ORIGINAL RESEARCH REPORT **NIGER. J. PLT. PROT. 37(2) 101-113 (2023)**

BIOEFFICACY OF PLANT POWDERS IN THE MANAGEMENT OF COWPEA WEEVIL, *Callosobruchus maculatus* (F.) IN STORED COWPEA, *Vigna unguiculata* (L.) Walp.

***Yusuf, A. U. and **Dakasku, A. M.**
*Department of Crop Protection, Bayero University, Kano
**Yobe State Ministry of Agriculture and Natural Resources, Damaturu
Author for correspondence: abdulhameedy@yahoo.com

SUMMARY

The study evaluated the insecticidal efficacy of leaf powders of four locally available plants namely, Indian jujube (*Ziziphus mauritiana*), Christis thron (*Ziziphus spina-christi*), Camel's foot (*Piliostigma reticulatum)* and Tallow tree (*Detarium senegalense*) against *Callosobruchus maculatus* (cowpea weevils) infesting cowpea seeds (*Vigna unguiculata* L.). Bioassay was done by direct application of each plant leaf powder using three concentrations of 1, 3 and 5 g/100 g (1%, 3% and 5% w/w, respectively) of cowpea seeds. Permethrin was added at 0.12 g/100 g cowpea seeds as standard check and untreated treatment with no plant leaf powder or synthetic insecticide served as control. Treatments were laid out in completely randomized design (CRD) with three replications. Data were subjected to analysis of variance using Genstat 17th Edition. Significant treatment means were separated using Student Newman Keuls (SNK) test at 5% level of probability. The results showed significant increase in mortality of *C. maculatus* at 3 % w/w treatment application (80-83%) after 7 days' exposure to leaf power of *Z. mauritiana* and *Z. spina christis* compared to the control (0.07%). Similarly, leaf powders of *Z. mauritiana* and *Z. spina christis* at 3 % w/w treatment application was the most effective in reducing oviposition (27.00), thereby bringing about a significant reduction in adult emergence (1.11-0.55), number of emergence holes (0.67) and grain damage (1.11), while it competed favourably with the synthetic insecticide (permethin). All the four plant leaf powders did not exhibit any significant negative effect on viability of the cowpea seeds tested. The results from present study showed that the plant leaf powders could be recommended for adoption by local farmers against *C. maculatus* infestation and damage to their stored cowpea seeds.

Key words: Bioefficacy, plant powders, *Callosobruchus maculatus, Vigna unguiculata*

Cowpea, *Vigna unguiculata* L. (Walp) is one of the most commonly stored food commodities in the tropics and sub-tropics (30). In west and Central Africa, the crop constitutes the cheapest source of dietary protein for low-income sector of the population, thus helping to alleviate protein malnutrition in human (35). It is also an important cash crop for many poor farmers that make up part of the export commodities for the countries cultivating it. Nigeria and Niger account for 66% of the world cowpea production (172). Other countries with significant production in West Africa include Barkina Faso, Ghana, Senegal and Mali (40).

Cowpea production is affected by insect pest infestations and infection by plant

pathogens which lead to economic losses. Insect damage is the major constraint to cowpea grain production in most cowpea producing nations (40). The major insect pest that attack cowpea right from the field to the store is cowpea weevil *(Callosobruchus maculatus F.)* (Coleoptera: Chrysomelidae). It is polymorphic and has been confused with *C. analis,* which has non serrate antennae; *C. chinensis* which has a more angular outline; and *C. subinotatus* which lacks the dark spots on the elytra and is larger (21). Eggs are laid by the female bruchids on cowpea seeds or pods and the hatched larvae bore into the seed where the entire immature life is spent. The adults emerge out through circular holes they made leaving the seeds damaged. Under favorable conditions, up to 18 adult bruchids can emerge from a single seed (14) and each window left means that one-tenth (1/10) of a seed has been lost (13). A global conservative estimate puts grain legume losses during storage at between 15-25 percent annually (36). Damage of up to 40 percent of cowpea in storage has been recorded in several parts of Africa (41), but Ahmed (3) reported that *C. maculatus* particularly accounts for over 90 percent of cowpea seed damage. Infestation of cowpea by *C. maculatus* also leads to loss in weight and quality of seeds. It also causes discoloration, changes of flavor, mould formation, reduced nutritional value due to lowered protein levels and poor germination of seeds due to embryo damage (32). Other damaging effects of *C. maculatus* infestation to stored cowpea include esthetic contamination of seeds by dead insects, larvae and pupal cocoons and the integument of the insect has been found to contain various carcinogenic compounds such as ethyl, methyl and methoxy quinines which cannot be denatured by boiling or baking (19).

Over the years, the destructive activities and menace of storage pests have been effectively suppressed with synthetic organochlorine and organophosphate compounds (1). However, the application of these chemicals as pest control agents is associated with problems such as high persistence of the compounds, resurgence and genetic resistance of pests, negative effects on non-target organisms, poor knowledge of application by farmers, direct toxicity to the users, non-availability of the chemicals and increasing costs of application (10;37).These led to the searches for alternatives to the synthetic pesticides that are safe, cost-effective and eco-friendly (44). The present study was therefore, aimed at investigating the insecticidal potentials of Camel's foot (*Piliostigma reticulatum),* Tallow tree (*Detarium senegalense*), Indian jujube (*Ziziphus mauritiana*) and Christis thorn (*Z. spina-christi*) leaf powders against *C. maculatus* development and damage to stored cowpea seeds.

MATERIALS AND METHODS

Experimental site

The experiment was conducted in the Entomology Laboratory of the Department of Crop Protection, Faculty of Agriculture, Bayero University, Kano during the months of September – December 2019. \

Source of cowpea seeds and their preparation

A local cowpea variety (Kananado) was purchased from Dawanau International Grains Market, Kano. The seeds were visually checked to ensure that they were not infested. The seeds were then placed in freezer for 3 days to ensure that all stages of insect present were destroyed by the cold.

Maintenance of *C. maculatus* culture

The initial culture of C. maculatus were obtained from already infested cowpea

seeds maintained in the laboratory and was used to establish new cultures on fresh uninfested cowpea seeds. The stock cultures of *C. maculatus* were raised by placing 100 unsexed adults in 1 Kg of disinfested kananado cowpea seeds contained in two-litre jar. Muslin cloth was used to cover the top of the jar so that cowpea weevils could not escape. This was allowed for mating, oviposition and further multiplication of the insects until the required numbers were obtained after six weeks of inoculation. The F_1 progenies which emerged from the cultures were used for the experiment.

Collection and preparation of plant materials

The plant leaves from camel's foot (*Piliostigma reticulatum),* tallow tree (*Detarium senegalense*), Indian jujube (*Ziziphus mauritiana*) *and C*hristis thorn (*Z. spina-christi*) used as treatments in the study were collected from the vicinity of Bayero University Kano (New Site). The plant leaves from these plants were separately washed and dried under shade for seven days in the laboratory and ground to fine powders using electric blender (Master Chef MC-B144). The powders were further sieved through 1 mm^2 perforation. The powdered materials were separately kept in air-tight containers, labeled, and stored at room temperature until needed for the experiment.

Source of synthetic chemical

Permethrin powder (0.6 a.i.) was purchased from Sabon Gari market, Kano State. The expiry date was checked properly to ensure that the chemical used was not an expired product.

Bioassay

The first experiment comprised of a study on the evaluation of insecticidal potentials of the botanicals. Hundred grams of cowpea seeds were placed in a 500 ml glass jar and then thoroughly mixed with the various plant leaf powders at three dosage/concentration levels of 1, 3 and 5 g/100g of cowpea seeds (1 %, 3 % and 3 % w/w, respectively), while a synthetic insecticide (permethrin) was applied at 0.12g/100g of cowpea seeds as standard check, and untreated cowpea seed served as control. Five (5) pairs of newly emerged adults were then introduced into each container of cowpea using entomological aspirator. The containers were covered with muslin cloth and tightly secured with rubber bands. The experiment was arranged in completely randomized design (CRD), replicated three times, and kept on laboratory bench for eight weeks and the following data were recorded:

Mortality rate: At 7 days after infestation, dead insects in each treatment and replicates were removed, counted and recorded. Insects were probed three times with a tip of pen to confirm mortality (44). Mortality rate was calculated using the formula:

Mortality rate =

$$\frac{\text{Number of dead } C.\ maculatus \times 100}{\text{Total number of } C.\ maculatus}$$

Fecundity of *C. maculatus*: The insects were allowed to mate and oviposit for 10 days, after which the number of seed with eggs were counted with the aid of dissecting microscope and recorded from each of the experiment unit, while the seeds from each treatment were examined individually (7).

Egg Hatchability and Progeny Development of *C maculatus*: After 10 days of oviposition, 30 treated and untreated seeds that contain eggs were selected and placed into a new plastic container containing clean uninfested cowpea seeds. Adult that emerged were recorded 30 days after the exposure (28).

Percentage adult emergence was calculated from each of the treatments and replicates,

using the formula:

% Adult emergence =

Number of adult emerged x 100

Number of eggs laid

Number of holed cowpea grains: At the end of the experiment, the number of exit holes was assessed by counting the number of holes which appeared on each seed with the aid of dissecting needle. The seeds were turned upside down and from side to side to ensure that no hole was left uncounted

Percentage seed damage: At the end of the experiment, 30 seeds were randomly selected from the sample bottles and the seeds were separated into damaged and undamaged categories and each was counted. Thus percentage seed damage was calculated using the formula:

% Seed damage =

Number of seed damaged x 100

Total number of seeds

Loss in grain weight: At the end of the experiment, treated and untreated treatments were sieved to remove dead insects and other debris in the cowpea seeds and the seeds were weighed to obtain the final seed weight. Percentage seed weight loss was calculated using the formula (38*):*

% weight loss =

Initial weight-Final weight x100

Initial weight

Germination percentage: At the end of the experiment, 10 seeds were randomly picked from each jar in all the treatments and replicates and placed in Petri dishes lined with moistened filter paper. These were left on the laboratory bench at ambient temperature and relative humidity for 7 days after which germination percentage was calculated using the formula after Olisa *et al*. (33):

% Germination =

Number of germinated seed x 100

Total number of seed planted

Residual Toxicity

Adult mortality: Data on residual toxicity were collected by counting the number of dead insects from the F_2 progeny produced by the parents at 60 days after treatment.

Larval and pupal mortality: Larval and pupal mortality was obtained at the end of the experiment by opening the cowpea seeds with a scalpel and a pair of forceps. Dead larvae and pupae inside the seeds were counted separately and each expressed as percentage of the seed examined (7).

Data Analysis: Data collected were subjected to analysis of variance (ANOVA) using Genstat 17th Edition computer software. Significant treatment means were separated using Student Newman Keuls (SNK) test at 5% level of probability.

RESULTS

Treatment effects on mortality

Table 1 shows that the synthetic chemical had significantly higher mean adult mortality (0.9) rate, but was statistically similar with cowpea seed treated with *Ziziphus mauritiana* and *Z. spina-christi* leaf powders at 3 and 5g concentrations. Lowest mean mortality was recorded in the untreated control (0.07), except that this was not significantly ($P<0.05$) different from the mortalities recorded in grains treated with *Piliostigma reticulatum* and *Detarium senegalense*, irrespective of the rate of application.

Treatment effect on fecundity of *C. maculatus* on stored cowpea seeds

All the tested plant materials caused reduction in the mean number of eggs laid by *C. maculatus*. Cowpea seed treated with *Z. mauritiana* leaf powder at 5g/100 cowpea seed concentration had the lowest mean number of eggs (26.67), but was not significantly different from that of *Z. spina-*

christi at 3 and 5 g/100g cowpea seed; and synthetic chemical at 0.12 g/100 cowpea seed (25.33). The untreated control had the highest mean number of eggs (100.67) and was significantly (P<0.05) higher than all other treatments (Table 1).

Treatment effect on adult emergence of *C. maculatus* on stored cowpea seeds

All the plant leaf powders irrespective of their concentrations significantly affected adult emergence of *C. maculatus* 30 days after treatment (Table 1). *Z. spina-christi* leaf powder at 3 g/100 g cowpea seed concentration recorded mean of 0.00 adult emergence, although this did not differ significantly (P<0.05) with *Z. mauritiana* and *Z. spina-christi* leaf powders at 3 and 5g/100 cowpea seed, respectively and the chemical control (permethrin) at 0.12 g/100 g cowpea seed concentration. The untreated control recorded the highest mean number of adult emergence (36.11) and was significantly different from all other treatments.

Treatment effect on seed perforation

Table 1 shows the effect of plant materials on number of holed cowpea seeds caused by *C. maculatus*. Treatments with synthetic pesticide powder (permethrin) at 0.12 g/100 cowpea seeds had zero (0.00) seed perforation, although this was not significantly different from treatments with *Z. mauritiana* and *Z. spina-christi* leaf powders at 3 and 5g/100 g of cowpea seeds, respectively. The highest percentage seed perforation (76.00%) was in the untreated control seeds, and this was significantly (P<0.05) higher than the seed perforations in all the other treated seeds.

Effects of treatments on percentage cowpea seed damage caused by adult C. *maculatus*: There was significant difference (P<0.05) in percentage cowpea seed damage among all the treatment compared with the untreated control (Table 1). Seeds treated with *Z. mauritiana* at 5 g/100 g cowpea seeds and permethrin at 0.12 g/100 g cowpea seeds had 0.00% mean cowpea seed damage, although this were not significantly (P<0.05) different from treatments with *Z. mauritiana* leaf powder at 3 g/100 g cowpea seeds and *Z. spina-christi* leaf powder at 3 and 5g/100 g cowpea seed concentrations (1.11%). However, the untreated control which sustained the highest mean cowpea seed damage (43.33%) was significantly different from other treatments.

Treatment effects on seed weight loss

The percentage seed weight loss caused by adult *C. maculatus* on cowpea seeds treated with plant leaf powders revealed that the synthetic chemical powder (permethrin) at 0.12 g/100 g cowpea seeds had 0.00% seed weight loss but was not significantly different (P<0.05) from the weight loss (0.33%) in treatments with plant leaf powders of *Z. mauritiana* and *Z. spina-christi* leaf powders at 3 and 5g/100 g cowpea seeds concentrations. The control treatment had the highest seed weight loss (32.33%) and was significantly higher than the weight loss in other treated grains (Table 1).

Treatment effects on germination percentage

Table 1 shows the results of germination of cowpea seeds treated with various leaf powders. Seeds treated with *Z. mauritiana* leaf powder at 5 g/100 g cowpea seeds and *Z. spina-christi* leaf powder at 1, 3 and 5g/100 g cowpea seeds had the highest mean germination percentage of 96.67%, although these were not significantly different from the germination percentages in grains treated with the synthetic pesticide (permethrin).The untreated treatments had the lowest germination percentage (6.67%) and was significantly (P<0.05) different from other treatments.

Table 1: Effect of plant leaf powders on adult *C. maculatus* mortality, insect development, seed damage and percentage seed germination of cowpea

Treatment	Concentration (% w/w)	Adult mortality (Rate)	Number of eggs laid	% Adult Emergence	Number of holed cowpea seeds	% Cowpea seed damage	% Cowpea weight loss	% Seeds germination
Z. mauritiana	1	0.37b	63.67d	10.00c	19.00e	20.00d	5.00c	63.33b
	3	0.80a	27.00e	1.11d	0.67f	1.11e	0.33d	93.33a
	5	0.83a	26.67e	0.55d	0.33f	0.00e	0.33d	96.67a
Z. spina-christi	1	0.33bc	62.00d	11.11c	19.00e	26.66c	5.33c	66.67b
	3	0.83a	28.00e	0.00d	0.67f	1.11e	0.33d	96.67a
	5	0.83a	27.67e	0.55d	0.67f	1.11e	0.33d	96.67a
P. reticulatum	1	0.17d	77.33c	29.44b	62.67d	36.66b	29.00b	16.67c
	3	0.23cd	80.33bc	29.44b	64.00cd	35.55b	28.00b	13.33c
	5	0.17d	84.33b	30.55b	63.67cd	36.66b	28.67b	6.67c
D. senegalense	1	0.10d	81.00bc	30.55b	67.67b	36.66b	28.67b	13.33c
	3	0.20cd	80.33bc	30.00b	67.00b	36.66b	28.00b	10.00c
	5	0.10d	81.00bc	31.77b	65.67c	36.66b	28.00b	10.00c
Permethrin	0.12	0.9a	25.33e	0.33d	0.00f	0.00e	0.00d	96.67a
Control	0.00	0.07d	100.67a	36.11a	76.00a	43.33a	32.33a	6.67c
SE+	-	0.0398	1.373	0.855	0.638	1.784	0.512	3.87

Means followed by same letter(s) within same column are not significantly different at P=0.05 according to SNK test.

Effects of plant leaf powders on the mortality of adult, larval and pupal F_2 generation of C. *maculatus*:

Mortalities of larval, pupal and F_2 generation of *C. maculatus* were affected by the plant leaf powders, and results on Table 2 showed significant ($P<0.05$) differences among treatments. Seeds treated with *Z. spina-christi* leaf powder at 3% w/w had the highest mean adult mortality (7.33), followed by *Z. mauritiana* at 3 and 5% w/w and *Z. spina-christi* at 5% w/w, although there were no significant differences among them. The lowest F_2 mean larval mortality of *C. maculatus* (0.33) was recorded at treatments containing *D. senegalense* at 1% w/w and the synthetic pesticide (permethrin) at 0.12 g/100 g cowpea seeds, except that these were not significantly different from treatments with *P. reticulatum* at 5% w/w. Similarly, seeds treated with *Z. mauritiana* leaf powder at 3 and 5 % w/w recorded high pupal mortality (4.00 and 3.00, respectively) compared to permethrin and untreated control. Lower larval mortality was achieved on seeds treated with *P. reticulatum* leaf powder (0.00), but was statistically similar with other leaf powders and significantly different from the untreated control.

Table 2: Mean mortality of adult, larval and pupal F_2 generation of *C. maculatus* sixty days after treatment with leaf powders

Treatment	Concentration (% w/w)	Residual Toxicity		
		Adult Mortality	Larva Mortality	Pupal Mortality
Z. mauritiana	1	2.67bc	0.67bc	1.00c
	3	6.67a	0.67bc	4.00a
	5	6.67a	0.67bc	3.00ab
Z. spina-christi	1	2.33bc	0.33bc	1.33c
	3	7.33a	0.67bc	3.00ab
	5	6.67a	1.00ab	2.00bc
P. reticulatum	1	1.00ef	1.00ab	0.33c
	3	1.67cd	0.00c	0.76c
	5	0.67eg	0.33bc	0.33c
D. senegalense	1	0.33g	0.33bc	0.33c
	3	1.67cd	0.67bc	0.67c
	5	1.00ef	0.33bc	0.33c
Permethrin	0.12	0.33g	0.33bc	0.33c
Control	0.00	3.33b	2.33a	2.00bc
SE+	-	0.384	0.351	0.385

DISCUSSION

Plant leaf powders of *Z. mauritiana* and *Z. spina-christi* used in this research showed significant ($P < 0.05$) effect on the mortality and fecundity of adult *C. maculatus* as well as damage caused on cowpea seeds. All the leaf powders were observed to have affected the mortality of *C. maculatus* at varying amounts applied. The results of this study conform with the report of previous workers (34;27;1;19) who observed that certain botanicals were effectively toxic against storage insect pests including *C. maculatus*. The resultant mortality rates of *C. maculatus* in this investigation could be attributed to the insecticidal effects of the chemicals in the tested plant species.

The high toxicity of *Z. mauritiana* and *Z. spina-christi* could be attributed to the presence of phenolic and alkaloid metabolites which act as insecticidal, repellant and antifeedants against insects

(12;6;4). The present study is in line with the findings of Urbbi and Dipsikha (42), who reported the effect of phenolic extracts of *Ziziphus jujuba* leaves on *Aedes aegypti* (Diptera: Culicidae). Earlier report revealed that *Z. jujuba* has been effective against *Culex pipiens* larvae in which the petroleum ether extract and oil had caused pathological effect on pupa and adult (16).

Several researchers have worked on plants and naturally derived pesticides that are nontoxic to human and other animals (45;44;24). This serves as useful tool for the development of a safer, effective, sustainable and environmentally friendly bruchids control tactics. Promising results obtained in this study showed the insecticidal effect of *Z. mauritiana* and *Z. spina-christi* against *C. maculatus.* The identified compounds which are naturally occurring in most plant materials are known to be pesticidal, bactericidal and fungicidal in nature, thus conferring the pesticidal activity to plants (5).

The present study confirmed that leaf powders of *Z. mauritiana* and *Z. spina-christi* had relatively caused high mortality of *C. maculatus* on stored cowpea seeds. This corroborates the findings of Bhagat and Tripatri (11) and Lucy *et al.* (23), who reported an increasing efficacy of neem leaf powder as concentration increased from 1-3g/100 g seeds. On the other hand, the plant extracts might have interfered with the normal embryonic development by suppressing hormonal and biochemical processes. Similar physiological interferences were observed by Ofuya *et al*. (31) and Jayakumar *et al.* (20). Similarly, oviposition and adult emergence were suppressed in grains treated *Z. mauritiana* and *Z. spina-christi* leaf powders. This is similar with the findings of Yusuf and Ahmed (43), who reported that the ground parts of some plants (Neem, Chinaberry, Eucalyptus and Chilli) were effective in suppressing the emergence of the maize weevils *S. zeamais* on stored maize grains.

The effect of all the treatments with the exception of the control (untreated grains) proved effective in reducing the number of emergence holes, suggesting low amount of perforated grains treated with *Z. mauritiana* and *Z. spina-christi* leaf powders. This agrees with earlier findings of Asawalaam and Emosairue (9), who reported that powdered form of *Piper guineense* and pirimiphos-methyl were effective in controlling weevil perforation caused by *S. zeamai*s on stored maize grains. Grain damage caused by bruchids on cowpea seeds was highly reduced in all the treatments. The leaf powders of *Z. mauritiana* and *Z. spina-christi* appeared to be more promising as it compared favourably with the synthetic insecticide (permethrin) treatment. These findings corroborate Dike *et al.* (15), who reported that phenolics are well known to be directly involved in protection of grains against insects through antixenosis and antibiosis mechanisms.

On the other hand, grains treated with *Z. mauritiana* and *Z. spina-christi* leaf powders showed no significant effect on loss in grain weight. This is similar to the findings of Yusuf (44), who reported that powdered form of five plant materials (neem, chinaberry, eucalyptus, chilli and mahogany wood ash) were effective in reducing grain damage and loss in grain weight caused by *S. zeamais* on stored maize grains.

Application of *Z. mauritiana* and *Z. spina-christi* leaf powders as treatments showed no significant effect on the germination of the seed after 60 days of treatment. This was similar to the findings of Obengofori and Dankwah (29), who reported that neem leaf

powder and actellic 25EC did not affect the germination of Bambara nut seed after 60 days of treatment. The finding from the present study was also in agreement with that of Mariappan *et al.* (26), who reported that seeds protected with *Jatropha curcas* pelleted with pungan leaf powder and *Pongamia pinna* seeds pelleted with neem leaf gave high germination percentage due to effective protection from fungal and insects attacks, thus increasing percent germination of the treated seeds.

Similarly, leaf powders *of Z. mauritiana and Z. spina-christi* were also effective in reducing adult, larval and pupal emergence of the F_2 progenies after sixty days. This corroborates with the findings of Asawalam and Anaeto (8), who reported that plants such as neem (*Azadirachta indica*), chili pepper (*Capsicum annum*), clove (*Syzygium aromaticum*), Ethiopian pepper (*Xylopia aethiopica*), etc. possess secondary metabolites which act as antifeedants, oviposition deterrents, larvicidal and insect growth regulators. These plants are known to repel insects and the products from these plants have been reported to be toxic to insects (2). Application of products of such plants, fresh or dried materials, extracts or oil to stored products have been shown to effectively protect stored products against *C. maculatus* infestation (22). Oparaeke and Dike (34), recorded success using plant oils from calabash nutmeg (*Monodora myristica*) and Onion (*Allium cepa*) as protectants against *C. maculatus* infesting stored cowpea seeds.

CONCLUSION

Ziziphus mauritiana and Z. spina-christi leaf powders performed better than camel's foot (*Piliostigma reticulatum)* and Tallow tree (*Detarium senegalense*) in reducing damage to treated cowpea seeds by *C. maculatus* irrespective of their concentrations and their activities were similar to that synthetic chemical (permethrin). However, higher adult mortality of *C. maculatus*; reduction in oviposition and seed damage; reduction of weight loss and inhibition of progeny emergence were achieved by using both the *Z. mauritiana and Z. spina-christi* leaf powders at 3 and 5% w/w. Therefore, based on the results from present study, it can be recommended that the use of *Z. mauritiana and Z. spina-christi* leaf powders at 3% w/w could be used for the management of *C. maculatus* on stored cowpea. Further investigations should also be carried out to determine the specific chemical substances responsible for the insecticidal activity of the plants used in the present study.

LITERATURE CITED

1. **Adedire, C. O., Obembe O. O., Akinkurolele, R. O., and Oduleye O., 2011.** Response of *Callosobruchus maculatus* (Coleoptera: Chysomelidae: Bruchidae) to extracts of cashew kernels. *Journal of Plant Disease Protection,* **118 (2):**75-79.
2. **Adesina, J. M., Adeolu, R. J., Yallapa, R. and Lawrence, A. A. 2015**. Entomology of *Xylopia aethiopica* and *Aframomum melegueta* in Suppressing *Callosobruchus maculatus* (Fab.) Infesting Stored Cowpea Seeds. *Jordan Journal of Biological Sciences* 8 (4): 263-268.
3. **Ahmed, M. E. A. 2010**. Fumigant toxicity of seven essential oils against the cowpea weevil, *Callosobruchus maculatus* (F.) and the rice weevil, *Sitophilus oryzae* (L.). *Egyptian Academic Journal of Biological Sciences,* 2 (1): 1-6.

4. **Akindele, A. J., Adeyemi, O. O. 2007.** Anti-inflammatory activity of the aqueous leaf extract of Byrsocarpus coccineus. *Fitoterapia*, 78: 25-28.
5. **Aqil, F., Ahmad I, Mehmood, Z. 2006**. Antioxidant and free radical scavenging properties of twelve traditionally used Indian medicinal plants. *Turkey Journal Biology,* 30: 177-183.
6. **Argal, A., Pathak, A. K. 2006.** CNS activity of Calotropis gigantea roots. *Journal of Ethnopharmacology*, 106: 142-145.
7. **Arong, G. A., Imandeh, G. N., Utsu, A. A. and Shaa, K. K. 2011**. The Influence of Food Type on Larval Growth in *Mussa domestica* and *Lucilla sericata* (Diptera) in Calabar, Nigeria. *Wold Journal of Science Technol*. 1: 73 – 77.
8. **Asawalam, E. F. and Emosairue, S. O. 2006.** Comparative Efficacy of *Piper guineense*. (Schum. Thonn.) and Pirimiphos-methyl as Poison Against *Sitophilus zeamais* (Motsch). *Electronic Journal of Enviroment, Agriculture and Food Chemistry*. 5(5): 1536-1545.
9. **Asawalam, E. F. and Anaeto, C. G. 2014.** Laboratory Evaluation of Five Botanicals as Protectants Against Cowpea Beetle *Callosobruchus maculatus* F. (Coleoptera: Bruchidae) on Stored Cowpea. *Advancement in Medical Plant Research.* **2**(2):41-46.
10. **Berger, A. 1994.** Using natural pesticides: Current and future perspectives. A report for the plant protection improvement in Botswana, Zambia and Tanzania. http://www>blakherbals.com/ using natural pesticides. Html: Downloaded 07/03/2005.
11. **Bhagat, O. P. and Tripathi, V. K. 1989.** The Efficacy in Combination with Tulsi Against *Rhyzopertha dominica* (F.) in Stored Maize. Neem Neewsletter. 6 (4). Indian Agricultural Research Institute, New Delhi.
12. **Bourgaud, F., Gravot, A., Milesi, S. and Gontier, E. 2001**. Production of plant secondary metabolites: a historical perspective. *Plant Science, 161: 839-851.*
13. **Caswell, G. H., 1981.** Damage to stored cowpea in the Northern part of Nigeria. *Samaru Journal of Agricultural Research.* **1**: 11-19.
14. **Credland, P. F. and Dick, K. M. 1986**. Food consumption by larvae of three strains of *Callosobruchus maculatus* (Coleoptera: Bruchidae) *Journal of Stored Product Research,* 3 (1): 31–40.
15. **Dike, M. C. and Mshelia, G. B. 1997.** Laboratory Assessment of Efficacy of Eucalptus leaf and Stem Powders in the Control of *Callosobruchus maculatus* F. on Stored Cowpea. *Sarmaru Journal of Agricultural Research*, 14: 16-19.
16. **El Husseiny, I. M., El Kholy, S. E., Othman, A. A. 2014.** Laboratory testing of the toxicity of jujube (*Zizyphus jujuba*) oil and leaf extracts against *Culex pipiens* (Diptera: Culicidae). *African Entomology.* 22 (4): 755-761.
17. **Food and Agriculture Organisation (FAO) 2012.** Agricultural production status worldwide. http:www.fao.org/faostat

accessed, 2012

18. **Ileke, K. D. 2012.** Bioactivity of *Thuja occidentalis* (L) and *Allium setivum* (L) powders and oil extracts against cowpea bruchid, *Callosobruchus maculatus* (Fab). *International Journal of Biology,* 4: 96-103.
19. **Ileke, K. D. and Oni, M. O. 2011**. Toxicity of some plant powders to maize weevil, *Sitophilus zeamais* (Motschulsky) (Coleoptera: Curculionidae) on stored wheat grains (*Triticum aestivum*). *African Journal of Agricultural Research.* **6 (13):** 3043-3048.
20. **Jeyakumar, P. and Uthamasamy, S. 2003**. Bio-efficacy of some synthetic insecticides and botanicals against *Liriomyza trifalli* Burgess. *Indian Journal of Entomology.* Vol. 59 No. 4.pp 347-350.
21. **Jurgen, P., Heinz, S. and Werner, K. 1977.** Diseases, Pest and Weeds of Tropical Crops. John Wiley and Sons, New York. 399-400pp.
22. **Kashere, M. A., Aliyu, M. and Fagam, A. S. 2015**. Evaluation of some plant materials for the control of *Callasobruchus maculatus* (F.) (Coleoptera: Bruchidae) on stored cowpea seeds (a review). *International Journal of Agriculture and Earth Science*. 1(7): 1-12
23. **Lucy, E., Aliyu, M. and Ojiekpon, I. F. 2016.** Effect of Neem Powders (*Azadirachta indica* A. Juss) on the Preservation of Gum Arabic (*Acacia senegal* L. Wild) infested with *Bruchus baudni* (Caill) in Gashua, Yobe State Nigeria. *Journal of Agriculture and Food Environment* 3 (2): 109-121
24. **Makur, M. D., Gyar, S. D., Pennap, G. R. I. and Anthony, P. 2008.** Phytochemical Screening and Antimicriobial Activity of the Ethanolic and Methanolic Extracts of the Leaf and Bark of *Khaya senegalensis*. *Africa Journal of Biotechnology*, 17 (9): 1216-1219.
25. **Malek, M. E. and Wilkins, R. M. 2014.** Toxicity of *Annonas quamosa* Linn. seed oil extract on *Tribolium casteneum* (Herbst) (Coleoptera: Tenebrionidae). Proceedings of the 6th International Working Conference on Stored Product Protection, Bangladesh, 30th December, 2014 2: 819-823.
26. **Mariappan, N., Srimathi, P., Sundaramoorthy, L., Paramathma, M. 2013.** Effect of Organic Seed Pelleting on Seed Storability and Quality Seedling Production in Biofuel Trees Species. *African Journal of Crop Science,* 1: 024-028
27. **Mukanga, M., Deedat, Y., and Mwangala. F. S. 2010.** Toxic effects of five plant extracts against the larger grain borer, *Prostephanus truncatus*. *African Journal of Agricultural Research.* **5 (24):** 3369-3378.
28. **Musa, A. K. 2013.** Influence of plant Powder on Infestation by Adult and Larvae of Khapra Beetle, *Trogoderma granarium* Everts (Coloeptera: Demestidae) in Stored Groundnut. *Australian Journal of Basic and Applied Sciences*, **7** (6): 427 – 432.
29. **Obeng-ofori, D. and Dankwah, J. A. 2002.** Biological Effect of Four Protectants applied to Stored

Bambara Groundnut Against Infestation by *Callosobruchus maculatus* (Fab.) (Coleoptera: Bruchidae). *Journal of Ghana Science Association.* 4 (2): 41-51.

30. **Odeyemi, O. O., and Daramola, A. M. 2000.** Storage Practices in **Food Storage and Pest Problems in** the Tropics, 1st edition MI. Nigeria. Volume 1: Dave Collins Publications. 253pp.
31. **Ofuya, T. I. and Dawodu, E. O. 2002.** Aspect of insecticidal Action Powders from *Dennetia tripetala* Bak. Against *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae). *Nigerian Journal of Experimental and Applied Biology,* 3 (2): 303-308.
32. **Okonkwo, E. U., Nwaubani, S. I., Otitodun, O. G., Ogundare, M. O., Bingham, G. V., Odhiambo, J. O. and Williams, O. 2017.** Evaluation of efficacy of a long lasting insecticide incorporated polypropylene bag as stored grain protectant against insect pests on cowpea and maize. *Journal of Stored Product Postharvest Research,* 8 (1): 1-10.
33. **Olisa, B. S., Ajayi, S. A. and Akande, S. R., 2010.** Physiology quality of seeds of promising African Yam Bean (*Sphenostylis sternocarpa* (Hoechst. Ex A. Rich) Hams and pigeon Pea (*Cajanus cajan* L. Mill SP.) Landraces. *Research Jounal of Seed Sciences.* 3 (2), 93-101.
34. **Oparaeke, A. M. and Dike, M. C. 2005**. *Monodora myristica* (Gaertn), (Myristicaceae) and *Allium cepa* (Lilliaceae) as protectants against stored cowpea seed Bruchid *(Callosobruchus maculatus)* infestation. *Nigerian Journal of Entomology.* **22**: 84-92.
35. **Rachie, K. O. 1995.** Introduction. In Cowpea: Research, Production and Utilization. (Singh, S. R. and Rachie, K. O. (eds). John Wiley and Sons, Chichesters, U.K. pp xx-xxviii.
36. **Samuel, D. A. 1980.** The role of Nigerian Stored Products Research Institute in Nigerian's march towards self-sufficiency in food. Paper presented on the visit to the Nigeria Stored Products Research Institute by members of the Science and Technology Committee of the House of Representative on 14th Feb. 1980.
37. **Sharma, A, Kaushal, P., Sharma, R, and Kumar, R. 2006.** Bioefficacy of some plant product against diamondblack moth, *Plutella xylostella* (L.) (Lepidoptera: Yponomeutidae). *Journal of Entomological Research.* **30:**213-217.
38. **Sibakwe, C. B. and Donga, T. 2015.** Laboratory Assessment of the Level of Resistance in Some Beans Varieties Infested with Beans Weevils (*Acanthosceilides obtectus* and *Zabrotes subfasciatus*.) *International Journal of plant and Soil Science*. 4 (2): 124 – 131.
39. **Singh, S. R. and van Emden, H. F. 1979.** Insect pests of grain legumes. Annu. Rev.
40. **Singh, S. R. 1997.** Cowpea cultivars resistant to insect pests in World germplasm collection. *Tropical Grain Legume Bulletin*, 9: 3-7
41. **Tropical Products Institute 1977.** The reduction of losses during

farmer storage of cereal and legume grain in Common Wealth Africa. Report to the Common Wealth Secretariat. London TPI London.

42. **Urbbi, D., Dipsikha, B. 2017**. Growth inhibitory effect of phenolic extracts of *Ziziphus jujuba* Mill. in dengue vector *Aedes aegypti* (L) in parent and F1 generation. *Asian Pacific Journal of Tropical Medicine.* 10 (8): 787–791
43. **Yusuf, A. U. and Ahmed, B. I. 2007.** Host-plant Resistance: A Viable Non-chemical and Environmentally Friendly Strategy of Controlling Stored Product Pest-A Review. *Emirate Journal of Food and Agriculture*. 19 (1): 1-12.
44. **Yusuf, A. U., 2009.** Comparative Efficacy of Plant Materials and Pirimiphos-Methyl in the Suppression of *Callosobruchus maculatus* F. (Bruchidae; Coleoptera) Development and Damage in Cowpea Seeds. *Savanna Journal of Agriculture.* 4: 45-53
45. **Yusuf, S. R., and Ahmed, B. I. 2005**. Potential of *Khaya senegalensis* on *Callosobruchus maculatus. Journal of Stored Product Research* 13: 19-23.