The Efficacy of *Alchornea cordifolia* Leaf Powder on Cowpea Beetle, *Callosobruchus maculatus* (Coleoptera: Bruchidae) as Oviposition and Egg Hatching Deterrent

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The efficacy of *Alchornea cordifolia* leaf powder was investigated against cowpea beetle, *Callosobruchus maculatus* on stored cowpea in the laboratory. The tested leaf powder was added as admixtures to 20 g of cowpea grains at the following rates of at 0 (control), 3, 4, and 5 g % (w/w) while in the control treatment there was no plant material added. Each of the treatments was tested by exposing five pairs of adult beetles in a Completely Randomized Design (CRD) to assess oviposition deterrent and egg hatching suppression by the plant material. The results showed that oviposition and percentage egg hatched were significantly (P <0.05) suppressed on seeds treated with higher dosage level of the powder. Leaf powder with the concentration of 5g% (w/w)/20g cowpea seeds was most effective in suppressing oviposition and egg hatched. Thus, the result revealed that *A. cordifolia* leaf powder has oviposition deterrent and ovicidal properties and as such can be used as an alternative to synthetic insecticides for controlling *C. maculatus* infestation on stored cowpea grains. Therefore *A. cordifolia* leaf powder can be incorporated into traditional storage pest management as well as integrated pest management and it may strongly recommended in developing countries.

**Keywords:** *Alchornea cordifolia, Callosobruchus maculatus,* egg hatching, oviposition deterrent, suppression

**INTRODUCTION**

Cowpea, (*Vigna unguiculata* (L) Walpers, Fabaceae), is an important edible legume crop in many parts of the world especially in tropical and subtropical regions. It is used as human food and animal feed due to its high protein content (Diouf, 2011). It is an annual herbaceous legume with trifoliate leaves. It is a drought tolerant and short warm weather crop well adapted to the drier regions where other food legumes do not growing well (Singh, 1987). Cowpea production is affected by insect pests and disease infestations which lead to economic losses. Notably among the many insects that attack this crop is Cowpea beetle, *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae) (Bamphitthi, 2015). The cowpea beetle, is a cosmopolitan field-to-store pest ranked as the principal post-harvest pest of cowpea in the tropics (Caswel, 1981). It causes substantial quantitative and qualitative losses manifested by seed perforation and reductions in weight, market value and germination ability of seeds (Obeng-Ofori et al., 1997).

Efforts to develop insecticide-based techniques for protecting grains in small traditional farm stores have only been partially successful because of problems such as high cost of synthetic insecticides and erratic supply due to foreign exchange constraints (Obeng-Ofori et al., 1997). Furthermore, the overuse of synthetic chemicals have led to serious problems, including development of insect resistant strains to insecticides, toxic residues on stored grains, health hazards to grain handlers, food poisoning, environmental pollution (Zettler and Coperus, 1990; White, 1995). These problems have stimulated research into plants with insecticidal properties grown locally that are readily available, effective, affordable, less poisonous and less detrimental to the environment (Tierto, 1994).
plants that are rich sources of compounds, have insecticidal properties (Obeng-Ofori et al., 1997), like Zanthoxylum xanthoxyloides (Udo, 2000) have been successfully used to control insect pests. Alchornea cordifolia is an important medicinal plant in African traditional medicine and much pharmacological research has been carried out into its antibacterial, antifungal and antiprotozoal properties, as well as its anti-inflammatory activities, with significant positive results (Agbor et al., 2004). In recent years, several authors revealed that the leaves, bark and roots of this plant was effective in controlling the stored products insect pests through contact toxicity and repellency activities (Koomson and Oppong (2018) and Koomson et al., (2018)). The present study, therefore, was undertaken to evaluate the efficacy of the leaf powder of A. cordifolia as a suppressant of egg hatchability and oviposition deterrent against C. maculatus in stored cowpea.

MATERIALS AND METHODS

The research was carried out at the Integrated Science Education Department laboratory of the University of Education, Winneba, Central Region, Ghana, at a temperature of 30 ± 2°C and 75 ±5% relative humidity.

Insect Culture

Initial C. maculatus stock used for the experiment was obtained from cowpea seeds that were bought from the Mandela market at Agona Swedru in the Central Region of Ghana. The cowpea grains were putted in different jars covered with net and adult C. maculatus were introduced into the jars. The jars were kept at room temperature in the Integrated Science Education Department laboratory of the University of Education, Winneba for the insects to breed and multiply under favourable laboratory conditions (temperature of 30±2°C, and relative humidity of 70±5%). The moisture content of cowpea grain was adjusted to 12 to 13% (Shiberu and Negeri, 2014). After three weeks of oviposition, the parent beetles were sieved out after oviposition to produce a steady and sufficient supply of beetles of known age for experimental purpose (Adesina, 2012). Later the grains with jars were kept in the laboratory for adult emergence while the emerging generation of same age insects re-cultured at temperature of 30 ± 2°C, and relative humidity of 70 ±5%. The F1 generation was used for the experiment.

Collection and preparation of A. cordifolia plants

A. cordifolia plants were collected from the Gomoa Otapirow area of the Central Region of Ghana. Leaves were separated from the plant, rinsed in clean water to remove sand and other impurities, air dried at room temperature in the laboratory for 15 days, after which, ground into very fine powder using an electric blender. The powders were further sieved to pass through 1mm² perforations. The powders were packed in plastic containers with tight lids to ensure that the active ingredients are not lost and stored it in the laboratory prior to use.

Source of cowpea substrate

The un-infested cowpea (local variety) seeds were used in the experiment, were procured from the Mandela market at Agona Swedru in the Central Region of Ghana. The seeds were properly sieved and handpicked, thus ensuring that the only whole and uninfested seeds were used (Olotuah et al., 2007; Adesina, 2012). The clean seeds showed no visible signs of beetle eggs, presence of adults or exit holes. Besides, the seeds were sterilized in an oven at 50°C for 4 hours to kill any immature stage of insect (if any) and allowed to cool for 1 hour before use (Idoko and Adesina, 2013). Twenty gram each of the un-infested cowpea seeds were weiged separately for experiment and kept at room temperature. The experiment was carried out in triplicate for each treatment.

Effect of Leaf Powder on Oviposition and Fecundity of C. maculatus

The experiment was laid out in Randomized Compete Block Design (RCBD) with three replications. Five (5) paired sexed adult insects of 1-2 days old C. maculatus were introduced into the a clean sterilized 250ml plastic containers containing 20g of uninfected sterilized cowpea seeds at 0, 3, 4, and 5g% (w/w) of A. cordifolia leaf powder, while in the control treatment there was no plant material added. The A. cordifolia leaf powder was weighed and added to the cowpea grains in each jar and shaken well for uniform coating. The sex of C. maculatus was determined by the pattern of Iloba and Ektrakene (2006). The jars were covered with muslin cloth and secured with rubber bands as a ventilated lid. The number of eggs laid by the female beetles on the seed coat was recorded on the 14th day after the introduction of beetles to seeds; this was used to calculate the percentage of egg hatching according to Abdullahi et al. (2011) and the percentage reduction of egg laying (Emman and Abass, 2010), as follows:

\[
\text{Percentage reduction of eggs laid} = \frac{\text{no. of eggs laid in control} - \text{no. of eggs on treated grains}}{\text{no. of eggs laid in control}} \times 100
\]

\[
\text{Egg hatching (\%)} = \frac{\text{no. of eggs hatched in each container}}{\text{no. of eggs in each container}} \times 100
\]

Statistical Analysis

Percentage data were transformed to square root of arcsine to normalize the data before analysis. Data from the 3 replicates of the experiment were pooled together and subjected to one way Analysis of Variances (ANOVA). Treatment means were separated using Least Significant Differences (LSD) at 5% probability level (Gomez and Gomez 1994).
RESULTS

Effect of A. chordifolia leaf powder on oviposition and fecundity of C. maculatus

The effect of A. chordifolia leaf powder on oviposition is summarized in Table 1. The results showed that the powders at all application levels significantly inhibited the female C. maculatus from laying eggs on treated cowpea seeds. The laying capacity gradually decreased with the increase in the treatment dose of each powder. The highest reduction in egg laying was observed with the 5g powder treatment of 63.23% whereas 21.53% was recorded in control. Statistically, there was a significant difference between the tested concentrations compared to control.

Table 1. Mean percentage reduction in number of eggs laid by female C. maculatus

<table>
<thead>
<tr>
<th>Treatment 20g/ cowpea</th>
<th>Percentage reduction in eggs laid</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>21.53 ± 2.3 d</td>
</tr>
<tr>
<td>3g</td>
<td>48.63 ± 2.1 c</td>
</tr>
<tr>
<td>4g</td>
<td>53.75 ± 0.5 b</td>
</tr>
<tr>
<td>5g</td>
<td>63.23 ± 1.7a</td>
</tr>
<tr>
<td>LSD</td>
<td>8.41</td>
</tr>
</tbody>
</table>

Effect of A. chordifolia leaf powder on Egg Hatching

The effect of A. chordifolia leaf powder on the egg hatching capability of C. maculatus revealed that there was a significant reduction in egg hatching. As the treatment dose increases, the egg hatching capacity decreases. The 5g concentration gave the maximum reduction of 4.93% as against 49.27% hatched eggs in control (Table 2). Statistically, there was a significant difference between the tested concentrations compared to control.

Table 2. Mean percentage of egg hatching of C. maculatus from treated cowpea seeds

<table>
<thead>
<tr>
<th>Treatment 20g/ cowpea</th>
<th>Percentage egg hatching</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>49.27 ± 0.1 a</td>
</tr>
<tr>
<td>3g</td>
<td>17.21 ± 2.5 b</td>
</tr>
<tr>
<td>4g</td>
<td>10.39 ± 0.4 b</td>
</tr>
<tr>
<td>5g</td>
<td>4.93 ± 2.0 c</td>
</tr>
<tr>
<td>LSD</td>
<td>7.84</td>
</tr>
</tbody>
</table>

It could be deduced that the complete inhibition in adult emergence of C. maculatus by A. chordifolia leaf powder might be due to total mortality observed at early days after treatment. This resulted in inability of the insects to mate, which deterred oviposition and hence, inhibited emergence (Adesina and Ofuya, 2015). It is also reported that the leaf powder might be toxic to the few eggs deposited and as such led to reduced number of emergence in grains treated with the powder concurring with (Chudasama et al., 2015) that toxic substances present in the leaf powder may enter into the egg through chorion and suppressed further embryonic development. Further, Ojo and Ogungyele, (2013) concluded that the non-emergence of F1 generation of insects treated with some botanical powders could be as a result of high mortality of adult insects, thus disrupting mating and sexual communication as well as deterring females from laying eggs and complete suppression of the developmental stages of insects. Results have shown that there was positive correlation between egg deposition and adult emergence. This was clearly observed in untreated grains where significant oviposition and adult emergence were recorded. The outcome is corroborative with what has already been previously reported (Iloba and Ekrakene, 2006). The egg mortality and the failure to hatch on seeds, treated with the powder, were probably attributed to the toxic component of the powder and also to the physical properties, which caused changes in the surface tension and the oxygen tension within the eggs (Adesina and Ofuya, 2015). The ovicidal effect of the leaf powder on the bruchid may also be explained in terms of asphyxiation by blocking the major route of gas exchange between a thin area of the chorion and outside (Credland 1992), which ultimately reduced the emergence of the insects from the treated seed (Copping and Menn, 2000). Results from this study equally suggest that the plant material might interfere with the normal embryonic development by suppressing hormonal and biochemical processes. A similar physiological inference was observed by Ofuya et al., (1992). Studies on the effect of plant on the egg hatching of pulse beetle are available. However, Adesina...
and Ofuya, (2015) found a significant effect on reduced egg hatchability of *C. maculatus* when laid on seeds treated with plant extracts and powder, respectively, at different doses, which is in accordance with the present study. This finding suggests that the *A. chordifolia* leaf powder successfully inhibit egg hatching into the seed and ultimately suppress the F1 progeny emergence. The present study clearly indicates that *A. chordifolia* leaf powder possess anti-oviposition and ovicidal activities that can be employed in the management of *C. maculatus* infestation on stored cowpea. Further studies are needed to explore the metabolic target of the plant in the body of the insect.

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