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BIOACTIVITY OF *ESSENTIAL OILS OF* SELECTED PLANTS AGAINST *Callosobruchus maculatus (*F.) (COLEOPTERA: CHRYSOMELIDAE) ON STORED COWPEA SEEDS (*Vigna unguiculata* L. Walp)

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ABSTRACT

The use of synthetic insecticides in the control of stored product insect pests including *Callosobruchus maculatus* has led to the development of resistance and other undesirables side effects. Therefore, present study was conducted to evaluate the bioactivity of *essential oils of* coriander, fennel and sweet almond against *C. maculatus (*F.) on stored cowpea seeds. *The bioassays used three dosages of each essential oil (2.0, 4.0 and 6.0 ml /100 g seed and the untreated control 0.0 g/100 g seed)* at 27 ± 2°C and 45 ± 5% relative humidity (r.h.) to assess adult mortality, number of adult emergence, percentage seed damage, weight loss and germination. At 1 day after treatment (DAT), 100% adult mortality was observed at the highest dosage of coriander essential oils (6 ml/100 g) which was significantly ($p < 0.05$) different from the untreated control. Similar trends followed at 3 and 5 DAT. All the treatments significantly ($p < 0.05$) reduced F_1, F_2 adult emergence, seeds damage as well as weight loss compared to the untreated control. They also *negatively affected* germination *of cowpea seeds. It is* therefore concluded that *essential oils of* coriander, fennel and sweet almond could be used against *Callosobruchus maculatus and* can serve as alternative to synthetic insecticides.

Keywords: *Callosobruchus maculatus*; *essential oils;* coriander; fennel; sweet almond

INTRODUCTION

Cowpea (*Vigna unguiculata* L. Walp.) is a member of the Phaseoleae tribe of the Leguminosae family (Timko *et al*., 2007). It is known in Hausa as “waake”. The other names used to describe it include “southern peas,” “black eyed peas,” “field peas,” “pink eyes,” and “crowders” (Timko *et al*., 2007; Olajire *et al*., 2011). It is an important edible legume crop in many parts of the world especially in tropical and subtropical regions (Snapp *et al*., 2018). The tender green leaves are an important source of food in Africa. Also, immature green pods are used as snap beans, often mixed with cooked dry cowpea seeds or with some other foods (Tarawali *et al*., 2002). Freshly-shelled cowpea seeds are boiled and used as a fresh vegetable or may be canned or frozen. Dry mature seeds are also suitable for boiling and canning. Cowpea foliage is an important source of high-quality hay for livestock feed in many parts of the world (Tarawali *et al*., 2002; Timko *et al*., 2007).

The total world production of cowpea is estimated at 6.99 million metric tons of dry grains, of which 64% is produced in Africa. It was estimated that 12.30 million hectares of the crops are planted annually around the world; and about 10.48 million hectares are planted in West Africa, making the region the largest producer and consumer of cowpea in the world. Nigeria produces about 3.02 million tons of cowpea (FAOSAT, 2018).

*Callosobruchus maculatus (*Fabricius) has been recognized for decades as the major insect pest of cowpea. *It* is a cosmopolitan species which are found in both tropical and subtropical regions of the world. The larvae are the most destructive stage in its life cycle and the adult do not feed (Olajire *et al*., 2011). Aboua *et al. (*2010) reported that feeding by *C. maculatus* larvae inside cowpea seeds caused up to 80% weight losses after six months of storage. The protection of cowpea seeds in storage relied on the use of synthetic insecticides, but the repeated use of synthetic insecticides resulted in the development of resistance, undesirable effects on non-target organisms and the environments, toxic residues in the treated products, health hazards to operatives and pest resurgence (Audu *et al*., 2015). All these have necessitated the search for alternative grain protectants that are effective and harmless to both people and the environment. Among them, essential oils take an important role.

Botanical insecticides, including powders, extracts and essential oils have been used to protect crops for many years (Isman, 2006). The use of botanicals or plant derived insecticides played a significant role in the traditional storage method in many parts of Africa (Bekele and Hassanali, 2001). Plants possess compounds such as terpenoids, alkaloids and phenols that demonstrated various effects against insect pests including toxicity, antifeedant, repellency, growth inhibitory, feeding deterrence and so on (Koul, 2004). There are numerous studies on the insecticidal activity of powders, extracts and essential oils from family Apiaceae and Rosaceae (Kim and Ahn, 2001; Al-Jabr, 2006; Ebadollahi, 2011; Abdulhay, 2012; Lucca *et al*., 2015; Mohamed and Helaly, 2018; *Sarwar et al., 2019).*

Recently, the research focused on essential oils, which play a significant role in protecting stored grains against insect infestations (Regnault-Roger, 1997; Bakkali *et al*., 2008; Pérez *et al.,* 2010). Essential oils (EOs) are volatile, natural, complex compounds characterized by a strong odour and are formed by plants as secondary metabolites. In nature, those compounds play an important role in the defense of the plants against insects, fungi, bacteria, virus and others herbivores (Bakkali *et al*., 2008; Pérez *et al.,* 2010). Regnault-Roger (1997) reported that essential oils are important industrially in the production of cosmetics, perfumery and detergents. They also play a role in the food industry as aromatics and in insect pest management. Several studies have demonstrated the potential of EOs as insecticides, repellents, anti-feedants, antimicrobial, nematicidal and antifungal (Regnault-Roger, 1997; *Koul et al., 2008;* Pérez *et al.*, 2010; *Mossa, 2016). You need to add how much protection these or similar plants have given against this or other insect pests.*

Coriander (*Coriandrum sativum* Linn.) *is a member of the Apiaceae family (formerly Umbelliferae) (*Önder, 2018*) and locally known as "Khusbara"*). It is an annual herbaceous plant originated from the eastern Mediterranean regions and is now grown in many parts of the world for its leaves and seeds as well as in the production of essential oil (Anwar *et al*., 2011). It is widely cultivated in India, Pakistan, Bangladesh, Russia, Central Europe, Morocco, and China (Bhuiyan *et al*., 2009). It is considered as an important herb/spice because of its culinary (leaves and seeds are used as a seasoning condiment), aromatic and medicinal uses (Verma *et al*., 2018).

Fennel (*Foeniculum vulgare* Miller); *belongs to the family Apiaceae is a* perennial, aromatic umbelliferous herb (Khan and Musharaf, 2014; *Cabral et al., 2017) and locally what language? known as "shammar|".* This aromatic plant is grown in central Europe, Mediterranean, tropical regions and almost all over the world both as an ornamental and as a seed crop (Khan and Musharaf, 2014; *Cabral et al., 2017). Its* fruits are oblong, ellipsoid or cylindrical, straight or slightly curved, greenish or yellowish brown in colour and each fruit weighs between 6 and7 mg (Khan and Musharaf, 2014). This plant is commonly used as a culinary spice in Middle Eastern, Mediterranean, Indian and Asian cuisines because of its aniseed flavor. Furthermore, it is useful as flavouring agent in pharmaceutical industries (Diao *et al*., 2014).

Sweet almond is the fruit of a tree called *Prunus amygdalus (*Mill.), a member of the *family* Rosaceae which also includes apples, pears, prunes, and raspberries, are one of the most popular tree nuts on a worldwide basis and rank number one in tree nut production *(*Esfahlan *et al*., 2010; Rao and Lakshmi, 2012; *Moradi et al., 2017).* They originated in a region which extends from India to Persia; from where it spread to East and West of its native region thousands of years before Christ *(*Rao and Lakshmi, 2012*) and is adapted to grow in climatic conditions with cool winter and warm summer (*Rao and Lakshmi, 2012*).*

Despite the important of essential oils of coriander, fennel and sweet almond in the stored product protection. Very little work has been done on the evaluation of these essential oils (coriander, fennel and sweet almond) in the study area. The present study was therefore undertaken to evaluate the bioactivity *of essential oils of* coriander, fennel and sweet almond against *C. maculatus (*F.) on stored cowpea seeds.

MATERIALS AND METHODS

Study Site

The experiments were conducted in a laboratory, Department of Agricultural Technology, Ramat Polytechnic Maiduguri. Maiduguri is located on latitude $11^{o}15$ N and longitude $13^{0}15$ E. The experiments were conducted under ambient laboratory conditions at a temperature of 27 ± 2°C and 45 ± 5% relative humidity (r.h.)

Cowpea Variety Used

A local variety of cowpea (cv. Biu Brown) was used for the study, it is brown in colour and one of the most marketable varieties. The seeds were obtained from Muna market in Maiduguri, Borno State-Nigeria. The damaged seeds were sorted out from the healthy seeds by handpicking. The clean seeds were stored in an air tight plastic buckets till used for the experiment. Before the beginning of the experiment, the seed were sterilized in a hot air oven at 60^{0}c for 2 hours to eliminate hidden infestation. These seeds were conditioned for about 48 hours under ambient laboratory condition at temperature of 27 ± 2°C and 45 ± 5% relative humidity (r.h.)

Source (s) of the Essential Oils

Three essential oils [(Coriander, *Coriandrum sativum* Linn., Fennel, *Foeniculum vulgare* Miller and sweet almond (*Prunus amygdalus* Mill.)] were used in this study. All tested plant oils were 100% concentration. They were purchased from Herbal Medicine Store at Maiduguri Monday Market- Nigeria. They were extracted by El- Hawag Company – Badr city, Cairo, Egypt.

Rearing of *C. maculatus*

Adults *C. maculatus* were reared on cowpea seeds (cv. Biu Red) which had been sterilized in a hot air oven at 60^0C for 2 hours. The parent stock of *C. maculatus* was obtained from infested stock cowpea seeds bought from Gamboru market, Maiduguri- Nigeria. Two hundred randomly selected un-sexed adults *C. maculatus* were introduced into 500 g of sterilized cowpea seeds in 1-litre rearing jars and kept in a laboratory, Department of Agricultural Technology, Ramat Polytechnic Maiduguri. The seeds were sieved to remove all insects at 7 days after introduction and emergence of F_1 adults began at 32 days after introduction and the emerging F_1 adults (1-2 days old) were used for the experiments.

Toxicity Bioassay of the Three Essential Oils and Adult Emergence

Three doses (2.0, 4.0 and 6.0 ml) of each of the essential oils were thoroughly mixed with 100g of cowpea (cv Biu Red) seeds in separate 500 ml capacity glass jar and an untreated control was also included. After treatment, all the jars, except the untreated control was vigorously shaken to ensure an effective admixture and content was allowed to settle for an hour, each jar was later infested with twenty adult *C. maculatus* of mixed sexes (aged 1-2 days). Each jar was covered with a wire mesh to facilitate ventilation and prevent escape of the insect. The jars were labeled and arranged in a Completely Randomized Design (CRD) replicated three times on the laboratory table under ambient condition at temperature of 27 ± 2°C and 45 ± 5% relative humidity (r.h.) for 90 days. The temperature and relative humidity in the laboratory were recorded using Digital Thermometer and Hygrometer (Model KT-907; Digital Series – China).

Mortality was assessed at 1, 3 and 5 days after treatment (DAT) by emptying the content of each jar on a plastic tray, where dead and live insects were counted and recorded. The dead insects were removed while the live ones were returned into their respective jars. When no leg or antennal movements were observed, insects were considered dead. Thereafter, the jars were left undisturbed under the same condition for adult emergence. The progeny count started at 30 days after treatment and infestation for the F_1 adult and counting was stopped at 42 days to avoid overlapping generation. Also, counting for F_2 adult emergence started at 70 days after treatment and infestation and stopped at 84 days. All the newly emerged adults were sieve out, counted and recorded.

Ninety 90 days after treatments, percentage seed *damage* was determined by taking samples of *100 grains from each jar and the number of damaged (grains with characteristic hole) and undamaged grains were counted and recorded and* percentage seed damaged was calculated according to Ibrahim *et al*. (2012):

$$\text{Percentage seeds damaged} = \left[\frac{\text{Number of damaged seeds}}{\text{Total number of seeds}}\right]\times 100$$

Seed weight loss was determined by taking the difference between initial and final weight of cowpea seeds after infestation. The percentage seed weight loss was calculated according to Ibrahim *et al*. (2012):

$$\text{Percentage weight loss} = \left[\frac{\text{Initial weight - Final weight}}{\text{Initial weight}}\right] \times 100$$

Effect of the Treatments on the Germination of Cowpea Seeds

To assess the viability of seeds, germination test was conducted 90 days after treatments. From each jar after the assessment of seeds damage and weight loss, 50 seeds were randomly taken and placed in 9 cm petri dishes lined with moistened filter paper (Whatman No. 1) and arranged in a completely randomized design (CRD) on the laboratory table under ambient conditions for five days. The number of germinated seeds in the petri dishes were counted and recorded and percentage of seed germination was thereafter determined according to Ibrahim *et al*., (2012):

$$\text{Percentage seed germination} = \left[\frac{\text{Number of germinated seeds}}{\text{Total number of seeds}}\right] \times 100$$

Statistical Analysis

Data on adult mortality were converted to percentages mortality. *Abbott's (1925) formula was used to correct mortality in the control as well as* data on percentage seed *damaged, percentage seed weight loss and seed germination percentage were arcsine transformed.* Data on the number of adult emergences were square root transformed. The transformed data were subjected to one-way analysis of variance. *Minitab version (17.0) was used for the analysis.* Means were separated using Tukey-Kramer's (HSD) test at $p < 0.05$.

RESULTS

The effect of *essential oils from* coriander, fennel and sweet almond on mortality of adults' *C. maculatus* is presented in Table 1. The results show that adult mortality had significantly ($p < 0.05$) increased with increase in dosage and exposure intervals. At 1 DAT, 100% adult mortality was observed in the highest dosage of coriander essential oils (6 ml/100 g) which was not significantly ($p > 0.05$) different from highest dosage of fennel and sweet almond essential oils but, was significantly ($p < 0.05$) different from the untreated control. At 3 DAT, complete adults' mortality (100%) was recorded at the highest dosage of the essential oils from coriander then followed by highest dosage of essential oils from fennel (93.3%) and sweet almond (86.6%). At 5 DAT, over (60%) adults' mortality were recorded in two dosages (4.0 ml and 6.0 ml) of all the essential oils which was significantly different ($p < 0.05$) from the untreated control.

Table 1: Toxicity of *essential oils from* Coriander, Fennel and Sweet almond on adults *Callosobruchus maculatus* mortality in cowpea seeds

Treatment	Dosage (ml/100g seed)	Mean adult mortality (% ± SE) days after treatment		
		1DAT	3DAT	5DAT
Coriander	2.0	33.3±8.8^{cd}	43.3±12.0^{d}	53.3±12.0^{c}
	4.0	56.7±3.3^{bc}	66.7±3.3^{bcd}	70.0±0.0^{bc}
	6.0	100.0±0.0^{a}	100.0±0.0^{a}	100.0±0.0^{a}
Fennel	2.0	26.7±3.3^{cd}	40.0±11.5^{d}	40.0±11.5^{c}
	4.0	36.7±3.3^{cd}	53.3±3.3^{cd}	66.7±3.3^{bc}
	6.0	90.0±5.8^{a}	93.3±6.7^{ab}	96.7±3.3^{a}
Sweet almond	2.0	26.7±3.3^{cd}	40.0±5.8^{d}	53.3±8.8^{c}
	4.0	30.0±5.8^{cd}	56.7±12.0^{cd}	70.0±5.8^{bc}
	6.0	80.0±11.5^{ab}	86.7±8.8^{abc}	93.3±6.7^{ab}
Untreated control	0.0	10.0±0.0^{e}	10.0±0.0^{e}	10.0±0.0^{d}

Means followed by different letters in the same column differ significantly at $p < 0.05$ according to Tukey-Kramer's (HSD) test; DAT = Days after Treatment.

The effect of *essential oils f*rom coriander, fennel and sweet almond on *C. maculatus adults' emergence* is presented in Table 2. The number of *C. maculatus* adults that emerged in the untreated control was significantly higher than in the treated cowpea seeds. The highest number of F_1 adults (17.7) emerged in seeds treated with the lowest dosage of essential oils from sweet almond (2ml/100g) and was significantly different ($p < 0.05$) from adult emergence in the untreated control. At F_2, adults' emergence decreased with increase in dosage of the treatment and there was no significant difference ($p > 0.05$) amongst the treatments compared to the untreated control (Table 2).

Table 2: *Callosobruchus maculatus* adults' emergence *on cowpea seeds treated with the essential oils of* Coriander, Fennel and Sweet almond

Treatment	Dosage (ml/100g seed)	Mean number adult emergence (±SE)	
		F_1	F_2
Coriander	2.0	8.0±0.6^{bc}	2.0±1.5^{b}
	4.0	1.0±0.6^{d}	1.0±1.0^{b}
	6.0	0.7±0.7^{d}	1.0±0.0^{b}
Fennel	2.0	13.3±0.9^{b}	12.3±3.2^{b}
	4.0	4.0±1.2^{cd}	4.7±2.3^{b}
	6.0	2.7±0.3^{cd}	4.3±1.5^{b}
Sweet almond	2.0	17.7±2.9^{b}	9.7±1.2^{b}
	4.0	4.7±2.0^{cd}	6.0±1.5^{b}
	6.0	4.3±0.7^{cd}	3.7±0.7^{b}
Untreated control	0.0	141.0±9.2^{a}	705.7±10.7^{a}

Means followed by different letters in the same column differ significantly at $p < 0.05$ according to Tukey-Kramer's (HSD) test.

The mean percentage seed damage and *weight loss* of cowpea seeds infested by *C. maculatus* is presented in Table 3. The result *showed that all treatments were effective against the attack of C. maculatus*. The *highest percentage seeds damage was recorded in untreated control (87.8%) which was* significantly different ($p < 0.05$) from the treated seeds. *Among the three essential oils tested sweet almond at (6.0 ml/100g) was found to be the most protective by recording (7.4%) seeds damaged which was* significantly different ($p < 0.05$) from the untreated control. Similarly, the mean weight loss in the different treatments of the essential oils were not significantly different ($p > 0.05$) from each other. However, the highest mean weight loss of (9.3%) was recorded on seeds treated with coriander at (2.0 ml/100 g) then followed by sweet almond (8.6%) at (2.0 ml/100 g) and the lowest was at sweet almond (5.6%) at (4.0 ml/100 g) which was significantly different ($p < 0.05$) from the untreated control (Table 3).

Table 3: Percentage seed damage and *weight loss* of cowpea seeds infested by *C. maculatus*

Treatment	Dosage (ml/100g seed)	Mean percentage seed (±SE)	
		damage	weight loss
Coriander	2.0	10.6±0.6^{bc}	9.3±1.8^{b}
	4.0	9.1±0.6^{bc}	8.2±1.0^{b}
	6.0	10.6±0.7^{bc}	7.6±0.5^{b}
Fennel	2.0	8.4±1.5^{bc}	7.0±0.4^{b}
	4.0	8.6±1.1^{bc}	7.8±0.8^{b}
	6.0	9.3±0.5^{bc}	7.3±0.8^{b}
Sweet almond	2.0	13.0±1.5^{b}	8.6±1.5^{b}
	4.0	8.4±0.1^{bc}	5.6±1.0^{b}
	6.0	7.4±0.1^{c}	7.1±0.7^{b}
Untreated control	0.0	87.8±2.0^{a}	58.2±1.6^{a}

Means followed by different letters in the same column differ significantly at $p < 0.05$ according to Tukey-Kramer's (HSD) test.

Mean percentage germination of cowpea seeds treated with *the essential oils from* coriander, fennel and sweet almond is presented in Tables 4. The results showed that the germination of cowpea seeds was significantly affected by the essential oils treatment as lowest germination percentage were recorded in the treated seeds. There was significant difference ($p < 0.05$) in germination percent between the untreated control and treated seeds, germination percent of cowpea seeds ranged from (3.3%) in the highest dosage (6 ml/100g) of essential oils from coriander then followed by (4.0%) in the highest dosage (6 ml/100g) of essential oil from sweet almond. The highest (20.6%) germination percentage was recorded in the untreated control, which was significantly different ($p < 0.05$) from the treated seeds.

Table 4: Mean percentage germination of cowpea seeds treated with *the essential oils from* Coriander, Fennel and Sweet almond

Treatment	Dosage (ml/100g seed)	Mean percentage seed germination (±SE)
Coriander	2.0	14.6±1.7^{b}
	4.0	6.0±1.1^{c}
	6.0	3.3±0.6^{c}
Fennel	2.0	10.0±1.1^{b}
	4.0	7.3±3.5^{c}
	6.0	13.5±5.2^{b}
Sweet almond	2.0	11.3±1.3^{b}
	4.0	4.6±1.3^{c}
	6.0	4.0±1.1^{c}
Untreated control	0.0	20.6±2.3^{a}

Means followed by different letters in the same column differ significantly at $p < 0.05$ according to Tukey-Kramer's (HSD) test.

DISCUSSION

All the oils from the plants tested showed some level of toxicity against adults *C. maculatus* which vary with the dosage and the exposure periods. It is clear that the essential oils at the rates of 4ml and 6ml/100g are the most toxic against adults *C. maculatus.* This result suggests that *essential oils from* coriander, fennel and sweet almond could be successfully used for the control of *C. maculatus* and may serve as alternative to the synthetic insecticides. This may be attributed to the coating of the seeds by the essential oils which prevent contact between the seeds and the insects, leading to starvation and subsequent death of the insects. The results are in agreement with previous studies (Al-Jabr, 2006; Islam *et al*., 2009; Ebadollahi, 2011; Heydarzade and Moravvej, 2012; Ghanem *et al*., 2013; Eljazi *et al*., 2017) which demonstrated the insecticidal activity of essential oils from coriander, fennel and sweet almond against several stored product insects. *These essential oils* cause symptoms such as hyperactivity, seizures, and tremors followed by paralysis (knock down) which are very similar to those produced by synthetic insecticides such as organophosphates and carbamates (Kostyukovsky *et al*., 2002).

Adults *C. maculatus* emergence in treated seeds was significantly lower ($p < 0.05$) as against the adult emergence in the untreated control. This may be attributed the toxicity of the essential oils on the treated seeds which leads to the laying of fewer eggs as well as these essential oils may restrict movement of *C. maculatus* and which subsequently affected copulation and oviposition. Also, the oils may block the insect spiracle leading to asphyxiation and death. High doses of ***Cymbopogon martinii*** oil significantly inhibited oviposition and reduced adult emergence by *Callosobruchus chinensis (Kumar et al., 2007*) Essential oil from *Ocimum basilicum, Acorus calamus, Thuja occidentails, Thymus vulgaris, Tagetes bipinata* and *Origanum majorana reduced the* number of emerged adults on cowpea seeds with increasing concentrations of essential oils (Baskaran *et al*., 2010). They also agree with Wahba *et al*. (2018) that high concentration of eugenol, isoeugenol, carvacrol and thymol; a monoterpenoid compounds derived from essential oils reduced *C. maculatus* adult emergence on cowpea seeds.

Seed damage and weight loss caused by *C. maculatus* was significantly reduced in all treatments compared to the untreated control and these demonstrated that the essential oils protect cowpea seeds against *C. maculatus* infestation, suppress adult emergence and also reduce seed damage and weight loss. These may also suggest toxicidal, ovicidal, larvicidal and antifeedant activities of these essential oils. Eessential oils of orange peel reduced seed weight loss in haricot bean caused by *Zabrotes subfasciatus (*Dawit and Bekele (2010). Also, neem seed powder, citrus peel powder and their oil extracts were effective against *S. zeamais* on local and improved varieties of sorghum, when used at 0.75, 1 and 1.5 ml. They also reduced seed damage and weight loss caused by *S. zeamais* and were comparable with Malathion 5% dust (Gebreegziabiher *et al*. (2017). Alabi and Adewole (2017) reported that *essential oil* from *Moringa oleifera (Lam.) roots* applied at dosages of 0.5 l, 1.0 l, 1.5 and 2.0 ml protected cowpea seeds against damage and weight loss caused by *C. maculatus.*

The germination of cowpea seeds treated with essential oils from coriander, fennel and sweet almond were not significantly different from each other. The treatments with essential oils reduced germination of cowpea seeds compared to untreated control. The study indicated that coriander, fennel and sweet almond *essential oils* inhibited germination of cowpea seeds, which could be attributed to the volatile constituent present in these essential oils which showed inhibitory effect on germination of cowpea seeds. Eessential oil of *Ocimum suave* (Willd) reduced the germination of maize seeds (Adgeh, 1994). Amri *et al*. (***2013) reported that the*** *presence of monoterpenes and sesquiterpenes in essential oils could be linked to phytotoxicity,* germination inhibition and reduced seedling growth *of* some weeds and cultivated crops. Also, Ajayi *et al*. (2014) observed that the essential oil constituent, carvacrol, 1-8-cineole and eugenol applied at 10 and 20 µl/L reduced cowpea seeds germination and seedling growth. Arora *et al*. (2015) who evaluated the *allelopathic potential of the essential oil of Tagetes minuta* l. *against Chenopodium murale* L., *Phalaris minor* Retz. and *Amaranthus viridis* L. and the result showed that the volatile oil of *T. minuta* significantly reduced the germination, growth, chlorophyll content and respiratory ability of recipient weeds in a dose dependent manner. Similarly, the untreated control had significantly lower germination percentage and this may be attributed to the higher number of emergence holes as well as depletion of the available nutrients in the seeds by developing the larvae which resulted in lower seed germination.

CONCLUSION

Present study showed that essential oil of coriander, fennel and sweet almond are toxic against *C. maculatus* in a dose dependent way; that is higher dosage was more toxic than low dosage. Therefore, these essential oils can be used effectively in protecting cowpea seeds against infestation by *C. maculatus* and can be used as an alternative to synthetic chemical insecticides. Further studies are required to develop appropriate technology for the extraction of essential oils at farm level and for large scale application of these essential oils.

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