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Full Length Research

Assessing the efficacy of wild basil (*Ocimum americanum* L. (Walp)) in the management of cowpea weevil (*Callosobruchus maculatus*)

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ABSTRACT: Cowpea (*Vigna unguiculata* (L.) Walp) belongs to the family Fabaceae and is one of the pulses that suffer postharvest losses greatly. The major insect that attacks stored cowpea seed in Kenya is the cowpea weevil (*Callosobruchus maculatus*). The insect can damage 100% of stored cowpea seeds causing weight loss of up to 60%. Although insecticides are widely available, they have high potential risks to users and also pollute the environment. In drier areas of Kenya where the pest is common, small-scale farmers use botanicals with varying levels of success. This study sought to assess the effectiveness of a locally available botanical, *Ocimum americanum*, in the management of the cowpea weevil. Different plant parts of *O. americanum*, the leaves, flowers and whole mature young plants were dried and ground into powder. From each plant part, 0.5, 1.0, 2.0, 4.0 and 8.0 g were used to determine their effectiveness against the weevil in stored cowpea seed. Two controls were used, that is, no protectant and Actellic super dust. For each treatment, 10 g of cowpea seeds were placed in plastic vials containing ten pairs (male and female) cowpea weevil adults. The experiments were laid out in a completely randomized design at the Kenya Agricultural and Livestock Research Organization (KALRO), Nairobi, Entomology Laboratory. Lowest post-harvest weight loss (3.0 g) of cowpea seed and highest mortality (92.5%) of cowpea weevil was recorded when 8 g of leaf powder were used. Since wild basil is a common weed in drier parts of Kenya such as Mbeere, Tharaka-Nithi, Kitui, Makueni and Mwingi, it can be utilized in these areas as a cheap control bioinsecticide for cowpea weevil.

Keywords: Cowpea, cowpea weevil, postharvest loss, mortality rate.

INTRODUCTION

Cowpea is an annual herbaceous legume belonging to the family of Fabaceae and sub-family Papilionaceae (Davids, 1991). It is native to the drier regions of the world (Jefferson, 2005). It is widely grown in Africa, Latin America, South East Asia and in southern United States. Cowpea is a primary source of plant protein with the grain, leaf, green pods and fresh shelled green peas being great sources of food and vegetables for human diets (Gondwe et al., 2013). Additionally, cowpea is an important component of the traditional cropping systems because it fixes atmospheric nitrogen and contributes to soil fertility improvement particularly in smallholder farming systems where little or no fertilizer is used (Kyei-Boahen et al., 2017).

About 84% of the world's production area of cowpea is found in Africa, with over 80% of African production in West Africa. According to FAOSTAT (2016), cowpea was grown on an estimated 12.3 million ha in Africa in 2014 with the bulk of production occurring on 10.6 million ha in West Africa, particularly in Nigeria, Niger Burkina Faso, Mali and Senegal. In Kenya, cowpea is the third most important grain legume after beans and pigeon pea and covers about 24,431 hectares (HCD Report, 2016).

Callosobruchus maculatus is a beetle that belongs to the order Coleoptera, family Chrysomelidae, and genus Callosobruchus (Legalov et al., 2020). Adults move about readily and can infest seeds in the field, but can also breed continuously in stored dry cowpea grain. The larva burrows and feeds on the bean endosperm and embryo, undergoes a series of molts, and burrows to a position just underneath the seed coat prior to pupation. There is complete metamorphosis of the larval maggot to winged adult during pupation. The weevil generally enters the cowpea pod before harvest and lays eggs on the dry seed (Legalov et al., 2020). Severe *C. maculatus* infestations can affect 100% of the stored cowpea grain and cause up to 60% loss within a few months (Mashela and Pofu, 2012). The most common methods of control involve the use of insecticides, the main pesticides used being carbamates, synthetic pyrethoids, and organophosphates (Jackai and Adalla, 1997).

The increasing concern on environmental safety and global demand for pesticide residue-free food has evoked interest in pest control through use of botanicals (Dalavayi et al., 2021). Botanicals are extracted from various plant parts such as leaves, stems, seeds, roots, bulbs, rhizomes, unripe fruits, and flower heads of different plant species. These have broad spectrum activity, are less expensive and easily available because of their natural occurrence. They also pose least or no health hazards and environmental pollution (Dalavayi et al., 2021).

In Kenya, *Ocimum americanum* occurs wild and it is known in a diversity of names depending on the country's ethnic community where it is found. For instance it is known as chemishwa (Tugen), mutei (Kikuyu), gathereti/ makori (Meru), chenekom/sipko (Pokot), embuke/emboa (Bukusu), lemurran (Samburu), mwonyi/lizuranza (Luhya), mutaa (Kamba) and rigorio/mbirirwa (Marakwet) (Charika et al., 2011). The diversity of names imply that *Ocimum americanum* is a popular plant in Kenya.

Thus, the objective of this study was to assess the effectiveness of different plant parts of a locally available botanical, *Ocimum americanum*, in the management of the cowpea weevil.

MATERIALS AND METHODS

Source of cowpea weevil

Adult cowpea weevils were obtained from Katutu market, in Kitui West District and reared at Kenya Agricultural and Livestock Organization (KALRO) Kabete NARL in Nairobi Kenya, Insect Science Laboratory, maintained at 28 ± 2°C and 70 ± 5% relative humidity as described by Porca et al. (2003). The seeds of commercial variety KVU 27-1 were brought from KALRO Katumuni Research Unit, Machakos and were disinfested in an oven at 40°C for 6 hours and kept in the air cooled condenser before use. The seeds of KVU 27-1 were used as food substrate for *C. maculatus*. Fifty pairs of unsexed adult *C. maculatus* were placed in 1-litre glass jars containing 200 g of the disinfested seeds to start the culture. This was meant to increase the population of weevils to be used in 21 treatment combinations. Each treatment required 10 pairs of the weevils. The jars were sealed with muslin cloth which is porous to allow gaseous exchange. Wax was used to seal the jar. The parent weevils were sieved out after 10 days of ovipositon and seeds were kept under laboratory condition until the emergence of F1 progeny.

Preparation of treatment material

Mature young plants of wild basil were collected from Mutua's farm in Kitui County. Dried parts of the plant were ground into a fine powder using a milling machine. The twenty one (21) treatments were: control one (no protectant), leaf powder (0.5, 1.0, 2.0, 4.0 and 8.0 g), flower powder (0.5, 1.0, 2.0, 4.0 and 8.0 g), whole basil plant powder (branches, leaves, flowers and roots) (0.5, 1.0, 2.0, 4.0 and 8.0 g), control two: 1% standard Actellic Super (Pirimiphos methyl) dust (0.5, 1.0, 2.0, 4.0 and 8.0 g).

Subjecting cowpea weevil (*Callosobruchus maculutus)* to wild basil treatments

Ten (10) grams of disinfested (clean and free from pest attack) *V. unguiculatus* seeds, were placed in each of the twenty 0.5-litre plastics jars and 10 pairs (ratio of 1:1, male: female) of 1-3 days old adult *C. maculutus* were introduced to each of the treatment of 0.5, 1.0, 2.0, 4.0 and 8.0 g of ground different plant parts of wild basil. The treatments were replicated four times and experiment was arranged in a complete randomized design (CRD) since this was a laboratory experiment where conditions were homogenous. Data on mortality and seed weight loss were collected in each jar after infestation. Mortality data were recorded after 72 hours while seed weight loss data were taken after 90 days.

Data analysis

Data collected on mortality of *C. maculatus* and weight loss of cowpea grain was analyzed using Genstat software and means separation was by Fischers protected least significant difference at $p \leq 0.05$.

RESULTS

Mortality of adult *C. maculatus*

Table 1 shows the toxic effects of *Ocimum Americanum* powder on mortality of *C. maculatus* after 72 hours in storage. Percentage mortality ranged from 92.5, 72.5 and 12.5% when 10 grams of seeds were subjected to each

Table 1. Effect of *Ocimum americanum* on mortality of *C. maculatus* after 72 hours of storage of infested cowpea seeds.

Treatments	Control (Atelic super dust)	Percentage nortality of *C. maculatus*		
		Leaf	Flower	Whole plant
0.5 g	25.0[a]	0.0	0.0[a]	0.0[a]
1.0 g	50.8[a]	0.0	0.0[a]	0.0[a]
2.0 g	83.5[b]	12.5[a]	3.0[b]	3.3[b]
4.0 g	95.8[c]	72.5[b]	4.2[c]	5.8[c]
8.0 g	100.0[d]	92.5[c]	11.3[d]	14.5[d]
LSD (p<0.05)	0.62	0.29	0.25	0.22

Table 2. Effect of *Ocimum americanum* on weight loss of stored cowpea seeds infested with cowpea weevil.

Treatments	Control (Atelic super)	Mean percentage weight loss of cowpea grains		
		Leaf	Flower	Whole plant
0.5 g	12.43[a]	61.00[a]	84.75[a]	77.75[a]
1.0 g	3.25[b]	51.25[b]	71.00[b]	62.5[b]
2.0 g	0.64[c]	44.50[c]	64.00[c]	57.50[c]
4.0 g	0.41c[d]	36.00[d]	52.75[d]	48.50[d]
8.0 g	0.00[d]	3.00[e]	41.50[e]	29.50[e]
LSD (p<0.05)	0.432	0.543	0.556	0.564

treatment of 10 pairs of cow pea weevil and *O. americanum* leaf powder at 8.0, 4.0 and 2.0 g respectively. There was significant ($p<0.05$) difference among the concentrations of the leaf powder treatments. Atelic super dust (control) was significantly better than the plant extracts. *O. americanum* flower powder had the least effect on *C. maculatus* mortality. Extracts from flowers and whole plant had minimal effect on mortality rate of *C. maculatus* after 72 hours in storage. Percentage mortality of *C. maculatus* when 10 grams of seeds were subjected to treatment of whole plant extracts at 8.0, 4.0 and 2.0 g ranged from 14.5, 5.8 and 3.3% respectively. Treatment of seeds with flower extracts 8.0, 4.0 and 2.0 g recorded the least mortality rate of *C. maculatus* of 11.3, 4.2 and 3.0% respectively

Weight loss of cowpea seed

Table 2 shows significant ($p<0.05$) decrease in percentage weight loss with increase in leaf powder dosage from a high value of 61% to comparatively low value of 3% at 8.0 g leaf powder per 10 g of seeds. Similarly, weight decreased progressively from 12.43% in seeds treated with control (Atelic super dust) to 0.54% at 8.0 g Actellic Super per 10 g seeds. Flower powder at all dosage levels resulted to highest weight loss after 90 days of treatment.

There was significant ($p<0.05$) difference between the weight of cowpeas seeds three months after treatment among different quantity levels of grounded *O. americanum*. Lower quantities had fewer weevils killed. This implied greater attack of the cowpea grains resulting in higher weight loss. Higher quantities of ground *O. americanum* had more weevils killed hence less attack on grains and little weight loss of the cowpea seeds was realized.

DISCUSSION

The findings of this study indicate that powdered parts of *Ocimum americanum* significantly reduced the attack by *C. maculatus* on treated cowpea seeds in storage. Among the plant parts studied, powdered leaf had the best results and compared well with the standard commercial chemical, Actellic Super dust. Studies have shown that derived extracts and phytochemicals of *O. americunum* possess antimicrobial and insecticidal activities (Shadia et al., 2007). All female moths resulting from larvae fed on leaves treated with basil for 24 hours were deformed and died before oviposition (Abd El-A ziz et al., 1997). Cavalcanti et al. (2004) demonstrated that the essential oils of *O. americanum* and *O. gratissimun* had larvicidal activity against *Aades aegypti* mosquito and caused 100% mortality at a concentration of 100 ppm. Shadia et al. (2007) revealed Eugenol was identified as the major compound in the essential oil composition of *O. americanum* at 28.46%. Methyl chavicol was found to be the second main compound and accounted for 17.34% in the essential oil. Terpineol was identified as the third main constituent in the essential oil and its relative percentage accounted for 15%. Farnesene was identified as the main sesquiterpene with 9.2% while â-Bisabolene was identified as the second sesquiterpene in the essential oil and reached 4.5%. The same trend observed with farnesene was observed with â-bisabolene. 1, 8-cineole and limonene followed farnesene in the relative percentage and all treatments showed round figure of 7.0% of either cineole or limonene (Cavalcanti et al., (2004). This study has demonstrated that among the plant parts, the leaf powder at the rate of 8.0 g per 10 g of seed, (800 g of leaf powder per one kilogram of seed) caused significantly higher mortality rate of *C. maculatus* and low weight loss of cowpea grain. This implies that the leaf could probably be having a higher concentration of the phytochemicals that provide the insecticidal activity than other plant parts of *O. americunum.*

As expected, Actellic® Super dust was more effective than all plant powders. Actellic® Super dust is a conventional insecticide specifically formulated with high insecticidal activity on stored pests. Its continuous use raises questions regarding the potential health risk and environmental pollution. Effective bio-pesticides would provide an alternative to synthetic chemicals. Acheuk and Mitiche (2013) observed that alkaloids, flavonoids, and essential oils are chemical compounds that are toxic to target insect pests even at small concentrations. The chemical compounds can interfere with the respiratory system and nervous system of insects and inhibit the action of the acetylcholinesterase enzyme (Mann and Kaufman, 2012). In addition, flavonoids interfere with the insect's respiratory system which causes death in insects because they cannot breathe (Vladimir-Knezevic, 2014).

Surahmaida and Umarudin (2019) reported that phytochemical screening of basil (*O. sanctum)* with chemical reagents showed the presence of alkaloids, flavonoids and essential oils. Chemical compounds identified among others are neral; 2,4- (D2) menth-2-ene; 4,5- Diclorotricyclo [5.3.1.1 (2,6)] dodec-3-en-11-one; 1-(4-phenylcyclohexyl) -1-hexanone; ethyl linoleolate; 3 (5) -(4'-Chlorophenyl) -4- nitroso-5 (3) -phenylaminopyrazole; eicosane; 2- (Acetoxymethyl) -3- (methoxycarbonyl) biphenylene; 6H, 16H, 31H-5,9: 15,19- Dimethano-10,14-metheno-26,30-nitrilo-5H, 25H-dibenzo [b, s]. According to Surahmaida and Umarudin (2019), the toxicity test results showed that basil leaf extract can control houseflies. The findings of this study agree with Surahmaida and Umarudin (2019) that the leaf extracts have a high toxicity level and can be used as a biopesticide in the control of cowpea weevil.

Conclusion

This study has demonstrated that *O. americanum* leaf powder at the rate of 8.0 g per 10 g cowpea seeds can be effective in controlling cowpea weevil. Its preparation method is also easy and does not require high technical skills. Therefore in those regions of Kenya where the plant grows naturally, low resource farmers can be advised to use it in the control of *C. maculutus* in stored cowpea seeds. Since wild basil is a common weed in Kitui, Mbeere, Tharaka - Nithi, Makueni and Machakos, it can provide a natural, cheap and environmental friendly management option for cowpea weevil. The use of wild basil (*Ocimum americanum*) as botanical in control of *C. maculatus* in stored cowpea seed has a great potential of being developed into plant-based bio-pesticide.

CONFLICT OF INTEREST

Authors declare that they have no conflict of interest.

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