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Original Paper

Effect of cashew (*Anacardium occidentale*) nut shell stored and fresh extracts on cowpea bruchid, *Callosobruchus maculatus* (Fabricius.) (Coleoptera: Chrysomelidae)

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A laboratory study was carried out to evaluate the efficacy of cashew nut shell extract in the control of cowpea bruchid, *Callosobruchus maculatus* (Fab.) under prevailing laboratory conditions. Fresh ethanolic and stored extract of cashew nut shell served as treatments which were compared with untreated control. Data collected on adult mortality, total number of emerged progeny (adults), number and weight of damaged seeds (seeds with holes) and undamaged seeds (seeds without holes) and percentage seed weight loss, and average number of seeds per 50 g in a container and the data were subjected to a two-way analysis of variance and significant different means were separated using Duncan`s Multiple Range test (DMRT) at 5% level of significance. The results revealed that treated plants generally performed better than the untreated. The different rates of treatment recorded significant differences ($P < 0.05$) in causing adult mortality compared to the untreated control. The different rates of treatment also recorded significant differences ($P < 0.05$) in emergence of F1 adults of each treatment compared to the control. It was also noted that the extract reduced or suppressed the weight loss and grain damage as a result of treatment with the extract compared to the untreated control. However, freshly extract of cashew nut shell recorded the highest adult mortality rate and lowest emergence while control had the lowest mortality rate and highest emergence of the insect. The rates of application were indicative of bioactive characteristics of the extract.

Keywords: cowpea, *Anacardium occidentale*, *Callosobruchus maculatus*, botanicals, pest management

1 Introduction

Cowpea (*Vigna unguiculata* (L.) Walp) is originated from West and Central Africa, from where its cultivation and production spread to Latin America and South East Asia (Edeh & Igberi, 2012). About 95% of global production reported in FAOSTAT is in West Africa, with Nigeria being the largest producer and consumer of cowpea, producing 3.4 million tonnes in 2017 (FAOSTAT, 2019; Samireddypalle et al., 2017). Cowpea grains can be referred to "protein source for all" because it is also affordable for poor citizens and also a source of livelihood especially in rural areas (Akunne et al., 2013). Dry grains of Cowpea are used in many different food preparations and its nutrients concentrations range from 21 to 33% protein, 1.8% fat, 60.3% carbohydrate and is a rich source of iron and calcium (Ddamulira et al., 2015; Abudulai et al., 2016). Due to its high adaptability to both heat and drought and its association with nitrogen-fixing bacteria, cowpea is a versatile crop (Boukar et al., 2019). It has been reported that the crop is also a source of livestock feed and revenue in the tropics (Onekutu et al., 2015). Production of this crop faces enormous problems; notable among them is insect pest infestation. Post-harvest losses to storage insect pests limit cowpea production in Sub-Saharan Africa, which otherwise accounts for about 70% of total world production (IITA, 2010).

C. maculatus infestations have been reported to cause substantial reduction in quality and quantity of cowpea seeds within three to five months of storage (Ileke et al., 2012). This often leads to loss in weight, quality, and viability of seeds. The activities, such as respiration, of cowpea bruchid can trigger an increase in seed temperature and moisture content (Nwosu, 2014). When the population builds up, this leads to the formation of

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'hot spot', a condition of high temperature and moisture content which further predisposes the stored seeds to secondary infestation by thermophilic fungi leading to production of mycotoxin (Nwosu, 2014). It has been recognized that postharvest loss to storage coleopterans pests such as cowpea bruchid, *C. maculatus* is major constraint to food security in developing nations such as Nigeria (Udo, 2011).

Several authors reported that farmers used excessively chemical synthetic insecticides in other to control many destructive insects in order to produce high quality food. (Akinneye & Ogungbite, 2013; Ileke, 2014; Adekunle et al., 2017). Insecticides have a high purchasing cost, present potential risks to human health, the environment and lead to a new resistance of pests (Thiaw & Sembène, 2010).Currently, synthetic insecticides application is the major means of controlling beetles infestations in stored cowpea seeds (Onekutu et al., 2015). This could be in form of fumigation of stored product with phosphine or carbon disulphide and or dusting with carbaryl, pirimiphos methyl or permethrin (Ileke et al., 2012). However, consequent upon reported ozone depletion by methyl bromide and carcinogenic concerns with phosphine, conventional fumigation technology is under scrutiny in the developed countries (Adedire et al., 2011; Ileke et al., 2012) further highlighted problems associated with the use of conventional synthetic insecticides to include high mammalian toxicity, high level of persistence in the environment, poor application knowledge, exorbitant cost prices, pest resurgence, genetic resistance by the insect pest and deleterious effects on non-target organisms. One possible way to overcome the short comings of synthetic insecticides is to substitute synthetic insecticides with naturally-occurring plant insecticidal materials (Ileke et al., 2012; Khater, 2012). More so, researches have shown that botanicals have been extensively used on agricultural pests and to very limited extent on insect pests of stored products (Ijeh & Ejike, 2011; Ufele et al., 2013).

Cashew nut shell (CNSL) has been reported to be active against storage insects, termites and phytopathogenic fungi due to the presence of active substance such as anacardic acid, cardoland cardanol (Echendu, 1991; Davi et al., 2009; Bande et al., 2018). Cowpea seeds in storage are damaged by several species of insect pests in the former family Bruchidae (Gbaye & Hollway, 2011), the commonest being *C. maculatus* a field-to-store insect pest in the trophic (Udo, 2011). Therefore, The main objective of this study was to evaluate the effect of stored and fresh ethanolic extracts of cashew (*Anacardium occidentale*) nut shell on cowpea weevil *C. maculatus* (F.) (Coleoptera: Chrysomelidae).

2 Material and methods

2.1. Study area

This study was conducted at the Department of Crop Protection Laboratory of the University of Ilorin, Ilorin, Nigeria.

2.2 Source and preparation of seeds

The cowpea seed variety RSH 256 used was obtained from the International Institute of Tropical Agriculture (IITA), Ibadan, Oyo State, Nigeria. The seeds are white in colour with a maturity period of 60 days. The seeds were wrapped in a polyethylene bag and kept in the freezer compartment of a refrigerator in the Crop Protection Laboratory, University of Ilorin, to kill immature stages of insects. The seeds were removed 10 days after freezing and then spread on a laboratory desk to thaw.

2.3 Insect Culture

A culture of cowpea bruchid, *C. maculatus* was prepared under prevailing ambient temperature (30 ±3 °C) and relative humidity (68 ±3%). The initial stock culture was obtained from the Nigerian Stored Products Research Institute (NSPRI) headquarters, Ilorin. Freshly emerged adults of *C. maculatus* were used for the experiment. Fifty (50) unsexed adults of *C. maculatus* were picked with the aid of hair brush to infest cowpea seeds in a transparent plastic container which was covered with muslin cloth held tightly by perforated lid to ensure aeration and prevent escape of the insects. Freshly emerged adults were used for the study.

2.4 Source and preparation of cashew nutshell extract

Cashew nut shell used for the experiment were obtained from a local market (Oja-Tuntun), Ilorin. Physical operations were carried out on cashew nuts before extraction to get high quality product. Operations involved washing, drying, shelling and size reduction. The nuts were washed, air dried for 15 days, shelled using knife and then crushed using mortar and pestle. Cashew nut shell liquid was extracted using soxhlet extraction equipment according to the modified method adopted of (Edoga et al., 2006). Five hundred millilitres (500 ml) of ethanol was poured into the round bottom flask of the equipment. This was followed by putting 600 g of ground cashew nut shell into the thimble and fitted into the soxhlet extractor. The solvent was heated to 79 °C and concentrated in a steam bath. The fresh extract (CNSL) was used directly without being previously stored as a liquid. A component of the extract was stored for 7 months in an airtight container before use

2.5 Experimental procedure

Fifty grams (50 g) of cowpea seeds were weighed and put into transparent plastic containers. The extract of cashew nut shell liquid of fresh and stored extracts were applied at different concentrations 0.5 ml, 1.5 ml and 3 ml respectively. The containers were shaken to ensure even coating of the seeds with the treatments. Four (4) unsexed freshly emerged adults of *C. maculatus* were introduced into each container covered with muslin cloth held in place with the aid of a rubber band to allow aeration and prevent insects from escaping. The method was adopted from (Tiroesele, Bamphitlhi et al., 2014) with little modification. The experimental units were arranged in a completely randomized design including the control replicated three times.

2.6 Data collection

Data were collected on various parameters including adult mortality, total number of emerged progeny (adults), number and weight of damaged seeds (seeds with holes) and undamaged seeds (seeds without holes) and percentage seed weight loss, and average number of seeds per 50 g in a container, Counts of the emerged weevils commenced 23 days after infestation (DAI) and continued at intervals of 48 h to allow the emergence of the first filial (F1) generation.

The percentage seed weight loss was computed following the method of Haines (1991) as follows:

$$\frac{initial\ weight - final\ weight}{initial\ weight} \times 100$$

2.7 Data analysis

Data were subjected to analysis of variance and means were separated using Duncan`s Multiple Range test (DMRT) at 5% level of significance.

3 Results and discussion

Table 1 shows the effect of fresh and stored cashew nut shell liquid on mortality of *C. maculatus* over 7-day period. Fresh cashew nut shell liquid applied at 3 ml 50 g^{-1} seeds conferred complete mortality against adults of *C. maculatus* at 1 day after treatment (DAT). However, the complete mortality was not significantly ($p > 0.05$) different from the mean mortality recorded in other rates of treatment except the lowest rate of 0.5 ml 50 g^{-1} seeds in both fresh and stored cashew nut shell liquid during the same period. It was observed that there was no significant ($p > 0.5$) difference in the number of dead adults of *C. maculatus* in seeds treated with different rates of the extracts from 2 to 7 days after treatment. It is evident that fresh extracts of cashew nut shell liquid controlled the bean weevil effectively by having increase in mortality (Table 1), this corroborate with (Bande et al., 2018) who stated that there is greater decreasing of

Table 2 Effects of stored and fresh extracts of cashew nut shell on F1 progeny of *Callosobruchus maculatus* on stored cowpea

Treatment (ml)	26	27	28	29
SCNSL 0.5	1.33b	1.23bc	0.33a	0.33a
SCNSL 1.5	1.30a	1.33abc	0.33a	1.00a
SCNSL 3.0	0.33ab	0.67ab	0.33ab	0.00a
FCNSL 0.5	1.3ab	1.67bc	0.00a	1.33a
FCNSL 1.5	1.3ab	1.0abc	1.00a	1.67a
FCNSL 3.0	0.00a	0.00a	0.00a	0.33a
CONTROL	2.33b	2.33c	0.00a	0.67a
SEM	0.44	0.28	0.31	0.42

values with the same letter(s) in the same column are not significantly different at 5% level of significance using Duncan`s multiple range test
DAT – days after treatment, SEM – standard error of mean SCNSL – stored extract cashew nut shell, FCNSL – fresh extract cashew nut shell

Table 1 Mean adult mortality of *Callosobruchus maculatus* exposed to stored and fresh extracts of cashew nut shell on stored cowpea

Treatment (ml)	1	2	3	4	5	6	7
SCNSL 0.5	1.00cd	0.67a	0.33a	0.67a	0.67a	0.00a	0.00a
SCNSL 1.5	3.33ab	0.00a	0.00a	0.00a	0.00a	0.00a	0.00a
SCNSL 3.0	3.67ab	0.33a	0.00a	0.00a	0.00a	0.00a	0.00a
FCNSL 0.5	1.67bcd	0.33a	0.33a	0.67a	0.00a	0.67a	0.33a
FCNSL 1.5	3.00abc	0.33a	0.33a	0.00a	0.00a	0.00a	0.33a
FCNSL 3.0	4.00a	0.00a	0.00a	0.00a	0.00a	0.00a	0.00a
Control	0.00d	0.00a	0.00a	0.00a	0.00a	0.00a	0.00a
S E M	0.44	0.36	0.22	0.28	0.18	0.22	0.25

values with the same letter(s) in the same column are not significantly different at 5% level of significance using Duncan`s multiple range test
DAT – days after treatment, SEM – standard error of mean SCNSL – stored extract cashew nut shell, FCNSL – fresh extract cashew nut shell

Table 3 Effect of cashew nut shell extracts on damage indices of stored cowpea seeds by *Callosobruchus maculatus*

Treatment (ml)	% Seed Wt. loss	Weight of damaged seeds	Weight of undamaged seeds	Number of damaged seeds	Number of undamaged seeds
SCNSL 0.5	18.3b	16.8a	21.1ab	102.3ab	108.3a
SCNSL 1.5	15.9b	15.8a	24.2a	86.3b	130.0a
SCNSL 3.0	12.3b	15.8a	22.7ab	77.3b	136.0a
FCNSL 0.5	15.3b	19.8a	20.1ab	98.3ab	108.3a
FCNSL 1.5	15.9b	15.8a	28.4a	86.3b	130.0a
FCNSL 3.0	11.3b	17.8a	25.7ab	78.3b	134.0a
CONTROL	31.4a	20.0a	16.0b	131.3a	74.7b
S.E.M	2.52	3.01	2.54	10.01	10.28

values with the same letter(s) in the same column are not significantly different at 5% level of significance using Duncan`s multiple range test
DAT – days after treatment, SEM – standard error of mean SCNSL – stored extract cashew nut shell, FCNSL – fresh extract cashew nut shell

Trichoderma sp higher the concentration. it was also reveal that cashew nut extract reduced progeny emergence compared to untreated (Table 2). The Cashew nut shell extract was also observed to have effects in reducing the damage on cowpea seeds by *C. maculatus* (Table 3). This was in agreement with (Kpoviessi et al., 2017).

The results of the study revealed that treatments differed in the adult mortality, total number of cowpea weevils found on seeds, number of exit holes on seeds and weight loss of cowpeas. It has been shown in this experiment that fresh extract of cashew nut shell liquid and stored extract had similar detrimental effect on cowpea weevils for the parameters measured. This insecticidal effect was in agreement with (Adedire et al., 2011; Babatunde et al., 2020; Babatunde & Musa, 2020). The extract used in this study could have caused insect mortality due to their physical action on respiration through blockage of the spiracles of the *C. maculatus* which may lead to suffocation as suggested by (Adedireet al., 2011). The differences in the adult mortality could be attributed to the active ingredients of cashew nut shell extract which could be linked to the presence of anacardic acid and cardinal (Rehm & Espig, 1991; Bande et al., 2018). Cashew nut shell extracts reduced progeny emergence of *C. maculatus* in treated cowpea seeds (Table 2). This could be attributed to the adult mortality already observed (Table 1) and the inhibition of oviposition as well as the remarkably high reduction in survival to adulthood of mature stages of *C. maculatus* compared to the control. This result corroborates that of Raja (2008) who found that the CNSL had both toxic and oviposition deterrence effect in blackgram seed as it caused low adult emergence, egg laying and percentage seed infestation. He opined that the reduced egg laying might be due to the oily nature, toxic substances or repellent compounds which caused altered insect behaviour. Generally CNSL is bitter, caustic and fumigatory with smokes that irritate and gives off choking fumes (Raja et al., 2013). The CNSL extract was also observed to have effects in reducing the damage on cowpea seeds by *C. maculatus* (Table 3). Damage on cowpea seeds may have been reduced as a result of the extracts acting as a deterrent to *C. maculatus*, keeping them from infesting and damaging the seeds. The extract inhibits locomotion which affect mating activities an effect that had been reported by many authors (Adedire et al., 2011; Ileke & Oni, 2011). The study reveals that CNSL extract could be very effective for use as biopesticides for protecting cowpea seeds from *C. maculatus* infestation and damage. It has been reported by the pest management specialists that botanicals are not known to leave any residue in any crop they are used to protect and the protective ability of essential oils could be attributed to interspecific insect responses to oil constituents (Enan, 2001; Babatunde & Musa, 2020).

4 Conclusions

The result obtained from this study confirmed that Cashew nut shell extract can be used as biopesticides because it as insecticidal potential for protecting cowpea against *C. maculatus*. These significantly reduced emergence rate of adults of *C. maculatus*, weight loss and seeds damaged. Thus farmers can use the extract of cashew nut in place of synthetic chemicals used against cowpea weevils.

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