliaceae* and *G. sepium* were used in this experiment. They were washed thoroughly by water and air dried in the laboratory to ensure that volatile active principles are retained in the dried samples. Each of them was grounded and pulverized separately into fine powder using electric grinding machine and 0.5 mm mesh size. Five different concentration levels (0.2, 0.4, 0.6, 0.8 and 1g) were prepared from the powdered botanical of each plant. The samples (root powders) were kept in specimen bottles and wrapped with cellophane paper and stored in a refrigerator for use in subsequent bioassays. There were a control treatment (0g) and Actellic super™ dust as standard checks (0.1g).

Bioassay test for oviposition deterrence

In order to study the oviposition deterrent of the plant powder, 25 grams of clean cowpea seeds (variety IAR-48) commonly grown by farmers in the study area were weighed into rearing jar. The twenty five grams of cowpea seeds were mixed with five different concentrations of the tested plant powders (0.2, 0.4, 0.6, 0.8 and 1.0g) in addition to two control checks comprising of 0.1g actellic dust and untreated cowpea. Each treatment was replicated thrice and arranged in a completely randomized design (CRD). Five pairs of one day-old adult beetle of *C. maculatus* were introduced into each rearing jar replicate. The bruchids were sieved out five days after the introduction and the total number of eggs laid on cowpea seeds were counted.

Contact toxicity and bioactivity

Another experiment was set up to investigate contact toxicity level of the three test plant powder and their impact on the emergence of F1 progeny of cowpea weevil. The bruchids were introduced following the same bioassay process for oviposition deterrence. The insect mortality was taken at intervals of time (1, 3, 5, 7, 14 and 21 days) after treatment (DAT), adults that do not move or respond to gentle touch with camel hairbrush were considered dead. All insects were removed 21 days post treatment and left undisturbed until the emergence of F1 progeny. Mortality data were expressed in percentages and arcsine-transformed before analysis. The reproduction inhibition rate was calculated following Tapondjou *et al*. (2002) as:

$$\text{Reproduction inhibition rate} = \frac{Ca - Ta}{Ca} \times 100$$

where: Ca = number of newly emerged adult insects in the untreated control, Ta = number of newly emerged adult insects in the treated seeds

Seed damage and weight loss assessment

The percentage seed damage and weight loss were determined using methods of Boxall, (1986) and Odeyemi and Daramola (2000). Seed damage was evaluated by counting the number of seeds with exit holes after proper visual examination and was expressed as a proportion of the total number of seeds in each plastic rearing jar, while weight loss was evaluated by calculating the difference between initial and final weights of cowpea seeds before and after different treatments as follows:

$$\text{Seed damage (\%)} = \frac{\text{No. of seeds with holes}}{\text{Total No. of seeds}} \times 100$$

$$\text{Weight loss (\%)} = \frac{\text{Initial weight - Final weight}}{\text{Initial weight}} \times 100$$

Statistical analysis

Data collected were analyzed using analysis of variance (ANOVA) and descriptive statistics, and where significant, means were separated using Tukey Honestly Significantly Difference (Tukey HSD) test at 5% level of probability.

RESULTS AND DISCUSSION

The toxicity of powders of all botanical was significantly ($P < 0.05$) influenced by the species of plant used, dosage level, period of exposure and their interactions (Table 1). After 1 day of treatment, the highest percentage mortality (93.33%) was recorded from cowpea treated with synthetic insecticide (Actellic super), followed by (10.00%) with *Z. zanthoxyloides* at concentration of (0.8 and 1.0g), *P. alliaceae* and *G. sepium* (both at a concentration of 1.0g), these were however insignificantly higher than values of other treatment applications. The lowest mortality (0.0%) was at untreated control, *Z. zanthoxyloides* and *G. sepium* (both at 0.2g dosage level). The trend was however the same on the 3rd, 5th and 7th days. At the 7th day however, the mean mortality % obtained (at 1.0g concentration) with *Z. zanthoxyloides* and *P. alliaceae* were insignificantly lower than those with Actellic treatment. At the 14th day post treatment, (100%) mean mortality was recorded from seeds treated with *Z. zanthoxyloides* and *P. alliaceae (*at 1.0g concentration), followed by *Z. zanthoxyloides* (90%) and *P. alliaceae* (86.67%) at (0.8g concentration) which was insignificantly higher than values with actellic. The lowest significant mean mortality % (3.33%) was recorded for untreated control. The percentage mortality recorded at *G. sepium* treatment at 21st day was significantly lower than what was obtained at *Z. zanthoxyloides*

Table (1): Percentage mortality of *C. maculatus* exposed to different concentrations of different plant powders at intervals of time in days

Treatments	Conc. (g/25g)	Mortality (% ± S.E.) at intervals of time in days					
		1st	3rd	5th	7th	14th	21st
Control	0.0	0.00 ±0.00^{b}	0.00 ± 0.00^{d}	0.00 ± 0.00^{f}	0.00 ± 0.00^{f}	3.33 ± 1.02^{g}	10.00 ± 1.68^{g}
Actellic super™	0.1	93.33 ± 2.24^{a}	100.00 ± 2.43^{a}	100.00 ± 0.00^{a}	100.00 ± 0.00^{a}	100.00 ± 0.00^{a}	100.00 ± 0.00^{a}
Z. zanthoxyloides	0.2	0.00 ± 0.00^{b}	6.67 ± 1.22^{bc}	20.00 ± 1.32^{ef}	53.33 ± 3.11^{bcd}	70.00 ± 1.44^{bcd}	90.00 ± 2.10^{abc}
	0.4	3.33 ± 0.21^{b}	10.00 ± 1.44^{bc}	23.33 ± 1.03^{def}	56.67 ± 1.95^{bcd}	70.00 ± 2.76^{bcd}	96.67 ± 1.77^{ab}
	0.6	3.33 ± 0.35^{b}	6.67 ± 1.52^{bc}	23.33 ±1.75^{def}	50.00 ± 2.12^{bcd}	76.67 ± 2.64^{bc}	100.00 ± 1.94^{a}
	0.8	10.00 ± 2.11 ^{b}	16.67 ± 1.42^{bc}	46.67 ± 1.31^{bcd}	63.33 ± 2.11^{bc}	90.00 ± 2.88^{ab}	100.00 ± 1.41^{a}
	1.0	10.00 ± 1.84^{b}	23.33 ± 2.11^{b}	60.00 ± 2.19^{b}	76.67 ± 1.03^{ab}	100.00 ± 2.19^{a}	100.00 ± 0.00^{a}
P. alliaceae	0.2	3.33 ± 0.12^{b}	6.67 ± 1.92^{bc}	23.33 ± 2.11^{def}	33.33 ± 1.93^{de}	56.67 ± 2.11^{cdef}	70.00 ± 1.82^{def}
	0.4	6.67 ± 0.52^{b}	13.33 ± 0.93^{bc}	26.67 ± 1.55^{cdef}	36.67 ± 1.43^{cd}	63.33 ± 1.91^{cde}	76.67 ± 2.11^{cde}
	0.6	3.33 ± 0.32^{b}	10.00 ± 2.74^{bc}	26.67 ± 1.39c^{def}	50.00 ± 1.44^{bcd}	70.00 ± 0.97^{bcd}	83.33 ± 1.88^{bcd}
	0.8	6.67 ± 0.21^{b}	20.00 ± 3.10^{b}	50.00 ±1.45^{bc}	63.33 ± 2.83^{bc}	86.67 ± 2.13^{ab}	100.00 ± 1.73^{a}
	1.0	10.00 ±0.45^{b}	23.33 ± 2.10^{b}	56.67 ± 1.32b	73.33 ± 2.43^{ab}	100.00 ± 0.98^{a}	100.00 ± 0.00^{a}
G. sepium	0.2	0.00 ± 0.00^{b}	6.67 ± 1.91^{bc}	26.67 ±0.83^{cdef}	30.00 ± 1.91^{de}	36.67 ± 1.74^{f}	56.67 ± 1.99^{f}
	0.4	3.33 ± 0.03^{b}	6.67 ± 1.11^{bc}	23.33 ± 1.83^{def}	33.33 ± 2.10^{de}	36.66 ± 1.32^{f}	60.00 ± 2.61^{f}
	0.6	0.33 ± 0.05^{b}	6.67 ±0.39^{bc}	23.33 ± 0.93^{def}	40.00 ± 3.10^{cd}	43.33 ± 1.83^{ef}	63.33 ± 5.63^{f}
	0.8	3.33 ± 0.33^{b}	6.67 ± 0.73^{bc}	23.33 ± 0.97^{def}	40.00 ± 2.19^{cd}	46.66 ± 1.63^{ef}	63.33 ± 3.43^{f}
	1.0	10.00 ± 1.25^{b}	10.00 ± 1.23b^{c}	30.00 ± 1.83^{cde}	43.33 ± 2.71^{cd}	53.33 ±0.76^{def}	66.67 ± 2.21^{f}
CV (%)		65.34	35.91	25.34	17.93	10.66	6.58

Each datum represents the mean of three replicates, each set up with 10 adults. (DAT - Day after treatment application).
Means with a column followed by the same letters are not significantly different ($P \leq 0.05$) (Tukey HSD test).
CV - Coefficient of variation

and *P. alliaceae*. The pulverized roots of *Z. zanthoxyloide* and *P. alliaceae* possessed a plant specific strong toxicity, although dose-dependent, than *G. sepium* with low toxicity to adult *C. maculatus* on stored cowpea seeds, significant mortality of (76.7 and 73.3%) occurred 7 days post application with *Z. zanthoxyloides* and *P. alliaceae*, respectively (at 1.0/25g) dosage level in comparison to the control with (0%) mortality. In the same vein, the botanicals used in this study showed a clear dose-dependent reductions of emergence of F1 progeny of *C. maculatus* in which cowpea seeds treated with *Z. zanthoxyloides* and *P. alliaceae* at 1.0/25g application rate recorded (99.4 and 99.2%) reductions, respectively compared to the untreated control.

The root powder of *Z. zanthoxyloides* and *P. alliaceae* (at 0.6, 0.8 and 1.0g) dosage level per 25g cowpea seeds caused significant ($P < 0.05$) reduced oviposition (22.67–38.67) compared to the control (Table 2). The lowest oviposition (3.67) recorded by Actellic super was not significantly different than the value of the highest dosage level of *Z. zanthoxyloides* (22.67). The highest oviposition was obtained at untreated control (86.33) and this was insignificantly higher ($P > 0.05$) than the values from *G. sepium* (at 0.2, 0.4 and 0.6g) concentrations. This study showed that roots of all the three botanicals tested, effectively reduced oviposition of *C. maculatus* on cowpea seeds. The gravid female that always looks for a suitable place to lay the eggs on the powdered-dusted seeds, this make them to have direct contact with toxicant on seed surface (Tapondjou *et al.*, 2002), but due to the presence of this toxic powder on seed surface, the ovipositing female could be deterred from laying the eggs into appropriate sites.

The comparative effectiveness of application of pulverized powder of *Z. zanthoxyloides*, *P. alliaceae* and *G. sepium* on adult *C. maculatus* F1 progeny emergence and reproduction inhibition rate significantly ($P < 0.05$) varied among different treatments (Table 3). The least mean progeny counts came from cowpea seeds treated with Actellic super (0.0). This was insignificantly lower than the values obtained from those seeds treated with all dosage levels of *Z. zanthoxyloides* and higher levels of *P. alliaceae*. The highest value (52.67) of F1 progeny was obtained at untreated control. Cowpea seeds treated with Actellic super had the highest mean reproduction inhibition rate (100 %) and it was not significantly higher than the values obtained from the seeds treated with *Z. zanthoxyloides* (all dosage levels) and higher dosage rates of *P. alliaceae*. The lowest reproduction inhibition rate was recorded from the lowest concentration of *G. sepium* (34.26%). Their strong reproduction inhibition effectiveness, which caused 70–99% F1 progeny reduction in addition to high toxicity – causing (73–77%) mortality within seven days of application proved further their insecticidal ability, and therefore can be used as grain protectant against *C. maculatus* and other stored-product insect pests. This finding agrees with Omoloye and Awolaja (2008) earlier reports that powdered root of *Z. zanthoxyloides* and *P. alliaceae* could adequately reduce emergence of F1 progeny and protect stored-products against storage insects. It also supported a report on the efficacy of *M. oleifera* on stored product insect pests causing (89–100%) mortality (Anita *et al.*, 2012 and Ojo *et al.*, 2013). The reduction in ovipostion and emergence of F1 progeny of *C. maculatus* as a result of plant-derived insecticide application could be that mode of action

Table (2): Ovipostion deterrence effect of different plant powders on *C. maculatus*

Treatments	Conc. (g/25g)	Mean oviposition ±SE
Untreated control	0.0	86.33 ± 4.32[a]
Actellic super™	0.1	3.67 ± 1.35[g]
Z. zanthoxyloides	0.2	58.00 ± 2.63[bcd]
	0.4	44.00 ± 1.23 [def]
	0.6	32.67 ± 0 25[ef]
	0.8	27.00 ± 3.12[f]
	1.0	22.67 ± 2.83[fg]
P. alliaceae	0.2	58.67 ± 2.94[bcd]
	0.4	51.67 ± 5.31[bcde]
	0.6	38.67 ± 1.42[def]
	0.8	27.67 ± 2.11[f]
	1.0	26.33 ± 1.23[f]
G. sepium	0.2	73.00 ± 2.04[ab]
	0.4	68.33 ± 1.62[abc]
	0.6	66.67 ± 3.11[abc]
	0.8	56.33 ± 1.43[bcd]
	1.0	50.33 ± 2.11[cde]
CV (%)		15.12

Table (3): Effect of different plant powders at different concentrations on F1 adults of *C. maculatus* after 35 days of treatment

Treatments	Conc. (g/25g)	F1 progeny counts (mean ± SE)	Reproduction inhibition rate (%)
Control	0.0	52.67 ± 10.60	-
Actellic super™	0.1	0.0 ± 0.00[g]	100.00[a]
Z. zanthoxyloides	0.2	12.33 ±3.71[cdefg]	76.59[abcd]
	0.4	9.33 ±2.23[defg]	82.29abc
	0.6	8.33 ±0.76[defg]	84.18[ab]
	0.8	4.33 ±3.03[fg]	91.78[ab]
	1.0	0.33 ±0.19[g]	99.37[a]
P. alliaceae	0.2	21.67 ±1.28[bcde]	58.86[cde]
	0.4	15.67 ±0.68[cdefg]	70.25[bcde]
	0.6	11.00 ±1.56[cdefg]	79.12[abcd]
	0.8	5.00 ±1.47[efg]	90.51[ab]
	1.0	0.33 ±0.13[g]	99.17[a]
G. sepium	0.2	33.33 ±7.72[b]	34.26[f]
	0.4	28.00 ±2.94[bc]	47.46[ef]
	0.6	24.33 ±2.77[bcd]	52.60[ef]
	0.8	22.67 ±3.54[bcd]	56.51[def]
	1.0	21.00 ±2.11[bcdef]	60.16[cde]
CV (%)		35.18	10.79

Means with a column followed by the same letters are not significantly different ($P \leq 0.05$) (Tukey HSD test),
CV - Coefficient of variation.

Table (4): Effect of different plant powders mixed with stored cowpea seeds on seed damage and weight loss caused by *C. maculatus*

Treatments	Conc. (g/25g)	Seed damage (%)	Seed weight loss (%)
Untreated control	0.0	89.67 ± 4.32[a]	10.37 ± 3.22[a]
Actellic super™	0.1	1.97 ± 1.35[g]	0.11 ± 0.05[g]
Z. zanthoxyloides	0.2	51.67 ± 2.63[c]	1.93 ± 0.14[ef]
	0.4	32.33 ± 1.23 [def]	1.67 ± 0.13[ef]
	0.6	24.67 ± 0 25[f]	1.27 ± 0.15[efg]
	0.8	22.67 ± 3.12[f]	0.87 ± 0.32[fg]
	1.0	19.67 ± 2.83[f]	0.77 ± 0.21[fg]
P. alliaceae	0.2	46.00 ± 2.94[cd]	2.50 ± 1.11[de]
	0.4	32.00 ± 5.31[def]	1.70 ± 1.01[ef]
	0.6	29.00 ± 1.42[ef]	1.40 ± 0.54[efg]
	0.8	22.00 ± 2.11[f]	1.17 ±0.32[efg]
	1.0	20.00 ± 1.23[f]	0.97 ± 0.31[fg]
G. sepium	0.2	67.33 ± 2.04[b]	7.70 ± 1.73[b]
	0.4	57.00 ± 1.62[bc]	3.90 ±1.24[c]
	0.6	45.33 ± 3.11[cd]	3.57 ±1.41[cd]
	0.8	43.33 ± 1.43[cde]	2.47 ±0.23[de]
	1.0	29.00 ± 2.11[ef]	1.97 ± 1.01[ef]
CV (%)		13.47	17.24

Means with a column followed by the same letters are not significantly different ($P \leq 0.05$) (Tukey HSD test.
CV - Coefficient of variation.

of the insecticide goes beyond physical effect, but could also be as a result of egg/larval mortality or reduction in hatching of the eggs (Ojo *et al.*, 2013), ovicidal action leading to reduced emergence of F1 progeny as reported with other plant-derived insecticides investigated (Tapondjou *et al.*, 2002; Abdelgaleil and Nakatani, 2003, and Omoloye and Awolaja, 2008), larvae must penetrate the seeds to survive (FAO, 1999), so eggs must be glued firmly to seed surface during oviposition. The observed oviposition deterrence, high mortality rate and reproduction inhibition effects could be considered as results of bioactive chemical principles or secondary metabolites like saponin, vanilla acid, inulin, flavonoids, terpenoids, present in the root of *Z. zanthoxyloides* (Boeke *et al*, 2004).

The *G. sepium* with a concentration of (0.2 and 0.4g/25g) seeds had a significant ($P < 0.05$) highest percent seed damage (67.33 and 57.00%, respectively) and weight loss (7.70 and 3.90%, respectively) in comparison to other treatments and the control (Table 4). The cowpea seeds treated with Actellic super had the lowest significant seed damage (1.97%), followed by the seeds treated with the highest level of *Z. zanthoxyloides* (19.67%). The highest seed damage and weight loss were obtained from untreated control (89.67 and 10.37%, respectively), while the lowest seed damage was obtained from seeds treated with Actellic super (0.11). The results of seed damage and weight loss as a result of the application pulverized powder of *Z. zanthoxyloides*, *P. alliaceae* and *G. sepium* showing a plant/dose-dependent effect. The count and loss method, either as percentage kernels damaged or weight loss were used to measure grain injury (Boxall, 1986). There was significant reduction in weight loss and seed damage as results of applications of biopesticides in comparison to the untreated control. The weight loss of (10.4%) recorded from untreated control agreed with the earlier report that storage insect pests cause (10-100%) losses

Table (5): Simple correlation between variables of cowpea seeds infested by *C. maculatus* as influenced by powdered botanicals

	Mortality (%)	Oviposition	Progeny emergence	Seed damage (%)	Weight loss (%)
Mortality (%)	1	-0.87	-0.98	-0.88	-0.89
Oviposition		1	0.92	0.95	0.82
Progeny emergence			1	0.93	0.93
Seed damage (%)				1	0.92
Weight loss (%)					1

Significant at 5% level of probability ($P < 0.05$).

(Mugisha-Kamatenesi *et al.*, 2008) which varied based on insect species, type of stored grains, storage conditions and other environmental factors. The fact that the root powder *Z. zanthoxyloides* and *P. alliaceae* at a higher dose of between 0.8-1.0/25g cowpea seeds successfully reduced damage to (20%) in comparison to the untreated control (90%) as a result of adult *C. maculatus* feeding that showed that they can easily adopt for stored-product protection by farmers because these biopesticides are sustainable, effective and promising.

There was a strong relationship between adult beetle mortality, oviposition, F1 progeny emergence, seed damage and weight loss in this experiment based on the simple linear correlation analysis (Table 5). Percent mortality had a strong negative correlation with ovipostion ($r = -0.87$), F1 progeny emergence (-0.98), seed damage (-0.88) and weight loss (-0.89), but there existed a strong positive correlation between oviposition, F1 progeny emergence, seed damage and weight loss. An increasing trend in mortality of adult beetle mortality led to a decrease in ovipostion, F1 progeny, seed damage and weight loss of cowpea. High oviposition rate led to the appreciable emergences of F1 progeny and more damage caused to the stored cowpea.

In conclusion, this study showed that the pulverized root of *Z. zanthoxyloides* and *P. alliaceae* are promising and potential protectant–toxicant, antifeedant, deterrent, repellent, of the agricultural stored produce against *C. maculatus* and other storage pests. Due to the fact that most of the farmers preferred to store their harvested grains and seeds until it commands high price in the market, the use of *Z. zanthoxyloides* and *P. alliaceae* can be adopted by these low-income farmers in Nigeria and other cowpea growing regions of the world, with the fact that these plants have a broad spectrum of bioactivity, locally available, inexpensive, can be easily collected and processed into powder for use and it does not pose any threat to the peasant farmers.

Therefore, these plant-derived insecticides which prove to be effective should be included in Integrated Pest Management methods and strategies for the control of thwe stored insect pests. Nevertheless, there is a need for further studies on the actual components responsible for insecticidal activities of these plants.

REFERENCES

Abdelgaleil, S. A. M. and Nakatani, M. 2003. Antifeeding activity of limonoids from *Khaya senegalensis* (Meliaceae). J. of Appl. Entomol. 127:236-239.

Akob, C. A. and Ewete, F. K. 2007. The efficacy of ashes of four locally used plant materials against *Sitophilus zeamais* (Coleoptera: Curculionidae) in Cameroon. Int. J. of Trop. Insect Sci. 27(1): 21-26.

Anita, S., Sujatha, P. and Prabhudas, P. 2012. Efficacy of pulverized leaves of *Annona squamosa* (L.), *Moringa oleifera* (Lam.) and *Eucalyptus globules* (Labill.) against the stored grain pest, *Tribolium castaneum* (Herbst.). Recent Res. in Sci. and Technol. 4(2):19-23.

Boeke, S. J., Baumgart, I. R., Van Loon, J. J. A., Van Huis, A., Dickie, M. and Kossou, D. K. 2004. Toxicity and repellence of African plants traditionally used for the protection of stored cowpea against *Callosobruchus maculatus*. J. of Stored Prod. Res. 40: 423-438.

Boxall, R. A. 1986. A critical review of methodology for assessing farm-level grain losses after harvest. Tropical Development and Research Institute, London, G191.

Ewete, F. K., Arnasan, J. I., Larson, L. and Philogene, B. J. R. 1996. Biological activities of extracts from traditionally used Nigerian plants against European corn borer, *Ostrinia nubilalis* (H.). Entomol. Exp. Appl. 80: 531-537.

FAO, 1999. Botanical oils as grain protectants. In: The use of species and medicinal as bioactive protectants for grains. FAO Agricultural Services Bulletin No.137. FAO, Vialledelle Terme di Caracalla, 00100 Rome, Italy.

Ileke, K. D. and Oni, M. O. 2011. Toxicity of some plant powders to maize weevil, Sitophilus zeamais (Coleoptera: Curculionidae) on stored wheat grains. African J. of Agric. Res. 6(13): 3043-3048.

Ileke, K. D., Odeyemi, O. O. and Ashamo, M. O. 2014. Entomotoxic effect of cheese wood, *Alstonia boonei* De Wild against cowpea bruchid, *Callosobruchus maculatus* (Fab.) (Coleoptera:

Chrysomelidae), attacking cowpea seeds in storage. Mol. Entomol. 5: 10-17.

Langyinyuo, A. S., Ntoukam, G., Murdock, L., Lowenberg-DeBoer, J. and Miller, D. J. 2004. Consumer preferences for cowpea in Cameroon and Ghana. Agric. Econ. 30: 203-213.

Mugisha-Kamatenesi, M., Deng, A. L., Ogendo, J. O., Omolo, E. O., Mihale, M. J., Otim, M., Buyungo, J. P. and Bett, P. K. 2008. Indigenous knowledge of field insect pests and their management around Lake Victoria Basin in Uganda. African J. of Environ. Sci. and Technol. 2:342-348.

Nwachukwu, I. D. and Asawalam, E. F. 2014. Evaluation of freshly prepared juice from garlic (*Allium sativum* L.) as a biopesticide against the maize weevil, *Sitophilus zeamais* (Motsch.) (Coleoptera: Curculionidae). J. of Plant Prot. Res. *54*(2): 132-138.

Odeyemi, O. O. and Daramola, A. M. 2000. Storage practices in the tropics. Volume 1 Food storage and pest problems 1st edition, Dave Collins Publications, pp235

Ojo, J. A., Olunloyo, A. A. and Akanni, E. O. 2013. Efficacy of *Moringa oleifera* leaf powder against *Callosobruchus maculatus* (F.) (Coleoptera: Chrysomelidae) on stored cowpea (*Vigna unguiculata* L. Walp). Researcher 5(12): 240-244.

Omoloye, A. A. and Awolaja, A. O. 2008. Efficacy of ashes and powder of *Petiveria alliaceae* L and *Zanthoxylum zanthoxyloides* Lam. as protectants of stored bambara groundnut against *Callosobruchus maculatus* F. (Coleoptera: Bruchidae). *J. of Trop. For. Res*. 24:1-11.

Tand *Zanthoxylum zanthoxyloides* Lam. as protectants of stored bambara groundnut against *Callosobruchus maculatus* F. (Coleoptera: Bruchidae). J. of Trop. For. Res. 24:1-11.

Tapondjou, L. A., Adler, C., Bouda, H. and Fontem, D. A. 2002. Efficacy of powder and essential oil from *Chenopodium ambrosioides* leaves as post-harvest grain protectants against six-stored product beetles. J. of Stored Prod. Res. 38: 395-402.

Velki, M., Plavsin, I., Dragojevic, J. and Hackenberger, B. K. 2014. Toxicity and repellency of dimethoate, pirimiphos methyl and deltamethrin against *Tribolium castaneum* (Herbst) using different exposure methods. J. of Stored Prod. Res. 59: 36-41.