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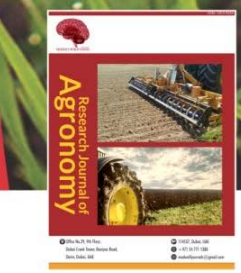

Insecticidal Potential of Indigenous Plant Powders Against Beetle, *Callosobruchus maculatus* (F.) (Coleoptera: Chrysomelidae) in Stored Cowpea

A.K. Musa and R.O. Uddin
Department of Crop Protection, University of Ilorin, Ilorin, Nigeria

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Corresponding Author:
A.K. Musa
Department of Crop Protection, University of Ilorin, Ilorin, Nigeria

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Abstract: Powders of bitter leaf, cashew leaf, orange peel and pawpaw leaf were tested at 2.5, 5.0 and 7.5% (w/w) for their insecticidal actions against bean beetle, *Callosobruchus maculatus* (F.) (Coleoptera: Chrysomelidae) in the laboratory. Results showed that the ovicidal and adulticidal actions of the plant powders depended on dosages and exposure time. Mortality of 16.28 and 18.75% were observed in bitter leaf powder applied at 7.5% (w/w) dosage within 24 and 48 h post infestation (HPI), respectively. In grains treated with 7.5% orange peel powder, 12.50 and 16.28% mortality were observed with in 24 and 48 HPI, respectively. Each of bitter leaf and orange peel powders was significantly different ($p<0.05$) in causing adult mortality at highest dosage compared with the control. No mortality was observed in the control within 48 HPI. Oviposition was inhibited in the highest dosage of the plant powders but the percentage oviposition in the lower dosages was three-fold lower than the control. The plant powders also significantly reduced progeny emergence and grain damaged by the beetle. No progeny emergence was observed in grains treated with bitter leaf powder at 27 days post infestation. Cashew and pawpaw leaf powders caused grain damage of 46.3-54.7 and 44.7-60.7% within three months of storage, respectively. There was decrease in insecticidal effects of the plant powders as indicated: bitter leaf>orange peel>ashew leaf>pawpaw leaf. It is recommended that incorporating these plant powders in pest management of stored products will guarantee user safety, confer ease of application, reduce environmental pollution and suppress insect infestation under small scale storage.

INTRODUCTION

Cowpea is a household name in Nigeria where it is commonly called ‘wake’ or ‘ewa’. It is rich in amino-acids especially lysine and tryptophan, making it a preferred plant protein (20-40%) for human consumption. The production areas are particularly in the middle belt and drier northern region (Ojuederie *et al*., 2009). Insect pests constitute the most visible and important constraint to cowpea production, infesting

mature pods and accounting for post-harvest reduction of grains (Musa, 2012). Cowpea is infested by bean beetle, *Callosobruchus maculatus* (F.) between harvest and storage leading to quantitative and qualitative losses of grains. The larvae feed within the grains and consume endosperm while the adults leave neat circular exit holes in the grains after emergence, showing that both larvae and adults of C. *maculatus* are responsible for cowpea grain damage. The use of synthetic insecticides for controlling stored product insects is associated with problems such as their persistent toxicity in grains, development of resistance in insect populations and effects on non-target organisms (Iram *et al*., 2013). In a bid to find sustainable and alternative approach to the use of these harmful chemicals, current researches focus on testing various plants and their products against insect infestation particularly in protecting stored products. The objectives of this study were to examine the insecticidal activities of powders of bitter leaf, cashew leaf, orange peel and pawpaw leaf against bean beetle, C. *maculatus* in stored cowpea.

MATERIALS AND METHODS

Insect culture: About 50 unsexed adults of C. *maculatus* were picked from existing stock in the Crop Protection laboratory, University of Ilorin, Nigeria and used to infest susceptible cowpea grains in a 500 ml Kilner jar. These insects were allowed to oviposit and then removed 7 days after infestation. Freshly emerged adults (1-2 days old) were used in the study.

Collection and preparation of plant powders: Bitter leaf, *Vernonia amygdalina* Dileli (Compositae), Cashew, *Anacardium occidentale* L. (Anacardiaceae) leaves, sweet orange, *Citrus sinensis* L. (Rutaceae) peels and pawpaw, *Asimina triloba* (L.) Dunal (Annonaceae) leaves were removed from their parent plants at various locations in Ilorin, Nigeria. These plant parts were washed, air-dried and separately ground in an electric blender. The powders were then passed through a sieve of mesh 0.01 mm to obtain uniform particles before they were kept in separate plastic containers and stored at ambient temperature and relative humidity of 28±3°C and 71±4%, respectively.

Source and preparation of cowpea grains: Cowpea grains (variety IT96k-610) properly wrapped in brown envelop were obtained from the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. The grains were poured in a polythene bag and kept in a deep freezer for 7 days to rid them of any insidious infestation and later allowed to air-dry to attain prevailing atmospheric condition.

Sex determination: The method of Blumer and Beck (2008) was adopted in identifying the sexes. The female beetle has enlarged and dark plate covering the end of the abdomen on both sides while the male beetle has smaller plate which lacks stripes.

Adult mortality: Cowpea grains were treated with 2.5, 5.0 and 7.5% (w/w) of bitter leaf, cashew leaf, sweet orange peel and pawpaw leaf powders. Thorough agitation of the mixture of the grains and plant powders was done for 3 min to obtain uniform spread. The treated grains were infested with two females and one male of *C. maculatus* in their respective containers. The open top of the containers was covered with muslin held in place with a rubber band and then arranged in a completely randomized design on a laboratory desk. Each treatment was replicated three times including the control. Adult mortality of beetle was assessed at 24 and 48 H Post Infestation (HPI).

Fecundity and progeny emergence: Powders of bitter leaf, cashew leaf, sweet orange peel and pawpaw leaf were separately mixed in three dosages of 2.5, 5.0 and 7.5% (w/w) of cowpea grains and gently shaken in their respective containers and allowed to settle on the laboratory desk. The mixture was then infested with two couples of freshly emerged (teneral) adults of C. *maculatus* and prepared in three replications including the control. Fecundity was calculated as the percentage of eggs laid in each treatment at 5 Days Post Infestation (DPI). Progeny emergence was calculated as the percentage of adults that emerged in each treatment at 27 and 32 DPI.

Grain damage: The number of grains damaged by C. *maculatus* was counted at 3 Months Post Infestation (MPI). This was carried out by counting the number of grains with emergent holes and then expressed as percentage of total number of grains using the eqution:

$$\frac{\text{Number of grains with holes}}{\text{Total number of grains}} \times 100$$

Data analysis: Data collected were subjected to Analysis of Variance (ANOVA) using Gen-stat Statistical Package (Discovery Edition 3). Where significant differences were recorded in the ANOVA, means were separated using Least Significant Difference at p = 0.05 level of significance.

RESULTS AND DISCUSSION

Adult mortality: The percentage mean adult mortality of C. *maculatus* exposed to different dosages of plant

Table 1: Efficacy of some plant powders against *Callosobruchus maculatus* in stored cowpea grains

Plant powder	Dosage (%)	Adult mortality (%) (HPI) 24	48	Fecundity (%) (DPI) 5	Progeny emergence (%) (DPI) 27	32	Grain damaged (%) 3 MPI
Bitter leaf	2.5	6.25^{c}	9.30^{b}	9.09^{b}	0.0^{b}	2.44^{b}	5.7^{e}
	5.0	12.50^{ab}	13.95^{ab}	9.09^{b}	0.0^{b}	2.44^{b}	5.3^{e}
	7.5	16.28^{a}	18.75^{a}	0.0^{c}	0.0^{b}	0.0^{b}	5.3^{e}
Cashew leaf	2.5	4.65^{d}	6.25^{cd}	9.09^{b}	2.44^{b}	9.30^{b}	54.7^{b}
	5.0	4.65^{d}	6.25^{cd}	9.09^{b}	2.44^{b}	9.30^{b}	53.3^{c}
	7.5	6.98^{cd}	12.50^{b}	0.0^{c}	0.0^{b}	0.0^{b}	46.3^{c}
Orange peel	2.5	6.25^{cd}	6.98c	9.09^{b}	2.44^{b}	4.65^{b}	11.0^{e}
	5.0	9.30^{b}	9.30^{bc}	9.09^{b}	2.33^{b}	2.44^{b}	8.7^{e}
	7.5	12.50^{a}	16.28^{a}	0.0^{c}	0.0^{b}	0.0^{b}	6.3^{e}
Pawpaw leaf	2.5	0.0^{e}	2.33^{d}	9.09^{b}	6.98^{b}	7.31^{b}	60.7^{b}
	5.0	0.0^{e}	2.33^{d}	9.09^{b}	2.44^{b}	4.65^{b}	52.7^{c}
	7.5	4.65^{d}	6.25^{cd}	0.0^{c}	0.0^{b}	0.0^{b}	44.7^{d}
Control	0.0	0.0^{e}	0.0^{d}	27.28^{a}	58.13^{a}	73.17^{a}	81.7^{a}

HPI = Hours Post Infestation; DPI = Days Post Infestation; MPI = Months Post Infestation

powders is shown in Table 1. Mortality of the beetle ranged between 6.25-16.28% for bitter leaf, 4.65-6.98% for cashew leaf, 6.25-12.50% for orange peel and 0.0-4.65% for pawpaw leaf powders at 24 HPI. Each of bitter leaf, cashew leaf and orange peel powders was significantly different ($p<0.05$) in causing adult mortality at all dosages compared with the control. Only the highest dosage of pawpaw leaf powder caused adult mortality of C. *maculatus*, suggesting a significant difference in its action when compared with the control. The mortality of 6.25% observed in 2.5% dosage of bitter leaf powder was comparable to 6.98% mortality in 7.5% dosage of cashew leaf powder 24 HPI. By 48 HPI, the 5.0% dosage of bitter leaf powder had caused 13.95% adult mortality which was not significantly different ($p>0.05$) from the mortality (18.75%) caused in the higher dosage of the same powder and mortality of 16.28% recorded in orange peel powder. Results showed that there was no significant difference in mortality recorded in 5.0 and 7.5% dosages of bitter leaf powder at 24 and 48 HPI, suggesting that the bitter leaf powder can be applied at lower dosage. In the 48 HPI, bitter leaf powder applied at 2.5 and 5.0% caused mortality of 9.30 and 13.95%, respectively which were not significantly different in the mortality of 12.50% in 7.5% dosage of cashew leaf powder and 9.30% in 5.0% dosage of orange peel powder. It was also observed that adult mortality of C. *maculatus* increased with increase in dosage of plant powders and exposure period. The pawpaw leaf powder was only able to confer lowest mortality of 2.33% in both 2.5 and 5.0% dosages at 48 HPI.

Fecundity and progeny emergence: The relationship between percentage fecundity and progeny emergence of C. *maculatus* can be deduced from Table 1. Results showed that the plant powders applied at the highest dosage (7.5%) inhibited egg-laying. The powders however, gave significant reduction ($p<0.05$) in percentage fecundity recorded in the grains treated with lower dosages and untreated grains by 1:3, respectively. Treatment of the grains with plant powders at various dosages either reduced or inhibited progeny emergence of C. *maculatus* in the study. No progeny emergence was recorded in different dosages of bitter leaf powder. The percentage reduction in progeny emergence in the lower dosages was calculated based on the total emergence in the control. The 100% reduction in emergence was observed in the highest dosage because of egg-laying inhibition. Emergence was significantly ($p<0.05$) reduced by 95.8-100% in cashew and orange peel powders, 88.0-100% in pawpaw leaf powder compared with the control at 27 DPI. At 32 DPI, the lower dosages showed reduction in emergence by 96.7-100% in bitter leaf powder, 87.3-100% in cashew leaf powder, 93.7-96.7% in orange peel powder and 90.0-93.65% in pawpaw leaf powder. All progeny emergence at various dosages of treatment was significantly lower than the control at 27and 32 DPI. Progeny emergence decreased with increase in dosage of the plant powders even though the emergence in different dosages compared favourably with one another.

Grain damage: Table 1 also reveals the percentage grain damaged by C. *maculatus* in the treated and untreated grains. There was significant difference ($p<0.05$) in percentage grain damaged by the beetle ranging between 5.3-5.7% in bitter leaf, 46.3-54.7% for cashew leaf powder, 6.3-11.0% for orange peel powder and 44.7-6o.7% in grains treated with pawpaw leaf powder. All treatments were significantly different in grain damaged by C. *maculatus* compared with the control. The lowest percentage grain damage was observed in bitter leaf powder which was not significantly different ($p>0.05$) from orange peel powder. Percentage grain damaged by the beetle increased significantly ($p<0.05$) as dosage of pawpaw leaf powder decreased. However, there was no significant difference in grain damage among the values obtained at various dosages of bitter leaf and

orange peel powders. Cashew and pawpaw leaf powders caused significantly higher grain damage at different dosage levels compared with dosage levels of other plant powders. It was observed that grains treated with cashew and pawpaw leaf powders were severely damaged through the 3 months of study. Values with the same superscript (s) in the same column are not significantly different at p = 0.05 using least significant difference.

Bean beetle is definitely a great threat to stored cowpea grains in the tropical region of the world including Nigeria. The current trend is to manage the population of the pest by seeking environmentally friendly approaches that would contribute to food security through reduction in stored product damage. In this study, it was observed that higher dosage of plant powder treatments had more insecticidal action on C. *maculatus* than lower dosage. The bitter leaf and orange peel powders suppressed bean beetle population in the stored cowpea grains better than cashew and pawpaw leaf powders within the period of investigation. The contact action of the plant powders with the beetle could not induce 100% mortality of C. *maculatus* in 48 HPI and probably reduced the insect population through inhibition of the normal behaviour of the insect. It was observed that mortality was dependent of dosage, type of plant powder and exposure period. Other researchers have attributed the insecticidal activity of the plant materials to the active ingredients in them. Kabeh and Jalingo (2007) reported that bitter leaf contained hydrocyanic acid and oxalic acid which may have been responsible for the insecticidal activity of the plant. Bitter leaf powder has insecticidal and feeding deterrent effects on C. *maculatus* on stored cowpea (Ibrahim and Aliyu, 2014). This study showed that bitter leaf powder was most effective in suppressing beetle population, inhibiting egg-laying, reducing progeny emergence and grain damage. Findings in this study showed that pawpaw leaf powder was the least effective when compared with other plant parts, compared to insecticidal properties of the plant reported by Jewel. Plant powders have been reported to be abrasive and sometimes adhere to grains (Belmain and Stevenson, 2001). Heaps of orange peels can be converted for use as protectant against pests thereby solving the problem of environmental pollution caused by the waste as observed by Emeasor and Okorie (2008). Orange peels contain secondary metabolites that show insecticidal activity against several coleopteran and dipteran (Belmain and Stevenson, 2001; Salvatore *et al*., 2004; Shrivastava *et al*., 2010).

This study has shown that the plant powders inhibited the normal behavioural activities of the beetle leading to low progeny emergence consequent upon reduced fecundity. The grain damage recorded was a function of number of holes created by the larvae, dosage of the plant powder and exposure period. It has been observed that mechanical effects of large quantities of plant powders could have an effect on oviposition (Rajapakse, 2006) and other physiological processes of the beetle. Most insect spiracles mostly on the ventral plate of the abdomen and leading to the trachea of the insect may have been blocked by the powders as observed by other researchers Komabonta and Falodu (2013), thereby causing suffocation. Previous researchers showed that when plant powders and their extracts were mixed with grains in storage, there appeared to be oviposition inhibition and suppressed adult emergence and reduced seed damage caused by stored product insects (Bakkali *et al*., 2008; Tripathi *et al*., 2009). It was observed that cleaning, sorting, packaging, winnowing, agitating and grain dis-infestation may have contributed to reduced grain damage.

CONCLUSION

It was found that bitter leaf powder was the most insecticidal material against adults of C. *maculatus*. The insecticidal activity of bitter leaf powder and orange peel powder could better be enhanced by examining their synergistic effects on the beetle. A higher performance of these plant materials would encourage their formulation and subsequent adoption by resource-poor farmers because of general safety and ease of handling.

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