Performance of Basil Powder as Insecticide against Maize Weevil, *Sitophilus Zeamais* (Coleoptera: Curculionidae)

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Abstract

*Sitophilus zeamais* Motschulsky continue to cause considerable damage to maize grain in most stores in Africa. A study was carried out to determine effectiveness of *Ocimum basilicum* plant part powders of leaf, bark and combined effect of the two (1:1). The results indicated that basil leaf powder repelled *S. zeamais* the furthest distance (6.6cm) in comparison of bark (4.2cm) and admix of the two (5.5cm) within the first 2-hour exposure period. Prolonging exposure duration to 96 hours led to reduction of repelence distance to 3.2cm for basil leaf and 2.0 and 2.6cm for leaf and the admix (1:1) of the two respectively. Basil plant effective powder lethal dose (LD₉₀) for leaf, bark and the admix (1:1) was achieved in 1.84, 1.83 and 2.25g powder amounts respectively. Plant powder shelf-life was determined to be a maximum of 2-weeks causing 40≥80% mortality of *S. zeamais*. These findings show that basil powders are only for a short duration as protectants against *S. zeamais*.

Key words: repellence, *Sitophilus zeamais*, exposure, lethal dose, *Ocimum basilicum*.

INTRODUCTION

Maize (*Zea mays L.*) is an important staple cereal crop for most people in sub-Saharan Africa (Nukenine et al, 2002). Besides being a major source of food for both human and animals World wide, it is also processed into various industrial products such as fuel ethanol and starches (Ogunsina et al., 2011). It is a major commodity in most farm product marketing channels and is relatively easily processed into several products such as cooking oil, flour, and maize germ, bran and breakfast cereals. In dairy industry, maize is an intermediary product as a constituent of animal feed formulation in Kenya (Nukenine et al. 2002; Kenya Maize Hand Book, 2007).

The maize weevil *Sitophilus zeamais* Motschulsky (Coleoptera: Curculionidae) and the larger grain borer (*Prostephanus truncatus*) cause considerable economic losses to smallholder farmers in Africa (Raj et al. 2001; Nukenine et al. 2002). In most of Africa, the greater proportion of maize is produced by resource poor farmers in remote villages with poor road networks and post- harvest storage facilities which often make them incur high post harvest losses (Ntonifor and Monah, 2001). Grain loss in Africa due to insect pests’ damage in storage systems is estimated at 20 to 30 % (Iman, 2006). Worldwide, *S. zeamais* cause more than 20% grain loss for untreated maize (Nukenine et al. 2002). Infestation by *S. zeamais* starts with the female laying eggs into the grain which on hatching the larvae feeds towards the inside of the grain until pupal stage is reached (Tadesse and Basedow, 2005). The adults emerge by eating their way towards the testa causing rugged exit holes resulting in an insect damaged grain (Arthur and Throne, 2003). While satisfactory pest control has been obtained by use of synthetic pesticides their adverse effects on environment and development of resistant weevil strains and residues in food crops have motivated the search for safer alternative methods. Inert dusts such as diatomaceous earth (Nikpay, 2006), ash and plant powders (Idoko and Adebayo, 2011; Tadesse and Basedow, 2005) are such products that fill this void. Kenya normally has a deficit in maize, which is filled by informal cross-border trade from Uganda and Tanzania; however, the present deficit is so large (estimated at 400,000 to 700,000 MT) that imports from the international market have been required (Kenya Maize Handbook, 2007).

The present study aimed to determine the effectiveness of leaf, bark and mixture of leaf and bark powders of *Ocimum basilicum* L. against the *Sitophilus zeamais* in stored maize grain and compare different amounts/volume of *Ocimum basilicum* plant parts in control of *Sitophilus zeamais* in stored maize. Further, it was found necessary to compare the performance of *Ocimum basilicum* to standard chemical insecticides.
MATERIALS AND METHODS

Collection of plant parts

Basil plant material for the experiment was collected from the county of Makueni at Kalawa location where it grows naturally in the less densely populated dry land vegetation. Farmers reported that they already knew of its insecticidal properties against storage pests. Three 90kg bags of up rooted basil plants were transported to KARI-Katumani Entomology Laboratory for processing into powders. The plants were separated of leaves and bark then sun dried for a week in khaki paper bags to avoid direct sun rays. The plant bark and leaf derivatives were pulverised using electric hummer-mill to fine powder and kept at room conditions for study of shelf life durations of 0, 7, 14, 21 and 28 days. Some 50g were kept in cool fridge to avoid degrading of the material by slowing escape of plant powder volatiles for subsequent use. Some 10kg maize invested with at least 1000 *Sitophilus zeamais* Motschulsky were purchased from the surrounding market centres for rearing in KARI Katumani entomology laboratory. The evaluation experiments were repeatedly carried out one month later.

Weevil repellence test

Some 13cm clear-plastic tube was cocked one side with clean cotton while the other treatment side had the test powder dusted on the cotton fibre. Weevil repellence was carried out by introducing freshly emerged 10 adults at the centre (0.0cm) and let to move in any direction of their choice with scoring of distance moved measured in cm with a ruler. The score time was 2, 5, 24, 48 and 96 hrs. Each of the experimental treatment was replicated three times and repeated to stabilize the results.

Determination of shelf-life

Basil leaf and bark powder was subjected to study of shelf life. Four replicates of 1 gram of each derivative powder was put in 3cm-diameter x 2cm height containers with 10 maize grains (5 KCB and 5 KH 50033A). Twenty freshly emerged weevils were introduced in each container and kept in the temperature-humid controlled room (26 ± 2 °C temperature, 60 + 3 % RH). Result scores were taken seven days on mortality of beetles. The study treatments were 0, 7, 14, 21 and 28 days of powder prepared material, to test what level of mortality on *S. zeamais* would be achieved if kept that long by farmers at room conditions. The procedure was repeated to stabilize the results.

Bioassay tests of *S. zeamais*

Twenty freshly emerged *S. zeamais* beetles were exposed to 0, 0.5, 1.5 and 2.0g of basil powder of leaves and bark. The leaves and bark were dried in the sun in khaki papers for two days before grinding them to fine powder for application on 100g of maize grain varieties KH 500 33A and KCB in ½-litre plastic jars.

Basil performance as insecticide

Twenty freshly two day old emerged beetles were introduced on 100g maize jar of 6cm-diameter x 8cm height, of leaf, bark and admix of the two of 2.0 g. The jars were placed in plastic rack and kept in temperature-humid controlled room. After 7 days some 30 sample maize separated from the 100g grain but kept in the smaller contains mentioned above, for new weevil emergence. Scores for percentage mortality on the treatments, number of larvae infested grains and finally total development period (days) of F1 generation was taken for comparison. One week later live beetle weight of the F1 generation and grain weight was calculated by subtracting present weight (g) from the original undamaged seed weight taken for comparison.

Data analyses

For repellence test mean distance (cm) values of beetle movement away from the tube centre (0cm) measured with a ruler data were subjected to analysis of variance (ANOVA) at 0.05 % significant level using SAS version V8. A post hoc
analysis was done using Duncan’s Multiple Range Test (DMRT). Mean values of percentage (%) mortality, total development period and grain percentage weight loss were compared. Where data values included zero entries log transformation (X+1) was carried out before analysis. Regression and correlation analyses were carried out find out correlation levels.

RESULTS

Basil powder weevil repellence

The ten freshly emerged weevils were observed after 2, 5, 24, 48 and 96 hours for the repellence test and the results are presented in Table 1. There was significant (P<0.001) difference of distant repellency of beetles after 2, 5, 48 and 96-hour durations across the different basil plant parts studied. *S. zeamais* was repelled most (6.6 ± 0.6cm) by Basil leaf powder within the first 2-hour exposure duration. In the same exposure duration Bark + Leaf admix (1:1) was second with 5.5 (± 0.7) cm beetle distance of repellence. At exposure duration of 5-hours Bark +Leaf powder led with longest distance of beetle repellency of 6.3cm which was not significantly different from repellence distance of 6.1cm of Leaf powder alone. The same Basil leaf powder led in the 48-hour exposure duration of 6.3 (± 1.0 cm). Actellic super dust though with total (100 %) beetle mortality exposed in the tubes had <4.0cm repellency distance in all the exposure durations. Admix of Bark + Leaf (1:1) did better than Bark powder alone.

Relationship of distance of beetle repellence and duration (hrs) was only significant (P<0.05) on the Leaf basil powder ($R^2 =0.801$). Conversely, the repellence distance of the beetles was scored as 6.6 cm within the first 2 hrs but gradually reduced to 3.2 cm by the 96th hr.

Plant powder lethal amount

The Basil bark, leaf and mixtures (1:1) subjected to bioassay tests of the freshly emerged *S. zeamais* for 0, 0.5, 1.0, 1.5 and 2.0 g concentrates amounts of powders were as indicated in Table 2. The leaf powder caused a mortality of 90 % and a bark caused a mortality of 77 % after applying 2.0 g in 100g of maize grain. There was no significant (P>0.05) difference for 1.0 and 1.5 g for bark, leaf and the admixture (1:1) of the two, where mortality was between 70-90 %.

Effective LD$_{99}$

Regression (probit) analysis showed that both leaf and bark had insecticidal potential against *S. zeamais* storage pest (Table 3). As shown in Table 3, each basil plant derivative had different powder effective LD$_{99}$ (leaf bark and admix of the two) for achieving 100 % beetle mortality carried out for seven days.

Powder shelf-life

It was observed that basil plant powders weakened with increasing storage time in days from the day of preparation (Figure 1). Least mortality (%) of beetles was realized when the basil powders stayed for 28 days. Basil leaf powder demonstrated the least decrease in efficacy against weevils causing mortality of 95, 85, 46 and 20 % after 0, 7, 14, 21 and 28 days of storage respectively. The efficacy of the basil bark powder deteriorated the fastest leading to 80, 77, 44, 20 and 15 % mortality over 0, 7, 14, 21 and 28 days of storage.

DISCUSSION

The repellence test demonstrated that the basil leaf had the highest fumigant effect which drove the beetles the longest distant. The combined leaf and bark powders indicated a less lethal effect on the efficacy of the botanical product of two plant parts. Bekele et al (1996) found that to determine period of repellence of basil exposure duration reflected fumigant effect to the weevil. The duration in the present showed the powders were only effective when freshly extracted (Bekele et al. 1996; Bekele 2002). From the present study it was observed by the third week the beetle mortality dropped to 20%. For the beetle juvenile development, the method developed by Frankenfeld (1948) on the determination of the deposited egg on maize grains by dipping in acid fuchsin to stain beetle egg plug was not employed in this study to determine fecundity because the grains were treated with powders, which might be lost during the staining process and
Table 1. *Sitophilus zeamais* beetle repellence by different basil plant part powders over time

<table>
<thead>
<tr>
<th>Insecticide</th>
<th>Exposure duration in hours</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Basil Bark</td>
<td>4.2 ± 1.8a^A</td>
</tr>
<tr>
<td>Basil Leaf</td>
<td>6.6 ± 0.6b^A</td>
</tr>
<tr>
<td>Bark + Leaf</td>
<td>5.5 ± 0.7b^A</td>
</tr>
<tr>
<td>Actellic dust</td>
<td>2.1 ± 0.9c^A</td>
</tr>
<tr>
<td>Control</td>
<td>2.9 ± 1.1c^A</td>
</tr>
</tbody>
</table>

Different lower case letters within treatment columns denote significance (P<0.001) of beetle movement repelled by powders while similar upper cases indicate insignificant (P>0.05) across time periods.

Table 2. Determination of effective powder amount lethal dose (g)

<table>
<thead>
<tr>
<th>Ocimum basilicum amount (g)</th>
<th>Percentage (%) ± Standard Error (SE) of <em>S. zeamais</em> mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bark</td>
</tr>
<tr>
<td>0.0</td>
<td>7.3 ± 1.2a</td>
</tr>
<tr>
<td>0.5</td>
<td>17.3 ± 1.1a</td>
</tr>
<tr>
<td>1.0</td>
<td>70.0 ± 2.6b</td>
</tr>
<tr>
<td>1.5</td>
<td>70.0 ± 8.9b</td>
</tr>
<tr>
<td>2.0</td>
<td>77.0 ± 2.5b</td>
</tr>
</tbody>
</table>

Different amounts (g) applied on *S. zeamais* weevil in 26 ± 2 °C temperature, 60 ± 3 % RH Column means with different letters are significantly different (P<0.001) at 1 % level (DMRT).

Table 3. *Sitophilus zeamais* beetle mortality (%) to lethal doses; (LD$_{50}$ and LD$_{99}$)

<table>
<thead>
<tr>
<th>Basil powder derivative</th>
<th>Probit analyses: Lower and Upper Limits (at 95 % Confidence)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Probit</td>
</tr>
<tr>
<td>Bark</td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td>0.99</td>
</tr>
<tr>
<td>Leaf</td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td>0.99</td>
</tr>
<tr>
<td>Bark + Leaf</td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td>0.99</td>
</tr>
</tbody>
</table>

In all derivative powders concentrations, 2.0g indicated promising results for 100 % beetle mortality.

probably affect the result of the experiment. Therefore, a larval tunnel was used as an indication for oviposited egg since a tunnel only form inside the grain when the deposited egg hatches even in the presence of insecticide. The absence of larval tunnel means no egg deposition, therefore, anti-oviposition action of the test materials is assumed. The varied insect survival was also recorded in all treatments except for grains treated with Actellic super dust having no insect survival. The introduced adult maize weevils were not able to lay their eggs on the maize grains because a week after insecticide introduction. The weevil growth on the maize grain both on treated and untreated maize grains except for Actellic-treated grains indicated the less efficacious property of basil in comparison to a synthetic insecticide like Actellic dust. This meant that the powdered test plant derivatives did not affect the growth and development of maize weevil inside the grain (Adedire and Ajayi 1996; Busungu and Mushobozy 1991).

Based on the result of the study, powdered weight/volume amounts of the test plants might not be effective in inhibiting larval growth probably due to the low active ingredient of the plants with insecticidal characteristics could not penetrate well inside the grains, thus, did not affect the development of the weevil (Adedire 2001; Bhaduri et al.1985).
Ukeh et al (2010) cited that maize weevil is an internal feeder. Thus, the different life stages developed successfully inside the grain (Walgenbach and Burkholder, 1986; Akob and Ewete 2007). The growth and development of the weevils from the untreated corn grains and those insects from grains treated with powdered test plants had similar number of days of weevil development therefore it could be assumed that the test powders and volatiles did not affect the insect development. The body weight of the insects from both treated and untreated maize grains did not show significant differences among treatments. Thus, *O. basilicum* like *O. suave* plant powders have volatiles of fumigant effect lethal to *S. zeamais* (Keita et al, 2000; Schmuttere, 1990). It was observed that The F1 generation which survived the potent toxins of basil started increasing exponentially from second month causing >20 % maize grain weight loss on the two varieties. The shelf life study showed that basil derivatives efficacy as maize grain protectant was temporary within the first 1-2 months after grain harvest.

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