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SUPPRESSION OF DAMAGING EFFECTS OF *Callosobruchus maculatus* (F.) (Coleoptera: Chrysomelidae) BY PLANT POWDERS

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ABSTRACT

Powders prepared from plant species available in Nigeria are reported to possess ovicidal, larvicidal, pesticidal, antifeedant and repellent properties against various insect pests and are regarded as environmentally compatible pesticides. This study evaluated the action of *Azadirachta indica* A. Juss*, Hyptis suaveolens* Poit*. Piper guineense* Thonn. & Schum *and Cymbopogon citratus Gaern against the damaging effects of Callosobruchus maculatus* (F.) in stored cowpea. The experiment was carried out at temperature of 30 ± 1^{o}C and relative humidity of 72 ± 3%. The plant powders were compared at the rate of 2.5 g per 50 g cowpea seeds including the untreated control. The experiment was laid out in a completely randomized design with three replications. The results showed that all the botanicals gave protection to the stored cowpea seeds and significantly ($p<0.05$) reduced mean adult emergence and seed weight loss (3.75-4.06%) caused by *C. maculatus* when compared with the untreated control (6.07%). The number of emerged adults from untreated seeds progressively increased with time of exposure compared to the treated seeds. The increasing order of effectiveness of the botanicals in terms of their insecticidal activities against *C. maculatus* was *P. guineense, C. citratus, H. suaveolens,* and *A. indica.* The study, therefore, shows that the botanicals could serve as protectants against *C. maculatus* in stored cowpea seeds.

Keywords: Botanicals, *Callosobruchus maculatus*, Cowpea, Damage, Mortality, Protectants

INTRODUCTION

Cowpea (*Vigna unguiculata* L. Walp) originated from Africa where a large number of primitive cultivars and semi-wild forms are found (Kwaifa *et al.,* 2012). It is grown for food and animal feed in the semi-arid tropics of Africa, Asia, *Europe*, Central and South America (Asante *et al.,* 2001). The crop is an important edible grain legume being very rich in protein required by man and livestock (Akinkurolere *et al.,* 2006). Cowpea, therefore, nutritionally complements staple low protein cereals and tuber crops and provides income for farmers and traders (Lanyintuo *et al.,* 2003).

In addition to the high protein content of cowpea, it also has high iron content but is low in fats. Cowpea has also been valuable in nitrogen fixation through its root nodules, and it grows well in poor soils with more than 85% sand and with less than 0.2% organic matter and low levels of phosphorus (Singh *et al.,* 2003).

Seed beetle, *Callosobruchus maculatus* (F.) is unarguably a major insect pest militating against food availability and security (Adedire, 2008). Storage of cowpea seeds over long periods, especially at small holder levels, is limited by bean beetle infestation. Huge losses of between 20 and 50% have been reported on stored cowpea due to attack by bean beetle, *C. maculatus* and sometimes the loss could be complete accounting for 100% loss (Udo and Harry, 2013). Bean beetle also attacks chickpeas (*Cicer* sp.), lentils (*Lens* sp.), garden peas (*Pisum* sp.) and mung beans (*Vigna* sp.) with distinctive damage. Their damage causes loss of weight, nutritional value and viability of stored seeds particularly caused by larvae. Adult female *C. maculatus* lays half its total eggs in the first two days after copulation (Uddin II and Sanusi, 2013).

The major problems associated with the use of synthetic pesticides against the pest include the dangers to the user, exorbitant costs, pesticide resistance and food residue. Improper application of synthetic pesticides poses a threat to man and the environment, particularly among rural farmers in Africa (Ofuya, 2003). These setbacks have made the quest for alternative approaches to the pest control including plant products, very expedient (Lale, 2002).

Currently, global research efforts now support the development of plant products with proven crop protection potentials (Aliyu *et al.,* 2011). Rahman and Talukder (2006) reported that grains mixed with leaf, seed powder, or plant extracts reduced oviposition, inhibited damage and suppressed adult emergence of *C. maculatus*.

In another investigation, plant powders applied at 2% of the weight of stored beans effectively controlled cowpea seed beetle in storage (Lale, 2002). In the tropics, some of the plant species that have been screened for insecticidal properties include *Azadirachta indica* A. Juss, *Piper* *guineense* Schum. & Thonn. and *Dennettia tripetala* G. Baker (Lale, 2006). The inclusion of plant products in pest management may offer a reliable and environmentally safe alternative to synthetic insecticides. This study therefore determined the efficacy of *A. indica, Hyptis suaveolens* Poit., *P. guineense* and *Cymbopogon citratus* Gaern against bean beetle, *C. maculatus* (F.) in stored cowpea.

MATERIALS AND METHODS

Experimental Study

The research was carried out at the Biotechnology Laboratory, University of Ilorin, Ilorin, Nigeria. The cowpea (variety *Beluko*) used for this experiment was purchased from an agro-allied shop, Amilegbe, Ilorin.

Insect Culture

The initial stock culture of *C. maculatus* was maintained in the laboratory of the Department of Crop Protection, University of Ilorin, Ilorin, Nigeria. Sub-cultures of the insect were prepared from 25 pairs of the adult insect randomly picked from the stock culture. The insects were raised on dry susceptible white cowpea seeds in plastic containers covered with muslin cloth to allow aeration and prevent insect escape. The culture was maintained under prevailing temperature of $30 \pm 1^{o}C$ and relative humidity of $72 \pm 3\%$. Freshly emerged adults were used for the study.

Seed Sterilization and Plant Powder Preparation

The cowpea seeds were sterilized in a freezer compartment of a refrigerator for 14 days to eliminate possible hidden insect infestation (Musa and Lawal, 2016). Four researched plants identified as *Azadirachta indica* A. Juss. (Ivbijaro, 1989), *Piper guineense* Thonn. & Schum. (Musa, 2007), *Hyptis suaveolens* Poit. (Musa, 2008; 2013), and *Cymbopogon citratus* Gaern (Dike and Mbah, 1992) were collected from the University of Ilorin campus and its environs. The leaves were air-dried for three weeks, ground separately and thereafter passed through a sieve to obtain fine powder. The plant powders were kept in air-tight vials prior to use.

Experimental Design

Azadirachta indica, *P. guineense*, *H. suaveolens*, and *C. citratus* leaf powders were evaluated for their ability to protect cowpea seeds against damage by *C. maculatus*. Each plant powder was applied at 2.5 g per 50 g cowpea seeds in separate plastic containers (7.5 cm in diameter) with ten *C. maculatus* (1-2 day old) adults introduced into each of the containers. Cowpea seeds without plant powder were put into a container and served as untreated control. The containers were covered with muslin cloth to allow aeration and prevent insect escape. The experiment was laid out in a completely randomized design with three replications.

Data Collection

Data collected included adult beetle mortality, adult beetle emergence, seed weight damaged and seed weight loss. The mortality rates were recorded at 1, 2, 3 and 4 days after infestation (DAI) and then expressed as percentage. The newly emerged adults were from the first day of emergence (29 DAT) to 35 DAT. The damaged seeds (seeds with exit holes) in each sample were determined by weighing. The seed weight loss was computed using the method of Musa and Lawal (2016) as follows:

$$W = W_1 - W_2$$

where:

W=weight difference

W_1=original weight (before infestation)

W_2=final weight (after infestation)

Data Analysis

Data were subjected to analysis of variance while means separation was carried out using Least Significant Difference at p=0.05 level of significance.

RESULTS

Effect of Plant Powders on the Mortality of *C. maculatus* Adults

Table 1 shows that *H. suaveolens* and *C. citratus* leaf powders had insecticidal effects against bean beetle at 1 DAT. At 2 DAT, *H. suaveolens* leaf powder caused significantly ($p<0.05$) higher mortality (40.0%) than *C. citratus* (20.0%) and *P. guineense* (20.0%) leaf powders against the insect. At 3 DAT, there were significantly ($p<0.05$) higher mortality of *C. maculatus* adults in seeds treated with *A. indica* (100.0%) than *P. guineense* (20.0%), *H. suaveolens* (60.0%) and *C. citratus* (60.0%). However, *H. suaveolens* leaf powder caused total mortality of *C. maculatus* adults at 4 DAT. On the whole, seeds treated with the leaf powders caused varying rates of mortality compared to no mortality in the untreated control during the study period.

Effect of Plant Powders on Adult Emergence of *C. maculatus*

Table 2 shows the emergence of *C. maculatus* adults from cowpea seeds treated with leaf powders of *A. indica, P. guineense, H. suaveolens* and *C. citratus* from 29 to 35 DAT. *Hyptis suaveolens* inhibited progeny emergence from 29 to 31 DAT while *C. citratus* inhibited progeny emergence from 29 to 30 DAT. The results for the number of emerged adults indicated a highly significant ($p<0.05$) difference. From 32 to 34 DAT, *H. suaveolens* recorded the lowest mean numbers of emerged adults ranging from 0.67-10.33, while the untreated control consistently recorded the highest mean numbers of emerged adults ranging from 10.33 to 70.00 between 29 and 35 DAT. *Azadirachta indica* and *H. suaveolens* showed significant ($p<0.05$) difference in the mean numbers of emerged adults compared to the untreated control except at 33 DAT. *Hyptis suaveolens*, *C. citratus* and *A. indica* were statistically the same in reducing the adult emergence at 35 DAT but the *H. suaveolens* caused significantly lower mean adult emergence compared to *C. citratus* and *A. indica* at 34 DAT. However, the performance of *H. suaveolens* in reducing adult emergence was significantly better than *A. indica, P. guineense* and *C. citratus* at 34 DAT.

Effect of Plant Powders on Cowpea Seed Damage

Table 3 shows the mean weight of cowpea seeds damaged by *C. maculatus* after being treated with the four different leaf powders. The highest mean weight of seeds damaged by the insect was recorded in *P. guineense* (4.02 g) while *A. indica* had the lowest mean value (1.57 g). All other treatments had intermediate values. There were no significant ($p>0.05$) differences among the mean weight of seeds treated with *A. indica, P. guineense, H. suaveolens*, *C*. *citratus* and the untreated control. The mean weight of undamaged cowpea seeds with different leaf powders was recorded to be the highest mean value in *A. indica* (46.55) and lowest mean value in *P. guineenses* (43.95) while other treatments had intermediate values. There were no significant ($p>0.05$) differences in the mean weights of undamaged cowpea seeds for all the treatments including the untreated control.

Effect of Plant Powders on Seed Weight Loss

Table 4 shows the mean seed weight loss caused by the four different leaf powders. There were no significant ($p>0.05$) differences among the mean weight loss of cowpea seeds treated with *A. indica, P. guineense, H. suaveolens, C. citratus*, ranging between 1.88 and 2.09 and the untreated control (3.18 g). The highest value (6.07%) and the lowest value (3.75%) of mean percentage loss of cowpea seeds were recorded in the untreated control and *A. indica* leaf powder respectively. Also, there was no significant ($p>0.05$) difference in mean percentage weight loss of cowpea seeds treated with the leaf powders of *A. indica, P. guineense, H. suaveolens, C. citratus* and the untreated control.

DISCUSSION

The literature shows that plant powders have insecticidal action against *C. maculatus* and other stored product insect pests (Adedire and Lajide,, 1999; Asawalam and Emosairue, 2006; Musa and Uddin II, 2016). Also, in a previous study, Oparaeke *et al*., (2002) reported that cowpea seeds treated with *Ocimum gratissimum* and *H. suaveolen* caused reduction in progeny development of *C. maculatus.*

The results of this study agree with the findings of Idoko and Adesina (2012) who reported that *P. guineense* caused the mortality of *C. maculatus* adults and eventual suppression of progeny emergence due to contact toxicity of the powder. Previous investigation showed that mortality of *C. maculatus* increased with increase in the rate of plant part powder applied with higher rate assumed to be having higher active ingredients against the insect (Musa, 2012).

The adult mortality recorded might be attributed to the leaf powders that may have caused abrasion of the insect cuticle. The increasing order of effectiveness of the botanicals in terms of their insecticidal activities against *C. maculatus* was *P. guineense, C. citratus, H. suaveolens,* and *A. indica.* The insecticidal properties of *A. indica* and *P. guineense* could be attributed to the presence of azadirachtin and piperine respectively (Oparaeke, 2006).

Hyptis suaveolens offered the better protection against the number of emerged adults of *C. maculatus* because it was consistently significantly better than the untreated control during the study period. Reduction in the number of emerged adults may be associated with possible ovicidal and larvicidal activities of the botanicals. In this study, *A. indica* had the lowest emergence of *C. maculatus* adults. The reduced adult emergence in all the plant powders may also be due to mortality of the adult beetle before oviposition. It could also be that the plant materials made the male sterile; thus made the females produced non-fertile eggs (Ojianwuna and Umoru, 2010). Among the plant powders, *H. suaveolens* conferred better protection of cowpea seeds through prevention of emergence during the study period. Generally, adult emergence increased with increase in exposure period despite the presence of the plant powders.

CONCLUSION

This study shows that the leaf powders afforded varying degrees of cowpea seed protection against bean beetle, *C. maculatus* under small scale storage. However, *A. indica* and *H. suaveolens* leaf powders offered better protection than *P. guineense* and *C. citratus* and are therefore recommended for further empirical investigation to be able to incorporate them into much desired preservation of bulk commodities.

Table 1: Mean percentage mortality of *Callosobruchus maculatus* adults on cowpea seeds treated with the same rate of different leaf powders

Plant Powder	**Days after treatments (DAT)**			
	1	**2**	**3**	**4**
A. indica	0.0_{b} (0)	0.0_{b} (0)	30.0_{a} (100)	30.0_{a} (100)
P. guineense	0.0_{b} (0)	6.0_{b} (20)	6.0_{c} (20)	18.0_{b} (60)
H. suaveolens	6.0_{a} (20)	12.0_{a} (40)	18.0_{b} (60)	30.0a (100)
C. citratus	6.0_{a} (20)	6.0_{b} (20)	18.0_{b} (60)	18.0_{b} (60)
Control	0.0_{b} (0)	0.0_{b} (0)	0.0_{d} (0)	0.0_{d} (0)
SE±	0.21	0.97	0.53	2.30
LSD $_{(0.05)}$	**0.73**	**3.36**	**1.84**	**8.04**

Values in the same column followed by common subscript do not differ significantly different at p = 0.05 using Least Significant Difference. Values in parentheses represent percentage mortality.

Table 2: Emergence of *Callosobruchus maculatus* adults on cowpea seeds treated with the same rate of different plant leaf powders

Plant Powder	Progeny emergence of *C. maculatus* (DAT)						
	29	30	31	32	33	34	35
A. indica	5.0_{b}	1.0_{b}	1.00_{d}	1.33_{c}	8.00_{ab}	18.3_{d}	21.33_{b}
P. guineense	6.0_{b}	3.33_{ab}	3.33_{b}	7.00_{b}	7.67_{ab}	27.00_{b}	70.00_{a}
H.suaveolens	0.0_{c}	0.00_{b}	0.00_{d}	0.67_{c}	1.00_{b}	10.33_{c}	21.67_{b}
C. citratus	0.0_{c}	0.00_{b}	1.33_{c}	2.00_{c}	16.33_{a}	18.67_{d}	34.00_{ab}
Control	10.33_{a}	10.33_{a}	11.0_{a}	13.00a	18.33_{a}	48.00_{a}	70.00_{a}
SE±	0.30	2.55	0.33	1.59	3.35	1.11	12.36
LSD $_{(0.05)}$	**1.04**	**8.86**	**1.15**	**5.53**	**11.65**	**3.86**	**42.99**

Values in the same column followed by common subscript(s) do not differ significantly different at p = 0.05 using Least Significant Difference. DAT= Days after treatments SE= Standard error

Table 3: Effects of different plant powders on cowpea seed damage

Plant Powder	39 DAT			
	Rate (g)	Wt. of damaged seeds (g)	Wt. of undamaged seeds (g)	Total weight (g)
A. indica	2.5	1.57 ± 0.89	46.55 ± 1.01	48.12 ± 0.14
P. guineense	2.5	4.02 ± 3.90	43.95 ± 4.45	47.97 ± 0.55
H. suaveolens	2.5	1.87 ± 0.77	46.16 ± 0.92	48.04 ± 0.21
C. citratus	2.5	1.83 ± 0.46	46.31 ± 0.60	48.11 ± 0.13
Control	0.0	0.56 ± 0.40	46.41 ± 0.82	46.97 ± 1.07
$LSD_{(0.05)}$		**NS**	**NS**	**NS**

NS: Not Significant

Table 4: Effects of different plant powders on the weight loss of cowpea seeds

Plant Powder	Mean Wt. loss (g)	Wt. loss (%)
A. indica	1.88 ± 0.14	3.75 ± 0.28
P. guineense	2.09 ± 0.61	4.06 ± 1.10
H. suaveolens	1.96 ± 0.21	3.87 ± 0.25
C. citratus	1.88 ± 0.13	3.77 ± 0.25
Control	3.18 ± 1.22	6.07 ± 2.13
$LSD_{(0.05)}$	**NS**	**NS**

NS: Not Significant

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