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Comparative effectiveness of the powders of some underutilized botanicals for the control of *Callosobruchus maculatus* (Fab.) (Coleoptera : Bruchidae)

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Abstract
Biological activities of eight plant powders including *Piptadeniastrum africanum* (rootbark), *Piptadeniastrum africanum* (leaf), *Piper guineense*, *Aristolochia repens*, *Alstonia boneei, Xylopia aethiopica, Garcinia kola and Picralima nitida* were assessed under prevailing atmospheric condition (28±2^{0}C, 70-75 r.h.) in laboratory on *Callosobruchus maculatus* (Fabricius) at four treatment levels of 0.5, 1.0, 1.5 and 2.0g of plant powders per 20g of cowpea seeds corresponding to 2.5, 5.0, 7.5 and 10.0% w/w. Percentage beetle mortality was scored at 24, 48, 72 and 96h after treatment. The results obtained showed that powder of *P. guineense* was the most toxic to *C. maculatus* evoking 100% mortality at day four with treatment levels of 5.0, 7.5 and 10.0 %w/w respectively. The plant powders of *P. africanum* (rootbark), *P. africanum* (leaf) and *A. repens* evoked 85.00%, 85.50% and 80.00% mortality at day four with treatment level of 10.00% w/w. The least toxic powders on the insect were those of *A. boonei, X. aethiopica, G. kola* and *P. nitida*. In a further evaluation of the plant powders on survival and development of *C. maculatus*, it was observed that fecundity and adult emergence were drastically reduced in all the treatments except *G. kola* and *A. boonei*
Key words: Plant powders, *Callosobruchus maculatus,* fecundity and adult emergence

1. Introduction

Agricultural produce cannot all be consumed at once; there is need for proper storage. One major problem encountered by farmers during storage of farm produce is insect pest infestation. This often leads to loss in both quality and quantity of the produce (Ogunleye, 2000).

The pulse beetle, *Callosobruchus maculatus* Fab. (Coleoptera : Bruchidae), is a major pest of economically important leguminous grains such as cowpeas, lentils, green gram and black gram (Talukder and Howse,1994; Okonkwo and Okoye, 1996; Mulatu and Gebremedhin, 2000; Raja et al.,2000; Park et al.,2003). The larvae bore into the pulse grain which becomes unsuitable for human consumption, viability for replanting, or for the production of sprouts. They are important pests of pulse crops in Asia and Africa under storage conditions (Ogunwolu and Idowu, 1994; Okonkwo and Okoye, 1996; Mulatu and Gebremedhin, 2000; Ajayi and Lale, 2001; Tapondjou et al., 2002).

The most effective insect pest control measure is the use of synthetic insecticides. Some of these insecticides include pirimiphos- methyl, fenitrothion and malathion. The continued and intensive usage of these insecticides has produced some undesirable toxic effects on man handling them and also on non target biotic components of the ecosystem. In a reaction to this problem, researchers all over the world have resorted to using more available and environmentally friendly botanicals for this purpose. Several botanicals have been screened for insecticidal activities. These include among others: *Zanthozylum zanthoxyloides, Nicotiana tabacum*, *Eugenia aromatica*, *Azadirachta indica* and *Dennetia tripetela* (Ogunleye, 2000; Ogunleye et al., 2004; Adedire and Lajide, 2000). Their main advantage is that they are cheap and readily available to farmers and small scale industries in form of crude or partially purified extracts. It was reported that when mixed with stored-grains; leaf, bark, seed powder or oil extracts of plants reduced oviposition rate and suppressed adult emergence of bruchids and also reduced seed damage rate (Talukder and Howse, 1994; Onu and Aliyu, 1995; Shaaya et al., 1997; Keita et al., 2001; Tapondjou et al., 2002). The present research was carried out to evaluate the insecticidal activities of various plant powders against the cowpea bruchid *Callosobruchus maculatus*.

2. Materials and Methods

2.1 Preparation of insect cultures

The parent stock of *Callosobruchus maculatus* was obtained from infested grains in Oja-Oba market in Ikole- Ekiti, Ekiti State, Nigeria. The insects were cultured in the laboratory under ambient temperature of 28±2^{0}C and 75±5% relative humidity. This was done by weighing 750g of the cowpea seeds into a kilner jar. Twenty unsexed adult of *C. maculatus* were then introduced into the kilner jar and kept in the laboratory for one month for the insects to lay eggs and multiply. All insects needed for this experiment were taken from this culture.

2.2 Plant materials

The plants used are presented in Table 1. They were bought fresh from Oja- oba market in Iklole-Ekiti, except the root bark of *P. africanum*, leaf of *P. africanum* and Stembark of *A. boonei* which were sourced fresh from a farm at Oke-Ayedun Ekiti, Ekiti- State, Nigeria. These plant materials were dried in an open laboratory and later pounded into fine powder with the aid of mortar and pestle. After pounding, the resulting powder was sieved using 40mesh screen and kept in the refrigerator to retain its freshness before application.

Table 1: Plant powders evaluated for insecticidal activities against *Callosobruchus maculatus*

Botanicals	Family	Parts used	Common name
Piptadeniastrum africanum	Fabaceae	Rootbark	Dahoma
Piptadeniastrum africanum	Fabaceae	Leaf	Dahoma
Piper guineense	Piperaceae	Seed	Black pepper
Aristolochia repens	Aristolochiaceae	Stem	Dutchman's pipe
Xylopia aethiopica	Annonaceae	Fruit	Ethiopian pepper
Picralima nitida	Apocynaceae	Seed	Picralima
Garcinia kola	Guttiferae	Seed	Bitter kola
Alstonia boonei	Apocynaceae	Stembark	Cheesewood

INSECT BIOASSAY

Clean and uninfested cowpea seeds were purchased at the Oja-oba market at Ikole- Ekiti. They were also kept in the deep freezer to ensure that any existing insect eggs and larvae are killed before the commencement of the experiment.

Portions of 0.5, 1.0, 1.5 and 2.0g was weighed and each added to a 20g of clean, undamaged and uninfested cowpea seeds in kilner jars. The seeds in the control contained no plant powders. The containers with their contents were gently shaken to ensure thorough admixture of the cowpea seeds and treatment powders. Ten pairs of newly emerged adults of *C. maculatus* unsexed were then introduced into each of kilner jars. All the experiments were replicated four (4) times. The percentage mortality was assessed after every 24h for 4 days. Adults were considered dead when probed with sharp objects and there were no responses. The effects of the plant powders were checked on the fecundity *of C. maculatus*. This was done by counting the number of eggs present on each cowpea in a cage and then sum it together to get the number of egg present in each of the cages and the result obtained was recorded. The number of adult emergence was assessed 30 days after treatment.

2.3 STATISTICAL ANALYSIS

All data collected were subjected to analysis of variance and where significant differences existed; treatments were compared at 0.05 significant level using Tukey's Test.

3. RESULTS

3.1 TOXICITY OF PLANT POWDERS

The mean percentage mortality of *C. maculatus* treated with eight plant powders is presented in Table 2. In each treatment, the percentage mortality of *C. maculatus* varied with the period of exposure, the type of plant powders and powder concentration. The result for the control experiment ranged from 0% after 24h to 6.25% after 96h.

Among the eight plant powders tested for insecticidal activities, the plant powders of *P. guineense*, *P. africanum* (rootbark), *P. africanum* (leaf) and *A. repens* were the most effective in controlling *C. maculatus* evoking 100%, 85%, 83.5% and 80% insect mortality respectively at the treatment level of 10.0%w/w after 96h of exposure. The level of effectiveness was followed by *A. boonei* and *X. aethiopica* evoking 51.25% and 48.75% at 10.0%w/w after 96h of treatment. The effect of *G. kola* and *P. nitida* were not significantly different ($P \geq 0.05$) from the control throughout the trial period.

Table 2: Mean percentage mortality of *C. maculatus* treated with eight plant powders

Plant powders treatment	Conc. w/w	Mean % mortality ± S.E. at 24 to 96h post			
	%	24h	48h	72h	96h
Piptadeniastrum africanum (rootbark)	2.5	3.75± 2.39^{a}	13.75± 2.39^{b}	31.25± 9.66^{bc}	60.00±8.42^{c}
	5.0	8.75± 1.25^{b}	21.25± 4.73^{bc}	41.25± 8.98^{c}	73.75±10.68^{c}
	7.5	5.00± 0.00^{a}	17.50± 2.50^{b}	41.25± 4.27^{c}	83.75±3.15^{cd}
	10.0	11.25 ±1.25^{ab}	20.00± 2.04^{bc}	48.75± 1.25^{c}	85.00±2.04^{cd}
Piptadeniastrum africanum (Leaf)	2.5	0.00± 0.00^{a}	28.75 ±1.25^{c}	35.00± 2.89^{c}	83.75 ±4.27^{cd}
	5.0	1.25± 1.25^{a}	26.25 ±5.54^{c}	43.75 ±3.75^{c}	83.75 ±3.15^{cd}
	7.5	2.50± 1.44^{a}	26.25± 6.88^{c}	48.75 ±4.27^{c}	83.75 ±1.25^{cd}
	10.0	5.00 ±2.04^{ab}	26.25 ±3.15^{c}	52.50 ±4.79^{e}	83.50 ±4.33^{cd}
Piper guineense	2.5	13.75± 5.15^{ab}	50.00± 5.40^{d}	91.25± 2.39^{d}	93.75± 2.39^{d}
	5.0	22.50 ±2.50^{c}	50.00 ±4.08^{d}	91.25± 3.15^{d}	100.00±0.00^{d}
	7.5	28.75± 4.27^{c}	51.25 ±4.27^{d}	92.50± 3.22^{d}	100.00±0.00^{d}
	10.0	26.25 ±4.27^{c}	71.25 ±2.39^{d}	92.50± 1.44^{d}	100.00±0.00^{d}
Aristolochia repens	2.5	1.25± 1.25^{a}	3.75 ±2.39^{a}	15.00± 2.04^{ab}	55.00± 3.54^{bc}
	5.0	2.50 ±1.44^{a}	8.75 ±3.15^{ab}	26.25± 2.39^{b}	67.50± 1.44^{c}
	7.5	5.00 ±3.54^{a}	11.25±1.25^{ab}	28.75 ±3.15^{b}	73.75 ±5.54^{c}
	10.0	3.75 ±1.25^{a}	21.25± 5.54^{bc}	33.75± 1.25^{c}	80.00 ±10.80^{c}
Alstonia boonei	2.5	3.75± 1.25^{a}	10.00 ±2.04^{ab}	17.50 ±3.23^{ab}	35.00± 2.04^{b}
	5.0	6.25± 2.39^{a}	12.50 ±4.33^{ab}	31.25 ±3.15^{c}	37.50± 4.33^{b}
	7.5	7.50 ±1.44^{a}	15.00± 5.40^{ab}	28.75± 2.39^{b}	43.75± 5.54^{b}
	10.0	3.75± 2.39^{a}	15.00 ±0.00^{ab}	31.25 ±3.15^{bc}	51.25± 1.25^{b}
Xylopia aethiopica	2.5	2.50 ±2.50^{a}	10.00 ±2.04^{ab}	20.00 ±2.04^{b}	46.25± 8.00^{b}
	5.0	1.25 ±1.25^{a}	3.75 ±1.25^{a}	8.75 ±1.25^{ab}	27.50± 3.23^{ab}
	7.5	6.25± 1.25^{a}	11.25 ±1.25^{ab}	13.75 ±1.25^{ab}	47.50± 4.33^{b}
	10.0	8.75± 1.25^{ab}	15.00± 2.04^{ab}	20.00 ±2.04^{b}	48.75± 1.25^{b}
Garcinia kola	2.5	0.00± 0.00^{a}	0.00 ±0.00^{a}	2.50± 2.50^{a}	11.25± 3.15^{a}
	5.0	0.00 ±0.00^{a}	0.00 ±0.00^{a}	1.25 ±1.25^{a}	8.75 ±2.39^{a}
	7.5	0.00 ±0.00^{a}	0.00 ±0.00^{a}	3.75 ±2.39^{a}	15.00 ±2.04^{a}
	10.0	0.00 ±0.00^{a}	0.00 ±0.00^{a}	6.25± 2.39^{a}	23.75± 3.75^{a}
Picralima nitida	2.5	2.50± 1.44^{a}	7.50± 3.23^{ab}	7.50 ±3.23^{a}	30.00 ±2.04^{ab}
	5.0	6.25 ±2.39^{a}	10.00± 2.04^{ab}	10.00 ±2.04^{ab}	31.25 ±2.39^{ab}
	7.5	3.75 ±1.25^{a}	8.75 ±3.15^{ab}	10.00± 0.00^{ab}	31.25 ±4.73^{ab}
	10.0	3.75 ±1.25^{a}	10.00± 2.04^{ab}	10.00± 2.04^{ab}	35.00± 2.04^{ab}
Control (Untreated)	0.0	0.00 ±0.00^{a}	0.00 ±0.00^{a}	0.00 ±0.00^{a}	6.25± 2.3^{a}

. Means followed by the same letter(s) in the same column are not significantly different ($P \geq 0.05$) from each other using Tukey's Test

Figure 1 shows the mean fecundity of *C. maculatus* treated with eight plant powders. The mean fecundity for the control was 160.50. Very low fecundity was recorded for all the dosages of *P. guineense*, *P. nitida* and the rootbark of *P. africanum*. The results for *P. guineense* were 31.75, 39.25, 28.00 and 22.25 from the least to the highest dose, that of *P. nitida* were 88.75, 38.25, 33.25 and 30.00 and for rootbark of *P. africanum*, 130.25, 66.00, 94.50 and 65.75 were recorded for all the doses from the least to the highest. All the other plant powders could not cause any reduction in insect fecundity for all the doses.

Fig.1: Mean fecundity of *C. maculatus* treated with plant powders.

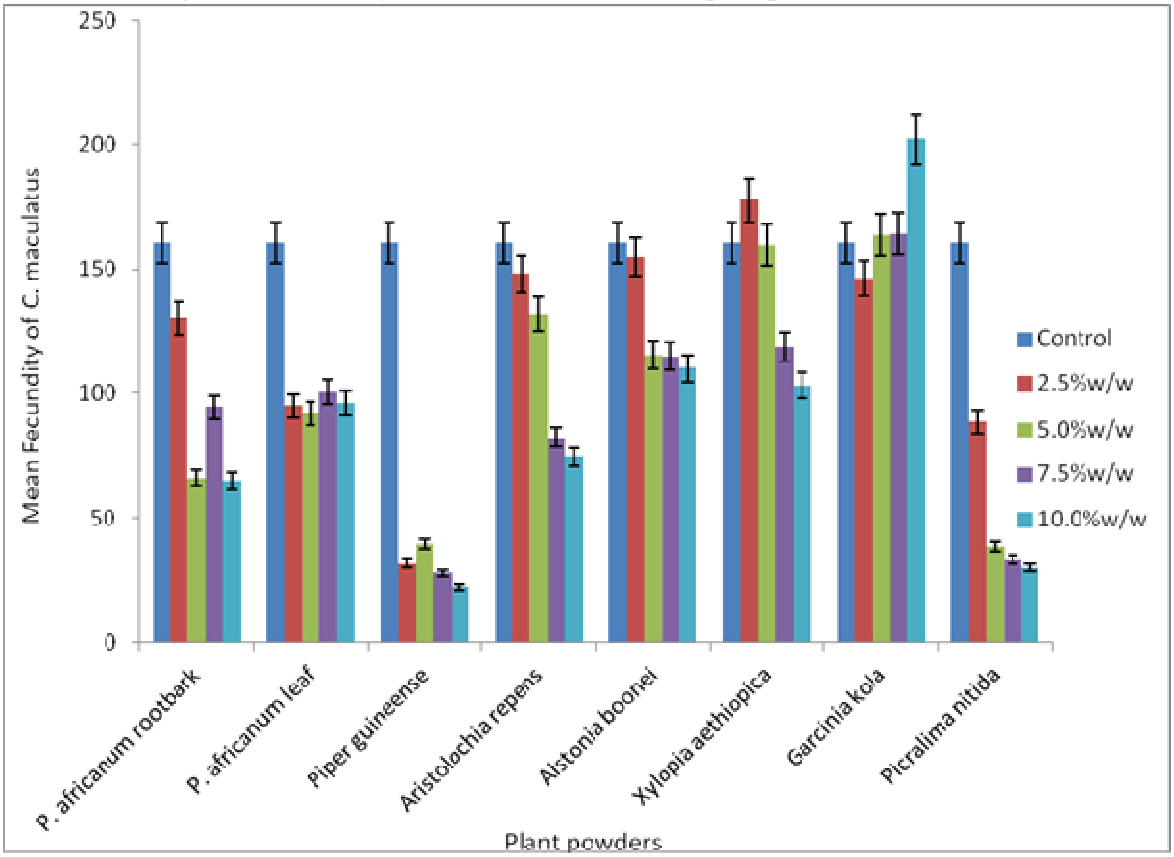
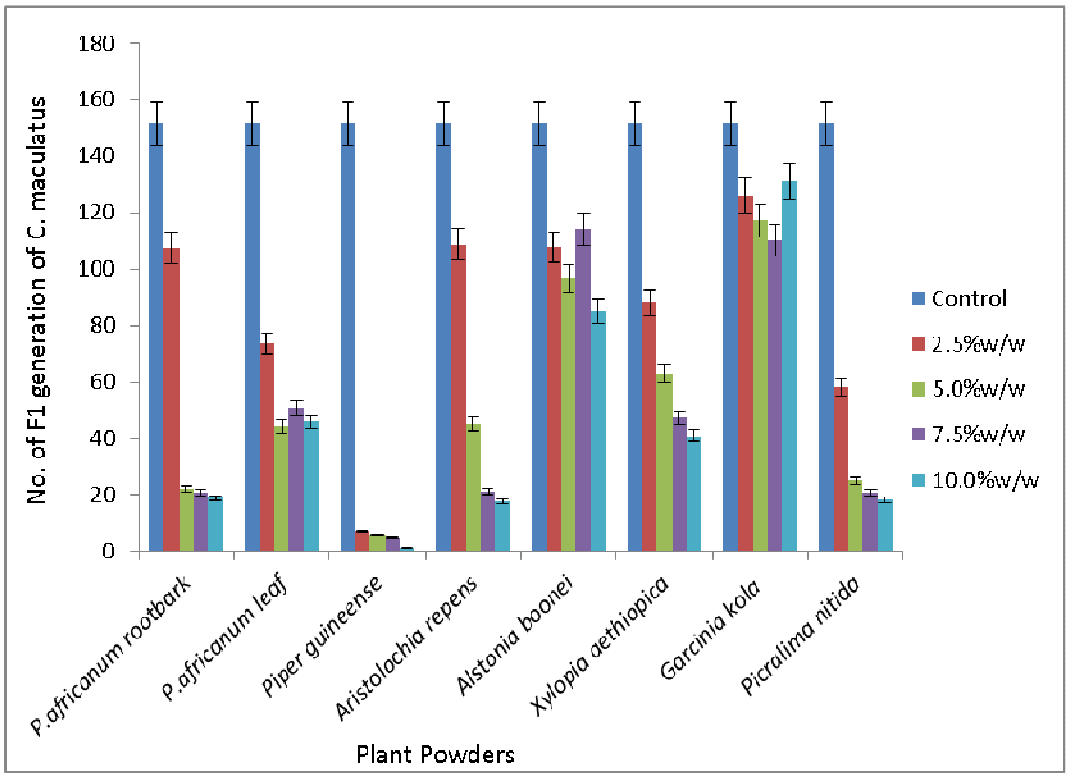


Figure 2 compares the effectiveness of the various plant powders at different dosage rates on adult emergence of *C. maculatus*. Apart from the plant powders *G. kola* and *A. boonei*, other plant powders significantly reduced the adult emergence of *C. maculatus* when compared with control.

The plant powders of *P. guineense* and *P. nitida* recorded the lowest number of adult emergence having a range of 1.25 to 7.25 and 18.25 to 58.25 adult emergence at all concentrations tested from the least to the highest. This was followed by rootbark of *P. africanum* (107.50, 22.25, 21.00 and 19.00), *A. repens* (108.75, 45.25, 21.25 and 17.75) and leaf of *P. africanum* (73.75, 44.25, 50.75 and 46.00). The plant powder of *G. kola* recorded the highest number of adult emergence having a range of 110.25 to 131.00 adult emergences at all the concentrations tested.

Fig.2: Effect of plant powders on adult emergence of *C. maculatus*



4. DISCUSSION

It is evident from the result of this study that among the eight plant powders tested for insecticidal activities, the plant powders of *P. guineense, P. africanum* (rootbark), *P. africanum* (leaf) and *A. repens* were the most effective in controlling the population of *C. maculatus.* However, their effectiveness was dependent on dosage rate and period of application. Plant powders have been used to suppress the population of storage pests (Ogunleye et al., 2004, Ogunleye, 2000 and Onu and Baba, 2003). In this study, the resultant high mortalities of adult *C. maculatus* observed on cowpea seeds treated with plant powders could be due to contact toxicity resulting in blockage of the spiracles (Lale, 2002 and Steve, 2010). This can lead to suffocation and death. Secondly, these powders when stocked under the wings of insects in the store coupled with the fact that the plant has great itching effects are capable of causing discomfort to them. It has also been observed in *C. maculatus* that the sequence of their behaviours (especially in females while ovipositing) normally makes them prone to acquiring toxic residues from treated surfaces (Ogunwolu and Idowu, 1994; Ofuya, 2001). The result from this investigation is similar to the observation of Ofuya and Dawodu (2001) who reported the susceptibility of different ages of *C. maculatus* to *P. guineense.* Oguntade and Adekunle (2010) reported that the wood ashes of *Nauclea diderrichi* and *Piptadeniastrum africanum* proved to be effective in preserving the manifestation of weevils (*C. maculatus*). Ogunleye (2011) reported that the powder of the young leaves of *Ficus exasperate* were capable of having significant mortality effects on *C. maculatus.*

The result obtained on fecundity showed that powders of *P. guineense, P. nitida* and *P. africanum* (rootbark) caused a significant reduction in insect fecundity for all the doses when compared with other trestments. The reduction in the rate of oviposition by *C. maculatus* is consistent with Adesina (2010) who reported that storing cowpea seeds admixture with plant powders would fill intergranular air spaces and prevent free movement of adults for mating and oviposition. Fasakin and Aberejo (2002) observed that *P. guineense* powder prevented oviposition on *C. maculatus* and *Dermestes maculatus* respectively. The reduction in oviposition could be due to respiratory impairment, probably affects the process of metabolism and consequently other systems of the body of the beetles (Onolemhemhem and Oigiangbe, 1991). Futhermore, all the plant powders suppressed adult emergence to some extent after 30 days of exposure. The resultant low adult emergence could be due to the fact that *C. maculatus* lay eggs on the seed coat thus bringing the eggs and larvae in close contact with the plant powders as reported by Adedire and Lajide (2001). The result of this study agrees with the work of Okonkwo and Okoye (1996) who reported that both the powder and extract of *P. guineense* and *Dennettia tripetala*

inhibited adult emergence of *Callosobruchus maculatus* and *Sitophilus zeamais* completely. The treatments with *P. guineense* had the highest percentage mortality as well as reduced the number of adult emergence than any other plant powders at all the concentrations tested. The plant family Piperaceae to which *P. guineense* belongs has been reported to possess some forms of insecticidal properties against eggs of cowpea storage bruchid (Adedire and Lajide, 1999) which are capable of suppressing various developmental instars of *C. maculatus.* Insecticidal property of any plant material would depend on the active constituents of the plant material. Okonkwo and Okoye (1996) reported that *P. guineense* contains piperine and chavicine, which are insecticidal while Lale (1995) included piperidine and alkaloids as the major active components of *P. guineense.* The saw dust of *P. africanum* is known to cause irritation of the skin, throat and eyes (Jiofack, 2008). The insecticidal activities *P. africanum* could be attributed to the presence of alkaloids, flavonoids and tannins (Oguntade and Adekunle, 2010). Also, the effectiveness of the powder of *A. repens* may be attributed to the presense of Aristolochic acid which is present in all the members of the genus Aristolochia (Mix et al., 1982). Considering the ease of powder application by farmers, the powder of *P. guineense, A. repens* and *P. africanum* (rootbark and leaf) could be admixed with cowpea seeds in order to protect them against *C. maculatus*.

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