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Effect of selected pesticidal plants leaf powder on *Callosobrunchus maculatus* in stored cowpea (*Vigna unguiculata* (L.) Walp

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Abstract

Among the major insect storage pests of cowpea are cowpea weevils (*Callosobruchus maculatus*) which is a big threat causing huge postharvest loss. This study used double bagging experiment to test the pesticidal activity of plants leaf powders of *Ocimum suave, Hyptis suaveolens* and *Dysphania ambrosioides* on *Callosobrunchus maculatus* in stored cowpea. The experiment was arranged in Randomized Block Design (RBD) with 3 replications. The plant powders were applied at the rates of 30, 60 and 90 g 1.5 kg^{-1} of cowpea seeds spread on the surface of the inner cotton bag of 2 kg filled with 1.5 kg of cowpea seeds. The storage time was three months consecutive. The effectiveness was compared with the synthetic pesticide Actelic® dust (2 g) as the positive control and untreated cowpea seeds as a negative control. Based on the results, all pesticidal leaf powder showed a different level of pesticidal activities at the tested rates. Higher dosages of plant leaf powders at 60 and 90 g for *H. suaveolens* and *D. ambrosioides* and 90 g for *O. suave* significantly ($P < 0.001$) affected insects' mortality, survivorship and reduced seed damage. Comparatively, *H. suaveolens* and *D. ambrosioides* at 90 g were more effective in inhibiting egg deposition by *C. maculatus* just as successful as the positive control. Therefore, this study demonstrates that, *O. suave*, *H. suaveolens* and *D. ambrosioides* leaf powder can effectively offer protection in stored cowpea seeds against *C. maculatus* when applied at high dosages.

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Introduction

Cowpea, *Vigna unguiculata* (L.) Walp, is a widely grown legume that belongs to the family Leguminosae, subfamily Papilionaceae (Mkenda *et al.*, 2015). It is an important grain legume grown in most parts of Eastern and Western Africa but also in Brazil and India (Ileke *et al.*, 2012). In Tanzania it is cultivated in semiarid areas like Shinyanga, Mtwara and Kigoma due to its ability to tolerate moisture stress (Mkenda *et al.*, 2015). Nutritionally, cowpea has high protein content of about 23 to 25 %, thus forming a cheap alternative source of dietary protein particularly for low income people who are unable to afford the cost of animal proteins foods (Brisibe *et al.*, 2011; Ileke and Olotuah, 2012). This helps in minimizing the risk of malnutrition to young children. In addition, cowpea contain high iron content with low fat content where the young green leaves are consumed as vegetables, thus providing additional nutrients including vitamins to consumers (Adedire *et al.*, 2011). This crop is usually grown as monocrop or intercropped with other cereal crops (Myaka *et al.*, 2002). Being a leguminous plant, it fixes nitrogen and thus, adds up soil fertility where it is grown (Brisibe *et al.*, 2011).

Cowpea production is constrained by high infestation of insect pest at storage which cause yearly economic loss of several billion dollars worldwide (Odeyemi *et al.*, 2006). In Africa, loss due to storage insect pests goes up to 80 % yearly, contributing to food insecurity and low-income generation to farmers (Brisibe *et al.*, 2011; Ileke and Olotuah, 2012). C. *maculatus* has been mention by several scholars as an important storage pest of cowpea (Adedire *et al.*, 2011, Mkenda *et al.*, 2015; Odeyemi *et al.*, 2006). Infestation of cowpea seeds primarily happens in the field where insects are then carried into store and multiplication continues very rapidly (Adedire *et al.*, 2011).

For many years, chemical control has been the employed method in the management of cowpea weevils (Odeyemi, 2006; Ileke *et al.*, 2013; Mkenda *et al.*, 2015;). Although chemical control seems to be effective in controlling *C. maculatus*, the negative impacts associated with the use of chemicals are eminent such as pest's resistance development, increased food toxicity, ecological consequences and sometimes lethal effects to non-target organisms have raised a concern to consumers and even researchers (Odeyemi, 2006; Ileke *et al.*, 2013). In addition, even the conventional fumigation technology used in the developed countries, is currently being inspected for a number of reasons such as ozone destruction potential of methyl bromide and carcinogenic concerns with phosphine (Adedire, 2011). All these have resulted into a call for new methods to control stored products insect pests that are readily available, affordable and even harmless to human health and the environment. In response to this, locally available plants with pesticidal properties can be used as an alternative to synthetic pesticide in the storage of cowpea. Therefore, this study aimed at evaluating the effect of pesticidal leaf powders derived from three known pesticidal plants *Ocimum suave*, *Hyptis suaveolens* and *Dysphania ambrosioides* on cowpea weevils (*Callosobruchus maculatus*).

Materials and methods

Experimental site

The experiment was carried out in a special storage room designed at Nelson Mandela African Institution of Science and Technology (NM-AIST), Arusha-Tanzania**.** The room was well ventilated with enough air circulation inside.

Insects

The Adult cowpea weevil (*C. maculatus*) used to establish a colony were obtained from highly infested cowpea grains bought from the local market in Moshi Tanzania. Insects were identified with a University Entomologist in the laboratory of Life Sciences and Engineering Department at the NM-AIST, Arusha, Tanzania. Rearing of cowpea weevil was done in ventilated 10 L plastic containers half filled with 5 kg of uninfected cowpea seeds, covered on top with 10 mm mesh sieve to allow free air movement while restricting weevils from escaping. Rearing was carried out at room temperature 25±3 °C and relative humidity (RH) 75±5 %. Adult weevils were kept for

20 days to allow their multiplication, after which they were harvested and used in the experiment.

Insecticidal plant materials

Plant materials used in this study were *Ocimum suave, Hyptis suaveolens* and *Dysphania ambrosioides*. *O. suave and H. suaveolens* were handpicked from farms at Kibosho village where as *D. ambrosioides* was collected at Lyamungo village both in Moshi Tanzania. These plant species were selected for this trial because they are traditionally used by farmers in the local areas as medicines and their readily available in the northern Tanzania (where this research was conducted). Matured plants leaves were dried under shed to reduce photolysis of bioactive compounds and then ground into a fine powder by using an electric mill, then packed into a plastic container with airtight lid to maintain the aroma and stored in the dark at ambient conditions of 25±3 °C and 75±5 % RH.

Cowpea seeds

Cowpea seeds used for this experiment were newly harvested by farmers from Tunduru District, in Mtwara –Tanzania. The seeds were free from insecticides. They were cleaned thoroughly by winnowing and mechanical sorting to remove infested and damaged grains. The clean seeds were sterilized by placing them into a freezer at 7 °C for 24 hours, then heated in an oven at 60 °C for 24 hours to kill any larvae and adult cowpea weevils that might remain in the process of cleaning.

Testing the Effect of Leaf Powder to C. maculatus

The dosages were set at different rates (0 g-negative control, 30 g, 60 g and 90 g 1.5 kg^{-1} of cowpea seeds) for each of the insecticidal plant powder used, so as to obtain the effective dose. To test the effect of leaf powder, 1.5 kg of healthy, fresh, clean, and unbroken cowpea grains were loaded into 2 kg sisal storage bags. Each bag with cowpea seeds was placed inside another bag of the same volume and the leaf powder of *O. suave*, *H. suaveolens* and *D. ambrosioides* at different rates (30, 60 and 90 g) were then spread on the outer surface of the inner bags (Double bagging experiment).

Three treatments (*O. suave*, *H. suaveolens* and *D. ambrosioides*) leaf powder at rates 30, 60 and 90 g 1.5 kg^{-1} cowpea seeds plus the positive and negative control were arranged in Randomized Complete Block Design (RCBD) in 3 replicates. Experimental bags in each treatment (including the negative control) were arranged to surround a single plastic container containing heavily infested cowpea seeds left opened to allow movement of weevils to the surroundings.

Data collection

A subsample of 1000 cowpea seeds was drawn out from each bag for insect pest's assessment. Counting of *C. maculatus* (live and dead) seeds with eggs on the surface, damaged seeds (seeds with holes and/or larval inside) was done after every 21 days. After assessment everything were taken back into the respective bag and the bags were sealed. The experiment ran for three consecutive months.

Analysis of data

Data collected were subjected STATISTICA (data analysis software system Version 8.0). to test for treatment effects over the study period. One-way analysis of variance (ANOVA) was used to analyze the collected data and Fishers Least Significant Difference (LSD) test was used to compare treatment means at 5 % confidence interval (P = 0.05).

Results

Effect of Pesticidal Leaf Powders on Live Adult *C. maculatus*

The application of plant leaf powders at rates of 30, 60 and 90 g 1.5 kg^{-1} of cowpea seeds, showed varied pesticidal effects on the survival of adult *C. maculatus* and their differences were statistically significant ($P \leq 0.001$) (Table1). The highest mean number of live *C. maculatus* were recorded in the bags with negative control all over 12 weeks of insect pest's assessment. For the first three weeks all tested plants leaf powder at the rates of 30, 60 and 90 g 1.5 kg^{-1} of cowpea seeds effectively inhibited adult *C. maculatus* emergence similar to the positive control (Actelic® dust) However, from 6 to 12 weeks, the effects were dose dependent whereby increased rate of leaf powder consequently increased pesticidal effect against *C. maculatus* on stored cowpea. *O. suave* at 90 g and *H. suaveolens* and *D. ambrosioides*, at 60 and 90 g significantly ($P \leq 0.001$) inhibited the emergence of adult *C. maculatus* when compared with their respective lower rates.

Table 1. Mean number of live *C. maculatus* in stored cowpea treated with three pesticidal leaf powder.

Treatments	Rates (g) 1.5 kg^{-1}	3weeks	6weeks	9weeks	12weeks
Control (-ve)	0	8.00±1.53a	10.67±1.20a	12.67±0.88a	85.67±5.21a
O. suave	30	0.33±0.33b	5.00±1.53b	6.00±0.58bc	26.33±4.91b
O. suave	60	0.33±033b	5.00±0.58b	5.00±0.58c	17.67±1.86b
O. suave	90	0.33±0.33b	1. 00±0.58c	0.67±0.67d	3.00±0.58c
H. suaveolens	30	1.67±0.33b	6.33±0.88b	7.33±0.88b	20.33±1.45b
H. suaveolens	60	0.00±0.00b	0.67±0.33c	0.67±0.33d	1.00±0.58c
H. suaveolens	90	0.67±0.67b	0.33±0.33c	0.33±0.33d	0.67±0.33c
D. ambrosieides	30	1.00±0.58b	6.33±1.20b	7.67±0.88b	22.00±3.21b
D. ambrosieides	60	0.00±0.00b	0.33±0.33c	0.67±0.67d	1.00±0.58c
D. ambrosieides	90	0.67±0.00b	0.67±0.33c	0.33±0.33d	0.33±0.33c
Actellic dust (+ve)	2	0.00±0.00b	0.00±0.00c	0.00±0.00d	0.00±0.00c
One Way ANOVA (F-statistics)		12.71***	30.15***	36.05***	54.65***

Control (-ve) = negative control, +ve = positive control; *** significant at $P \leq 0.001$ and means within the same column followed by the same letter (s) are not significantly different at ($P = 0.05$) from each other using Fisher's Least Significant Difference (LSD) test.

The Effect of Pesticidal Leaf Powder on the Mortality of Adult C. maculatus

Different effects were observed by supplying 30, 60 and 90 g of plant leaf powder on the mortality of adult *C. maculatus*. The results showed significant difference ($P \leq 0.001$) in the mean number of dead adult *C. maculatus* across treatments all over 12 weeks (Table 2).

The highest mortality was observed outside the bags treated with Actellic dust (2 g) throughout the study period. The result of the first week observation for *H. suaveolens* and *D. ambrosioides* at 90 g was statistically similar to positive control followed by 90 g for *O.suave* and 60 g for *H. suaveolens* and *D. ambrosioides*. There were increased numbers of dead insects in treatments involving *H. suaveolens* and *D. ambrosioides* plant leaf powder at the rates of 60 and 90 g and *O. suave* at 90 g 1.5 kg^{-1} of cowpea seeds after the first 3 weeks up to 9th weeks of treatment indicating high effectiveness of these plants materials in reducing the number of adult *C. maculatus* at high rates of application. However, mortality started to decrease after 12 weeks of treatment contrary to Actelic® dust 2 g that maintained its effectiveness.

This showed that, mortality of adult *C. maculatus* treated with plant leaf powder was affected by increased rate of plant material and its exposure time to cowpea seeds.

There were no dead insects found in untreated bags (negative control) throughout 12 weeks of assessment. In this case, the lowest mortality was observed in a negative control while the highest number was observed in the bags treated with Actelic® dust (positive control) where dead insects were observed outside the bags. Additionally, 30 g of all plant leaf powder had a low pesticidal effect on the mortality of *C. maculatus*.

Table 2. Mean number of dead *C. maculatus* in stored cowpea treated with three pesticidal leaf powder.

Treatments	Rates (g) 1.5 kg⁻¹	Week 3	Week 6	Week 9	Week 12
Control (-ve)	0	0.00±0.00e	0.00±0.00d	0.00±0.00f	0.00±0.00f
O. suave	30	6.67±1.20d	8.67±1.20c	12.00±1.15e	11.67±2.33e
O. suave	60	9.00±0.58cd	13.00±2.08bc	17.67±0.88cde	12.33±1.76de
O. suave	90	15.67±0.88b	17.00±1.53ab	24.33±2.03ab	17.33±0.88bcd
H. suaveolens	30	9.33±0.88c	12.00±2.52bc	12.00±1.73e	13.00±2.08cde
H. suaveolens	60	16.00±1.00b	20.00±1.53a	21.67±2.19abcd	17.33±1.20bcd
H. suaveolens	90	17.67±0.88ab	21.00±1.73a	23.33±5.36abc	19.33±0.33b
D. ambrosieides	30	7.67±0.88cd	10.67±1.45 c	16.00±1.53de	13.33±1.85cde
D. ambrosieides	60	15.67±1.45b	16.67±3.38ab	19.33±2.03bcd	18.33±1.45bc
D. ambrosieides	90	17.00±1.15ab	19.67±2.33a	21.33±1.20abcd	18.33±0.88bc
Actellic dust (+ve)	2	19.00±1.15a	21.67±2.73a	26.33±2.91a	29.67±4.98a
One-Way ANOVA (F-statistics)		61.54***	18.01***	19.96***	21.54***

Control (-ve) = negative control, +ve = positive control; *** significant at $P \leq 0.001$ and Means within the same column followed by the same letter (s) are not significantly different at ($P = 0.05$) from each other using Fisher's Least Significance Difference (LSD) test.

The Effect of Pesticidal Leaf Powder on the Oviposition of C. maculatus

Plants leaf powder supplied at rates of 30, 60 and 90 g 1.5 kg^{-1} of cowpea seeds displayed different effects on oviposition of *C. maculatus*. Although, the effectiveness depends on the dosage of plant leaf powder and its exposure time to *C. maculatus* yet, different rates of pesticidal leaf powder were statistically significant ($P \leq 0.001$) when compared with negative control which had highest mean number of cowpeas with eggs on the surface throughout the study (Table 3).

After the first 6 weeks of treatment, all pesticidal leaf powder at 60, and 90 g effectively inhibited eggs laying capacity of *C. maculatus* almost in a similar manner to the positive control. Generally, *H. suaveolens* and *D. ambrosioides* at the highest rate of 90 g tested in this study maintained their effectiveness up to 12 weeks of treatment.

Table 3. Mean number on oviposition by *C. maculatus* in stored cowpea treated with three pesticidal leaf powder.

Treatments	Rates (g) 1.5 kg⁻¹	Week 3	Week 6	Week 9	Week 12
Control (-ve)	0	50.33±4.91a	98.67±7.22a	234.33±3.53a	536.33±9.39a
O. suave	30	20.00±1.53b	47.00±4.16b	139.00±23.12b	246.67±41.91b
O. suave	60	6.67±1.45cd	12.67±3.18d	70.67±6.44c	124.00±22.54de
O. suave	90	2.33±0.33d	3.00±1.00de	64.67±23.47c	60.67±24.34f
H. suaveolens	30	18.33±6.36bc	31.67±1.86c	88.33±5.78c	210.00±25.32bc
H. suaveolens	60	6.67±3.18cd	3.33±1.20de	6.00±3.46d	56.33±4.33fg
H. suaveolens	90	1.33±1.33d	0.67±0.67de	5.33±1.76d	3.33±1.45h
D. ambrosieides	30	20.33±6.06b	31.33±3.48c	59.33±20.30c	172.00±20.26cd
D. ambrosieides	60	6.67±2.40cd	1.67±0.88de	5.67±1.20d	106.00±5.13ef
D. ambrosieides	90	3.3±2.40d	0.67±0.67de	4.67±1.20d	4.67±0.88gh
Actellic dust (+ve)	2	0.00±0.00d	0.00±0.00e	0.33±0.33d	2.00±0.58h
One-Way ANOVA (F-statistics)		19.38***	87.87***	49.82***	129.58***

Control (-ve) = negative control, +ve = positive control; *** significant at $P \leq 0.001$ and Means within the same column followed by the same letter (s) are not significantly different at ($P = 0.05$) from each other using Fisher's Least Significance Difference (LSD) test.

The trend was different from *O. suave* which showed less pesticidal activity after 9 weeks of treatment.

All pesticidal leaf powder at 30 g displayed the least effectiveness in affecting egg laying capacity by *C. maculatus*. Actelic® dust 2 g showed the greatest capacity to inhibit oviposition by *C. maculatus* than the rest of the treatments.

The Effect of Pesticidal Leaf Powder on Cowpea Damage by C. Maculatus

Supplying plant leaf powder at rates 30, 60 and 90 g 1.5 kg^{-1} of cowpea seeds, displayed varied pesticidal effects on protecting cowpea grains against *C. maculatus* damage. Actelic dust at 2 g showed high effectiveness in controlling cowpea damage by *C. maculatus* (Table 4).

Table 4. Mean number of damaged seeds by *C. maculatus* in stored cowpea treated with three pesticidal leaf powder.

Treatments	Rates (g) 1.5 kg^{-1}	Week 3	Week 6	Week 9	Week 12
Control (-ve)	0	27.67±4.98a	33.00±3.06a	107.67±13.13a	132.67±16.60a
O. suave	30	12.00±1.73b	18.33±1.45b	39.33±1.86b	77.00±6.25b
O. suave	60	10.67±0.88b	12.00±1.53bc	15.00±2.00c	68.67±6.57b
O. suave	90	7.00±1.15bc	8.67±0.88bcd	10.00±1.53c	9.67±0.67c
H. suaveolens	30	10.33±1.45b	11.00±1.15bcd	36.00±6.03b	70.00±7.77b
H. suaveolens	60	9.33±0.88b	7.33±1.20bcd	7.00±2.65c	7.67±0.88c
H. suaveolens	90	8.67±2.03b	6.67±1.20cd	7.00±2.08c	5.00±1.15c
D. ambrosieides	30	11.00±1.00b	12.67±2.73bc	33.33±8.37b	60.00±4.36b
D. ambrosieides	60	8.67±1.20b	8.00±1.53bcd	10.67±0.88c	8.33±0.67c
D. ambrosieides	90	6.33±2.85bc	7.33±2.03bcd	5.00±0.58c	5.00±0.58c
Actellic dust (+ve)	2	0.00±0.00c	0.33±0.33d	1.00±0.58c	1.33±0.33c
One-Way ANOVA (F-statistics)		15.77***	9.66***	49.01***	47.84***

Control (-ve) = negative control, +ve = positive control; *** significant at P ≤ 0.001 and Means within the same column followed by the same letter (s) are not significantly different at (P = 0.05) from each other using Fisher's Least Significance Difference (LSD) test.

The highest grain damage was observed in a negative control throughout the study period. All plants leaf powder at rates 30, 60 and 90 g 1.5 kg^{-1} of cowpea seeds displayed similar effect in reducing cowpea damage in the first three weeks of treatment. However, from 6 to 12 weeks, their differences were statistically significant ($P \leq 0.001$) and was dose dependent. Treatments with *O. suave* at 90 g, *H. suaveolens* and *D. ambrosioides* at rates 60 and 90 g showed promising results in protecting the grains against *C. maculatus* damage similar to synthetic chemical.

Discussion

Performance of O. suave on C. maculatus

Ocimum suave contains phtytochemical eugenol as a major bio-active compound that excite insecticidal activities such as repellency, fumigant, contact toxicity, mortality and deterrent effect against storage insect pest of different crop including *Sitophilus zeamais, Prostephanus truncatus* (Obeng-Ofori and Reichmuth, 1997; Obeng-Ofori *et al.*, 2000). In the present study, *O. suave* exhibited pesticidal activities against *C. maculatus* at high dosage (60 and 90 g) of plant leaf powder that effectively reduced oviposition and the number of adult *C. maculatus* emergence up to 6 weeks of their storage (Table 1 & 3). Obeng-Oforri and Reichmuth, (1997) reported on toxicity of Eugenol against four species of stored-product Coleoptera when the store time increased. In this regards, *O. Suave* can be used as a grain protectant in a short-term storage. Thus, there should be periodic reapplication of this plant materials if they are to be used for a long-term storage (Muzemu *et al.*, 2013). However, other studies have shown that mixing *O. suave* with other pesticidal materials such as *Cymbopogon citratus* effectively prolong the storage time of cowpea seeds against *C. maculatus* by inhibiting oviposition and number of adult emergence (Ojianwuna, 2011).

At higher dose of 90 g, plant leaf powder of *O. suave* showed effectiveness in increasing adult mortality of *C. maculatus*. This result is similar to the work of Bekele *et al.*, (1999) in which *O. suave* ground dry leaves worked best at the higher dosage and evoked 100% mortality of three stored insect pests *Sitophilus zeamais*, *Rhyzopertha dominica* and *Sitotroga cerealella*. *Ocimum* species are known to have repellent and toxicant effect against various stored insect pests (Bekele *et al.*, 1999; Hassanali *et al.*, 1990) which might be the reason for high mortality and reduced oviposition caused by this plant materials to *C. maculatus*. The protection of grains against insect damage by the leaves of *O. suave* form the basis for their use by small scale farmers as traditional grain protectant in short -term storage.

Performance of H. suaveolens on C. maculatus

Hyptis suaveolens is known to contain sabinene (41.0 %), terpinen-4-ol (12.31 %), β-pinene (10.0 %) and β-caryophyllene (8.0 %) as four major compounds with biological activities against *several field and storage insect pests* (Tripathi and Upadhway, 2009; *Sharma and Tripathi, 2008; Chi and Apiah, 2012; Hassan et al., 2018*). In this study, leaf powder of *H. suaveolens* showed high effectiveness on reducing oviposition, adult emergence, seed damage and increasing mortality of *C. maculatus* at the higher dose of 60 and 90 g over the period of 12 weeks (Table 2). The repellency property of *H. suaveolens* contributed to the reduced oviposition which consequently resulted into inhibition of larval development that could grow into pupa and hence low number of adult cowpea emergence. Hassan *et al.*, (2018) reported 100 % of eggs' mortality when leaf powder of *H. suaveolens* were tested on *C. maculatus* eggs to test the ovicidal activity. Other scholars have also reported on similar effect of the *H. suaveolens* plant materials on controlling cowpea weevils (Tripathi and Upadhway, 2009; Adebayo and Eyo, 2014) and maize weevils (Asawalam *et al.*, 2007). In this regards, *H. suaveolens* seems to have protectants ability against storage insect pests for a longer period than *O. suave* and hence can be used as an alternative to synthetic pesticide.

Performance of D. ambrosioides on C. maculatus

The chemical screening of *D. ambrosioides* identified the plant to have several chemical compounds including ascaridole (54 %), isoascaridole, (28 %) and p-cymene (8 %) (Dembitsky *et al.*, 2008; Mkenda *et al.*, 2015). It has been used for treating diseases and preserving postharvest grains from weevil attack (Tapondjou *et al.*, 2002; Dembitsky *et al.*, 2008; Salimena *et al.*, 2015; Mkenda *et al.*, 2015). In the present study, *D. ambrosioides* at the rates of 60 and 90 g, exhibited high effectiveness on reducing adult mortality, reduced seed damage and inhibition of adult emergences. The effectiveness of *D. ambrosioides* could be as a result of biological activity of ascaridole compound that contains insecticidal activity against insects' pests. Chu *et al.* (2011) reported ascaridole to be the active constituent against the storage weevil *Sitophilus oryzae*. Similar to other plant materials used in this study, *D. ambrosioides* was very effective at higher dosage of plant leaf powder. Mkenda *et al.*, (2015) reported a complete seed protection, higher mortality of *C. maculatus* and lower number of holes per cowpea seed using *D. ambrosioides* powder. Similar to results obtained in this study, the effectiveness of *D. ambrosioides* plant materials against several insect pests have been widely reported (Tapondjou *et al.*, 2002; Chiasson *et al.*, 2004; Denloye *et al.*, 2010; Mkenda *et al.*, 2015).

Conclusion

Generally, the three pesticidal leaf powder evaluated, provide protection to cowpea grains from *C. maculatus* at the high rates of plant leaf powder which may be as a result of ovicidal and larvicidal properties possessed by the tested plant materials that killed few eggs laid while preventing the few once that hatched to grow into larva. Furthermore, high mortality caused by plant leaf powder might also be due to contact toxicity of the tested plant powders which affect insect's survival thus kill them. Plants leaf powder showed decreased trend of insect mortality after the 12 weeks suggesting fast degradable nature of bioactive compounds present in these plants' material and hence safety for human health as well as little or no residue to environment.

Among the pesticidal leaf powder used, *H. suaveolens* and *D. ambrosioides* at 90 g effectively reduced the oviposition in stored cowpea similar to Actelic® dust. In this regards, small holder farmers residing in areas where these materials are locally available, can utilize these plant materials as grain protectants in stored cowpea. By considering that, adult cowpea weevils do not feed on stored cowpea seeds but only deposit their eggs, having good control to inhibit or in somewhat reduce eggs deposition could prolong the storage time for the grains. Therefore, based on the results obtained from this study, pesticidal plants leaf powder are good protectants of stored cowpea product as they can effectively protect the grains against *C. maculatus* however, its application can only be certain for high dose.

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