Peel and leaf powders of three fruits and a vegetable as promising botanicals against bean beetle, *Callosobruchus maculatus* F. in stored cowpea

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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 hours post infestation (HPI) respectively. In grains treated with 7.5% orange peel powder, 12.50 and 16.28% mortality were observed within 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 control. No mortality was observed in the control within the period. Oviposition was inhibited in the highest dosage of the plant powders but the percentage oviposition in the lower dosages was three-fold lower than control. The plant powders also significantly reduced progeny emergence and grain damaged by the beetle. No beetle emergence was recorded from grains treated with bitter leaf powder at 27 DPI. Cashew and pawpaw leaf powders caused grain damage of 46.3-54.7% and 44.7-60.7% respectively during the study period. There was noteworthy decrease in insecticidal effects of the plant powders as indicated: bitter leaf > orange peel > cashew leaf > pawpaw leaf. It is recommended that incorporating these plant parts in pest management of stored products will guarantee user safety, reduce environmental pollution and suppress insect infestation.

Key words: Beetle, botanicals, damage, mortality, progeny.

INTRODUCTION

Cowpea is a household name in Nigeria where it is commonly called ‘wake’ in Hausa or ‘ewa’ in Yoruba. 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. The adults leave neat circular exit holes in the grains after emergence. 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). For these reasons, there is a steady increase in the use of plant products as an easier and safer means of protecting small scale stored products against insect infestation. 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 introduction. 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, 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. The powders 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 before they were infested with two females and one male of **C. maculatus** in their respective containers. Thorough agitation of the mixture of the grains and plant powders was done for 3 minutes before infestation to obtain uniform spread. 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 hours post infestation (HPI).

**Fecundity and progeny emergence**

Powders of bitter leaves, cashew leaves, sweet orange peels and pawpaw leaves were separately mixed in three dosages of 2.5, 5.0 and 7.5% (w/w) per 20 g cowpea grains and gently shaken in their respective Petri dishes. The mixture was then infested with two couples of freshly emerged (teneral) adults of **C. maculatus** and allowed to settle on the laboratory desk after preparing three replications of each treatment including the control. Fecundity was calculated as the percentage of eggs laid in all treatments at 5 days post infestation (DPI). Progeny emergence was calculated as the percentage of adults that emerged in all treatments at 27 and 32 DPI.

**Grain damage**

The number of grains damaged per 100 grains 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 grain damaged using the formula:

\[
\text{Number of grains with holes} \times 100
\]
\[
\text{Total number of grains}
\]

**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**

**Adult mortality**

The mean percentage adult mortality of **C. maculatus** exposed to different dosages of plant powders is shown in Table 1. Mortality of the beetles ranged between 6.25-
Table 1. Evaluation of insecticidal potential of powders of plant parts against *Callosobruchus maculatus* in stored cowpea grains

<table>
<thead>
<tr>
<th>Plant powder</th>
<th>Dosage (%)</th>
<th>24 HPI</th>
<th>48 HPI</th>
<th>5 DPI</th>
<th>27 DPI</th>
<th>32 DPI</th>
<th>3 MPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bitter leaf</td>
<td>2.5</td>
<td>6.25c</td>
<td>9.30b</td>
<td>9.09b</td>
<td>0.0b</td>
<td>2.44b</td>
<td>5.7e</td>
</tr>
<tr>
<td></td>
<td>5.0</td>
<td>12.50ab</td>
<td>13.95ab</td>
<td>9.09b</td>
<td>0.0b</td>
<td>2.44b</td>
<td>5.3e</td>
</tr>
<tr>
<td></td>
<td>7.5</td>
<td>16.28a</td>
<td>18.75a</td>
<td>0.0c</td>
<td>0.0b</td>
<td>0.0b</td>
<td>5.3e</td>
</tr>
<tr>
<td>Cashew leaf</td>
<td>2.5</td>
<td>4.65d</td>
<td>6.25cd</td>
<td>9.09b</td>
<td>2.44b</td>
<td>9.30b</td>
<td>54.7b</td>
</tr>
<tr>
<td></td>
<td>5.0</td>
<td>4.65d</td>
<td>6.25cd</td>
<td>9.09b</td>
<td>2.44b</td>
<td>9.30b</td>
<td>53.3c</td>
</tr>
<tr>
<td></td>
<td>7.5</td>
<td>6.98cd</td>
<td>12.50b</td>
<td>0.0c</td>
<td>0.0b</td>
<td>0.0b</td>
<td>46.3c</td>
</tr>
<tr>
<td>Orange peel</td>
<td>2.5</td>
<td>6.25cd</td>
<td>6.98c</td>
<td>9.09b</td>
<td>2.44b</td>
<td>4.65b</td>
<td>11.0e</td>
</tr>
<tr>
<td></td>
<td>5.0</td>
<td>9.30b</td>
<td>9.30bc</td>
<td>9.09b</td>
<td>2.33b</td>
<td>2.44b</td>
<td>8.7e</td>
</tr>
<tr>
<td></td>
<td>7.5</td>
<td>12.50a</td>
<td>16.28a</td>
<td>0.0c</td>
<td>0.0b</td>
<td>0.0b</td>
<td>6.3e</td>
</tr>
<tr>
<td>Pawpaw leaf</td>
<td>2.5</td>
<td>0.0e</td>
<td>2.33d</td>
<td>9.09b</td>
<td>6.98b</td>
<td>7.31b</td>
<td>60.7b</td>
</tr>
<tr>
<td></td>
<td>5.0</td>
<td>0.0e</td>
<td>2.33d</td>
<td>9.09b</td>
<td>2.44b</td>
<td>4.65b</td>
<td>52.7c</td>
</tr>
<tr>
<td></td>
<td>7.5</td>
<td>4.65d</td>
<td>6.25cd</td>
<td>0.0c</td>
<td>0.0b</td>
<td>0.0b</td>
<td>44.7d</td>
</tr>
<tr>
<td>Control</td>
<td>0.0</td>
<td>0.0e</td>
<td>0.0d</td>
<td>27.28a</td>
<td>58.13a</td>
<td>73.17a</td>
<td>81.7a</td>
</tr>
</tbody>
</table>

HPI=Hours post infestation; DPI=Days post infestation; MPI=Months post infestation
Numbers followed by different letters in the same column are significantly different (p=0.05)

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 and orange peel powders was significantly different (p<0.05) in causing adult mortality at highest dosage compared with control which had no mortality. By 48 HPI, the 7.5% dosage of bitter leaf powder had caused 18.75% adult mortality which was not significantly different (p>0.05) from 16.28% recorded in orange peel powder. Results also 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. It was also observed that mortality increased with increase in dosage of plant powders and exposure regardless of the plant powder.

**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 treated and untreated grains by 1:3 respectively. Reduction rates in fecundity either reduced or inhibited progeny emergence of *C. maculatus* in the study. No progeny emergence was recorded in different dosages of bitter leaf powder. Emergence was significantly (p<0.05) reduced by 0.0-95.8% in cashew and orange peel powders, 0.0-88.0% in pawpaw leaf powder compared with control (58.1%) within 27 DPI. At 32 DPI, emergence was reduced by 0.0-96.7% in bitter leaf powder, 0.0-87.2% in cashew leaf powder, 0.0-93.6% in orange peel powder, 0.0-90.0% in pawpaw leaf powder and 73.2% in the control within 32 DPI. Highest progeny emergence of 6.98 and 7.31% recorded in the lowest dosage of pawpaw leaf powder were significantly lower than control within 27 and 32 DPI respectively. 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 grains damaged by *C. maculatus* in the treated and untreated grains. There was significant difference (p<0.05) in grain damaged 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 44.7-60.7% in grains treated with pawpaw leaf powder. All treatments were significantly different in grain damaged by *C. maculatus* compared to control. The least...
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.

DISCUSSION

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 regulatory approaches that would reduce food shortage. It was observed that higher dosage of plant powder treatment had more insecticidal action on the C. maculatus than lower dosage. In this study, bitter leaf and orange peel powders played observable role in suppressing bean beetle population in stored grains, although it was observed that packaging, winnowing, sorting, seed disinfestations carried out at the start of the experiment may have contributed to reduced damage. It was observed that mortality was dependent of dosage, type of plant powder and exposure period. The mortality in bitter leaf was dose and time dependent due to the presence of hydrocyanic acid and oxalic acid (Kabeh and Jalingo, 2007). Bitter leaf powder has insecticidal and feeding deterrent effects on C. maculatus on stored cowpea (Ibrahim and Aliyu, 2014). Bitter leaf powder was most effective in reducing beetle population, fecundity, progeny emergence and grain damage among different treatments applied. The insecticidal properties of pawpaw have been reported by Jewel (2008). Belmain and Stevenson, 2001 opined that plant powders are abrasive and sometimes adhere to grains depending on particle size. The use of these plants is acceptable to farmers because of general safety and ease of handling. Heaps of orange peels are sources of environmental pollution (Emeasor and Okorie, 2008) and converting them for use in crop protection would reduce pollution. 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 interfered with the developmental process of the insect by reducing the number of eggs laid and exerting ovicidal effects on the insect. In addition, more grain damage occurred in the lower dosages as a result of increased progeny emergence. This may be attributed to increased feeding and behavioural activities of C. maculatus. Fecundity and progeny emergence may have been affected by seed size, appearance and variety. The mechanical effects of large quantities of powders themselves could have an effect on oviposition (Rajapakse, 2006). An increase in progeny emergence apparently resulted in increase in percentage grain damaged.

Worldwide reports indicate that when mixed with stored grains, leaf, bark, seed powder, or oil extracts of plants reduce oviposition rate and suppress adult emergence of stored product insects, and also reduce seed damage rates (Bakkali et al., 2008; Tripathi et al., 2009). Most insects breathe through the trachea which usually leads to the opening of their spiracle. These spiracles might have been blocked by the powders and extracts thereby leading to suffocation (Komabonta and Falodu, 2013).

Conclusion and Recommendation

The study shows that bitter leaf powder was most effective in suppressing beetle population with subsequent reduction in cowpea grain damage. The insecticidal action of orange peel powder compared favourably with bitter leaf powder. The incorporation of the former will help reduce heaps of waste capable of causing environmental pollution. These crops are indigenous to Nigeria, easy to apply, affordable and produce no detrimental effects on the health of the user. They will therefore form a sustainable alternative to imported and hazardous synthetic insecticides. Efforts are being made to evaluate the synergistic effects of these plant powders in protecting stored products against insect pests.

REFERENCES


