Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

J E Z S Journal of Entomology and Zoology Studies

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2018; 6(2): 3111-3118

Received: 08-01-2018
Accepted: 09-02-2018

Sherin Megahed Mohamed Youssif Helaly
Zagazig University, Faculty of Agriculture, Department, Plant Protection, Zagazig -Egypt

Correspondence
Sherin Megahed Mohamed Youssif Helaly
Zagazig University, Faculty of Agriculture, Department, Plant Protection, Zagazig -Egypt

Insecticidal and biological effects of four plant oils on the cowpea beetle, *Callosobruchus maculatus* (F.)

Sherin Megahed Mohamed Youssif Helaly

Abstract
Four types of plant oils (fenugreek, jojoba, sweet almond and moringa) were evaluated for their effectiveness against adults of the cowpea beetle, *Callosobruchus maculatus* (F.) under constant conditions at 29 ±1 ºC and 70 ± 5% RH. Eight concentrations of each oil (1, 5, 10, 15, 20, 25, 30 and 35% v/v) were tested on adult mortality percentage and some biological effects. The obtained results showed that the percentage of adult mortality increased by increasing both of concentration of the tested plant oil and exposure period. Generally, jojoba oil was the most effective plant oil against C. *maculatus* recording the highest percentage of adult mortality (56.67, 80.00 and 63.33%) regardless of the concentration after 24, 48 and 72 hr. post – treatment. The highest percentage of egg hatchability (84.64%) was recorded with the control, while the lowest one (0.00%) was observed in seeds treated with fenugreek oil (at 35% concentration), jojoba oil (at 25, 30 and 35% concentrations), sweet almond oil (at 35% concentration) and moringa oil (at 25, 30 and 35% concentrations). There was no larval penetration (0.00) into cowpea seeds treated with all tested plant oils at the concentrations 25, 30 and 35%, compared with (64.51%) in control. The maximum of reduction in F_1 adult emergence (100.00) was observed with all tested oils at the concentrations 25, 30 and 35%.

Keywords: Plant oils, fenugreek, jojoba, sweet almond, moringa, cowpea beetle, *Callosobruchus maculatus* (F.), mortality percentage, biological effects

1. Introduction
Cowpea [*Vigna unguiculata* (L.) Walp.] is one of the most sources of dietary protein and essential nutrients. This crop is an important legume in many developing countries Adam and Baidoo [1]. It is very popular and unique in that it produced food for man and fodder for livestock. It suffers heavily from insects, both in the field and when seeds are stored after harvest. Yield reductions caused by insects can reach as high as 95%, depending on location, year and cultivar.

The main pests during the growing season are the aphids, while the main storage pests are the bruchids. Among the important insect pests of stored seeds, the cowpea beetle, *Callosobruchus maculatus* (F.). The economic importance of this insect pest in our country dose not need any emphasis as it is considered one of the major pests of leguminous seeds. Moreover, this species is world – wide in distribution, being found wherever legumes are stored. Reports by IITA [2] showed that *C. maculatus* consumed 50- 90% of cowpea in storage annually throughout tropical Africa. The bruchid infestation also affected seed quality, market value and reduced cowpea seed viability to 2% after 3 months of storage (Caswell [3]; and [4]; Ofuya and Gedland [5]. So, preservation of the quality of seeds for the following year is one of the worrying problems of farmers. Several methods are used in controlling insects in stored grains, including physical (smoking, sun-drying, heating) cultural biological (male insect sterilization, natural enemies, resistant grain varieties) and chemical (synthetic and natural products) methods. The most common and widely used is the chemical method involving mainly the use of synthetic insecticides. The use of synthetic insecticides is the most popular, their use is so desired due to the quicker and the complete protection it offers against diverse storage insect pests. However, the indiscriminate use of pesticides especially by grain merchants and farmers to protect grains in storage with its attendant adverse effects on man, the environment, non – target organisms as well as the evolution of resistant strains of insect pests has been a serious draw back to their use Dauda *et al.* [6].

Therefore, there is a need to develop safe alternatives control strategies that will be affordable and eco- friendly becomes expedient such as using some plant oils. The use of botanical pesticides to protect plants from pest is very promising because of several distinct advantages Parugrug and Roxas [7]. Many researches have evaluated plant oils as botanical insecticides and grain protectants and found them to be effective against storage beetles (Oparaeke *et al.* [8]; Oparaeke and Bunmi [9]. Hence, the current study was designed to investigate the effects of four plant oils; moringa oil, fenugreek oil, jojoba oil and sweet almond oil on the mortality of adults, some biological aspects and infestation parameters of the cowpea seed bruchid, *C. maculatus*.

2. Materials and Methods

The present investigation was carried out in Plant Protection Department, Faculty of Agriculture, Zagazig University during 2017.

2.1 Insect Culture

The insects used in this work were obtained from laboratory cultures. Cultures of *Callosobruchus maculatus* (F.) were setup by introducing newly emerged beetles in half – kg glass jars, half filled with previously sterilized and conditioned cowpes seeds *Vigna ungiculata* L. (Fitriat variety) and tightly covered with muslin, held in place by rubber bands and allowed to oviposit for 3 days at which time the adults are removed with a sieve. The glass jars were labelled and kept in an electrical incubator at 29 ± 1 ºC and 70 ± 5% RH. Cowpea seeds were brought from a local market in Zagazig, Egypt after ensuring they were not treated. The seeds were cleaned from dirts and sterilized by freezing in a refrigator for at least fourteen days to eliminate possible hidden infestation and developing stages of any insect pest (Obeng – Ofori [10]; Udo [11].

2.2 Tested plant essential oils

Four essential oils [fenugreek (*Trigonella foenum* Linn.), jojoba (*Simmondisa chinensis* Link.), sweet almond (*Prunus amygdalus* Mill.) and moringa (*Moringa oleifera* Adans.)] were tested in this study. All tested plant oils were concentrated 100%. Two of them were obtained from Industrial Zone – Al Asher of Ramadan – Cairo – Egypt (fenugreek and sweet almond), the third from El- Hawag Company – Badr city – Cairo (jojoba) and the last one (moringa) was obtained in the form of seeds and the seeds were extracted for oil as follows: extraction of the *Moringa oleifera* fixed oil was performed at room temperature using crushed seeds without kernel. Where, the dry powder seeds were steeped in petroleum – ether (60/ 80%) for one week. The petroleum – ether extract of moringa was filtered over anhydrous sodium sulphate. A rotary evaporator apparatus was used to remove the solvent; the oil was stored in dark brown bottles at 4˚C until use.

2.3 Surface Contact Treatment

Eight dilutions of each oil (1, 5, 10, 15, 20, 25, 30 and 35% v/v) were prepared in acetone. Aliquots of 2.5 ml of each dilution were sprayed on twenty five grams of cowpea seeds to achieve homogeneous distribution and the cowpea seeds were shaken throughly to obtain uniform oil coverage. Also, a control test (acetone instead of tested botanical materials) was used. Tests were repeated three times. The solvent evaporated in a few minutes leaving a thin film of the volatile oil on the external surface of seeds. After treatment, the treated seeds were put in half kg jar and the five pairs of *C. maculatus* newly emerged adults (0 – 24 hours old) were introduced into the jar and tightly covered with muslin, held in place by rubber bands and kept in an electrical incubator at 29 ± 1 ºC and 70 ± 5% RH. Data were collected daily on insect mortality till complete kill, even in the control. Percentage mortality was calculated using the following formula:

$$\text{Percentage mortality} = \frac{\text{No. of dead insects}}{\text{Total number of insects}} \text{ x100}$$

The total number of eggs laid, percentage of egg hatchability and the number of penetrated larvae into seeds were counted at all treatments after complete kill, even in the control. The seeds were then kept to observe the total number of emerged adults (F_1). Number of total seeds, uninfested seeds, infested seeds and number of holes were determined for each replicate. After adult emergence, the efficacy of plant oils against the insect infestation was determined by calculating the weight loss (%) and percentage of oviposition deterrence (POD) was calculated by the following formula given by Singh and Jakhmola [12]: POD = Cs – Ts / Cs × 100, where: Cs = number of eggs laid on control seeds, Ts= number of eggs laid on treated seeds. The percentage reduction in F_1 emerged adults (PRA) was calculated according to the following formula given by Singh and Jakhmola [12]: PRA = Ac – At / Ac ×100, Where: Ac = number of F_1 adults emerged from the control seeds, At= number of F_1 adults emerged from the treated seeds.

2.4 Statistical Analysis

All the obtained results were statistically analysed according to completely randomized plots design and factorial experiments. The appropriate methods were used for the analysis of data according to Little and Hills [13] and the proper "F" value was calculated as described by Fisher [14] and Snedecor [15] SPSS 14.0 for windows software package was used through least significant range test (L.S.R.) of one – way ANOVA at $p<0.05$ Duncan [16].

3. Results and Discussion

The main objects of the present work included the preservative effect of some plant oils i.e, fenugreek, jojoba, sweet almond and moringa at different concentrations by spraying cowpea seeds against the adults of *Callosobruchus maculatus* (F.). The obtained results can be presented and discussed as follows:

3.1 Adult mortality percentage

Results of adult mortality percentage caused by the tested plant oils are presented in Table 1. The obtained results revealed that the percentage of adult mortality 24 hr. post-treatment increased by increasing both of the concentration of the tested plant oil used and exposure period. The highest percentage of adult mortality (100.00%) was recorded at 35% concentration, when cowpea seeds were treated with sweet almond oil, while the lowest one (0.00%) was recorded at 1% concentration, when the seeds treated with fenugreek oil or sweet almond oil as well as in control experiment. After 48 hr. of exposure, the highest percentage mortality (100.00%) was recorded when cowpea seeds were sprayed with fenugreek oil (at 30 and 35% concentrations), jojoba oil (at 15, 20, 25, 30 and 35% concentrations) and moringa oil (at 25, 30 and 35% concentrations) and the lowest percentage (0.00%) was similar with that recorded after 24 hr in case of both fenugreek and sweet almond treatments. In case of 72 hr. post- treatment, the highest percent (100.00%) was noticed at

30% on cowpea seeds treated with sweet almond oil, while the lowest one (0.00%) was recorded with 0 concentrations (control). By comparing the tested plant oils regardless of the tested concentrations, it is worthy to mention generally that jojoba oil was the best (most effective) plant oil recording the highest percentage of adult mortality (56.67, 80.00 and 63.33%) regardless of the concentration after 24, 48 and 72 hr. post treatment. Irrespective of tested concentration and exposure period, the tested plant oils can be arranged descending according their efficiency against cowpea beetle adults as follows: jojoba, moringa, fenugreek and sweet almond showing 71.74, 65.83, 55.07 and 52.36% adult mortality. Statistical analysis showed that the differences between treatments were highly significant between adult mortality percentages as regards both concentration of oils and exposure period after treatment.

The present results are confirmed by those obtained by Al-Jabr [17] stated that the mortality percentage of *Oryzaephilus surinamensis* and *Tribolium castaneum* increased with exposure time of the same concentration. Bamaiyi and Zarafi [18] indicated that there was 100% mortality of *C. maculatus* at 24 hours after treatment with seed oil of mahogany at 1, 2 and 3 ml / 100 g of cowpea. Udo [19] in Nigeria who found that adult mortality of *C. maculatus* was observed in cowpea seeds treated with groundnut oil after 24 hours of application.

Table 1: Mortality percentages of the cowpea beetle, c*allosobruchus maculatus* (F.) adults 24, 48 and 72 hr. post – treatment with four plant oils under constant conditions of 29 ± 1 ºC and 70 ± 5% R H

Plant oil	Concentration (%)	Post – treatment period (by hours)			Mean
		24	48	72	
Fenugreek	1.0	0.00 m	0.00 j	3.33 ij	1.11
	5.0	13.33 klm	23.33 hi	33.33 gh	23.33
	10.0	26.67 ijkl	43.33 fg	66.67 de	45.56
	15.0	30.00 ijk	66.67 cd	70.00 de	55.56
	20.0	46.67 ghi	73.33 bc	80.00 bcd	66.67
	25.0	53.33 fgh	86.67 ab	90.00 abc	76.67
	30.0	66.67defg	100.00 a	-	83.34
	35.0	76.67bcde	100.00 a	-	88.34
Mean		39.17	61.67	57.22	55.07
Jojoba	1.0	13.33 klm	26.67 hi	43.33 fg	27.78
	5.0	26.67 ijkl	53.33 def	70.00 de	50.00
	10.0	36.67 hij	60.00 cde	76.67 cd	57.78
	15.0	56.67efgh	100.00 a	-	78.34
	20.0	63.33defg	100.00 a	-	81.67
	25.0	76.67bcde	100.00 a	-	88.34
	30.0	83.33abcd	100.00 a	-	91.67
	35.0	96.67 ab	100.00 a	-	98.34
Mean		56.67	80.00	63.33	71.74
Sweet almond	1.0	0.00 m	0.00 j	3.33 ij	1.11
	5.0	6.67 lm	13.33 ij	20.00 hi	13.33
	10.0	10.00 klm	16.67 i	30.00 gh	18.89
	15.0	13.33 klm	46.6 efg	66.67 de	42.22
	20.0	40.00 hi	63.33 cd	93.33 abc	65.55
	25.0	70.00 cdef	90.00 a	96.67 ab	85.56
	30.0	83.33abcd	93.33 a	100.00 a	92.22
	35.0	100.00 a	-	-	100.00
Mean		40.42	46.19	58.57	52.36
Moringa	1.0	13.33 klm	23.33 hi	40.00 fg	25.55
	5.0	16.67jklm	33.33 gh	53.33 ef	34.44
	10.0	26.67 ijkl	36.67 gh	66.67 de	43.34
	15.0	46.67 ghi	66.67 cd	76.67 cd	63.34
	20.0	70.00 cdef	90.00 a	90.00 abc	83.33
	25.0	80.00abcd	100.00 a	-	90.00
	30.0	83.33abcd	100.00 a	-	91.67
	35.0	90.00 abc	100.00 a	-	95.00
Mean		53.33	68.75	65.33	65.83
Control	0.0	0.00 m	0.00 j	0.00 j	0.00
F. test		**	**	**	

- ** indicates highly significant differences between means at 0.01 level of probability.
- Means in each column followed by similar letters are statistically insignificant at 0.05 level of probability.

3.2 Toxicity of the tested plant oils

Data presented in Table 2 and illustrated graphically in Fig. 1, 2 and 3 show the toxicity of four plant oils (jojoba, moringa, fenugreek and sweet almond) against the adult of cowpea beetle after 24, 48 and 72 hr. post – treatment. According to LC_{50}, jojoba was the most effective oil recording the lowest values of LC_{50} of 12.019, 4.69 and 1.482 after 24, 48 and 72 hr., respectively. Respecting the values of LC_{90} of the tested oils, it was found that the lowest values of LC_{90} of 32.715 (sweet almond oil), 32.136 (sweet almond oil) and 31.930 (fenugreek oil) after 24, 48 and 72 hr., successively. On the other hand, at LC_{90} toxicity level the efficacy of the tested plant oils somewhat varied to obviously show the highest effective oils were sweet almond after 24 and 48 hr. post – treatment (32.715 and 32.136, consecutively) and fenugreek after 72 hr. exposure (31.930). The slope values of the tested oils varied and ranged between 2.051 (jojoba) – 7.058 (sweet almond), 32.136 (sweet almond) – 455.371 (moringa) and

0.778 (moringa) – 2.563 (sweet almond) after 24, 48 and 72 hr., respectively. As regards the toxicity index, it is obvious that jojoba oil was the superior toxicant against the adults of *C. maculatus* after 24, 48 and 72 hr. post – treatment recording 100% toxicity index. On the contrary sweet almond oil proved to be have the least efficiency revealing the lowest toxicity indices of 55.809, 28.764 and 12.232 for the three tested exposure periods, successively.

Table 2: LC values of some plant oils against the cowpea beetle, *Collosobruchus maculatus* (F.) adults 24, 48and 72 hr. post – treatment with the tested plant oils under constant conditions of 29 ± 1 ºC and 70 ± 5% R H

Post – treatment period (by hours)	Plant oil	LC_{50}	LC_{90}	Slope	Toxicity index
24	Jojoba	12.019	50.668	2.051	100.000
	Moringa	15.081	34.657	3.547	79.696
	Fenugreek	20.794	67.098	2.519	57.800
	Sweet almond	21.536	32.715	7.058	55.809
48	Jojoba	4.690	125.560	0.989	100.000
	Moringa	11.449	455.371	0.801	40.964
	Fenugreek	9.397	38.173	2.105	49.910
	Sweet almond	16.305	32.136	4.349	28.764
72	Jojoba	1.482	37.253	0.915	100.000
	Moringa	2.555	113.375	0.778	58.004
	Fenugreek	7.502	31.930	2.038	19.755
	Sweet almond	12.116	38.323	2.563	12.232

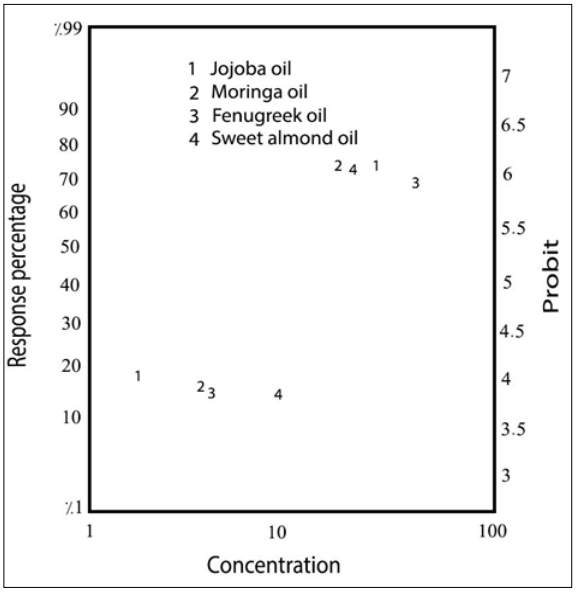

Fig 1: Toxicity lines of some plant oils against the cowpea beetle, *Callosobruchus maculatus* (F.) adults 24 hr. post –treatment under constant conditions of 29 ± 1 ºC and 70 ± 5% R H

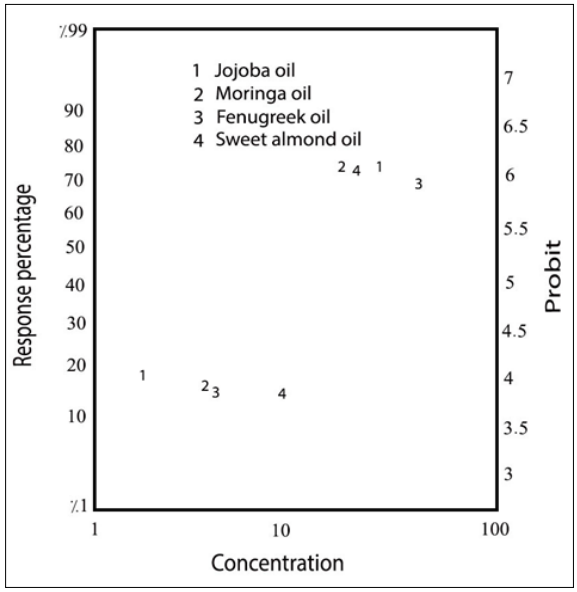

Fig 2: Toxicity lines of some plant oils against the cowpea beetle, *Collosobruchus maculatus* (F.) adults 84 hr. post – treatment under constant conditions of 29 ± 1 ºC and 70 ± 5% RH

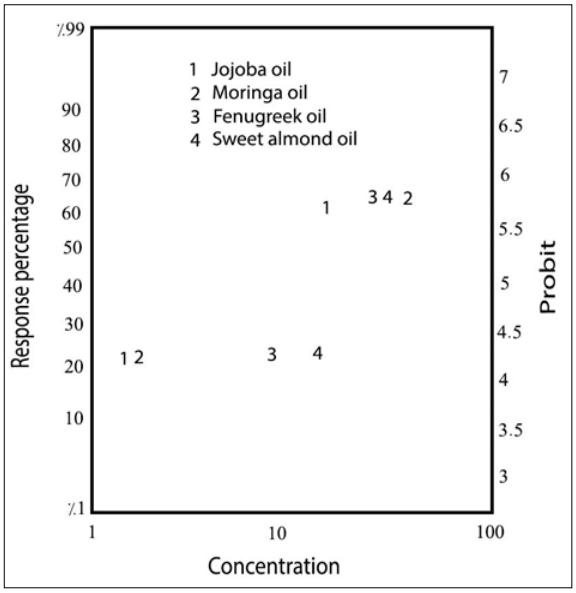

Fig 3: Toxicity lines of some plant oils against the cowpea beetle, *Collosobruchus maculatus* (F.) adults 72 hr. post – treatment under constant conditions of 29 ± 1 ºC and 70 ± 5% RH

3.3 Biological effects

3.3.1 Percentage of egg hatchability

From the results complied in Table 3, it is evident that the percentage of egg hatchability decreased by raising the concentration used, the highest percentages (84.64, 85.14 and 88.06%) were recorded with 0 concentration (control), 1.0% concentration of sweet almond and fenugreek, respectively, while the lowest one (0.001%) was observed in seeds treated with fenugreek oil (at 35% concentration), jojoba oil (at 25, 30 and 35% concentrations), sweet almond oil (at 35% concentration) and moringa oil (at 25, 30 and 35% concentrations). Among the four plant oils, seeds coated with jojoba oil caused maximum decrease in the percentage of egg hatchability followed by moringa, fenugreek and sweet almond oils regardless of the tested concentration. Statistical analysis of variance using F. test proved that there were highly significant differences between the means as concerns the percentage of egg hatchability occurred with different tested concentrations.

3.3.2 Percentage of larval penetration

As evidently shown in Table 3, it is worthy to mention that the percentage of larval penetration differed in the tested plant oils, and there was no penetration (0.00%) into cowpea seeds treated with all tested plant oils at the concentrations 25, 30 and 35%, compared with (64.51%) in control. According to F. test, it is obvious that the differences between the means were statistically highly significant at 0.01 level of probability.

3.3.3 Percentage of oviposition deterrence

Data tabulated in Table 3 evidently cleared that increasing concentration for the tested plant oils from 0 to 1.0, 5.0, 10.0, 15.0, 20.0, 25.0, 30.0 and 35.0% caused approximately a gradual increase in the percentage of oviposition deterrence. The highest percentage of oviposition deterrence (100.00%) in respect of cowpea beetle adult was recorded in seeds treated with fenugreek oil (at 35% concentration),

Table 3: Effect of four plant oils on some biological aspects of the cowpea beetle, *Callosobruchus maculatus* (F.) under constant conditions of 29 ± 1 ºC and 70 ± 5% RH.

Plant oil	Concentration (%)	Egg hatchability (%)	Larval penetration (%)	Percentage of oviposition deterrence (POD)	Percentage reduction in F_1 adult (PRA)
Fenugreek	1.0	88.06 a	73.68 a	66.07 no	67.19 gh
	5.0	72.90 abcd	70.09 ab	75.32 kl	81.67 e
	10.0	51.62 efgh	60.71 bcdef	80.00 ijk	90.06 bc
	15.0	53.10 defgh	63.13 abcd	87.04 fgh	94.14 abc
	20.0	38.33 ghij	27.31 jk	90.40 defg	97.47 a
	25.0	26.87 ijk	0.00 m	93.99 bcd	100.00 a
	30.0	11.11 kl	0.00 m	98.94 ab	100.00 a
	35.0	0.00 l	0.00 m	100.00 a	100.00 a
Mean		42.75	36.87	86.47	91.32
Jojoba	1.0	65.99 bcdef	49.25 efghi	70.76 lmn	82.55 de
	5.0	45.19 fghi	44.89 ghi	78.99 ijk	93.51 abc
	10.0	38.97 ghij	39.53 ij	86.90 gh	96.69 a
	15.0	34.72 hij	38.89 ij	94.79 bcd	98.65 a
	20.0	32.03 hijk	13.89 l	94.01 bcd	99.35 a
	25.0	0.00 l	0.00 m	99.83 a	100.00 a
	30.0	0.00 1	0.00 m	100.00 a	100.00 a
	35.0	0.00 l	0.00 m	100.00 a	100.00 a
Mean		27.11	23.31	90.66	96.34
Sweet almond	1.0	85.14 ab	66.40 abc	52.05 q	48.92 i
	5.0	84.15 ab	59.45 bcd	59.72 p	64.34 h
	10.0	76.44 abc	53.35 defgh	63.14 op	73.27 fg
	15.0	73.33 abcd	53.12 defgh	71.83 lm	82.70 de
	20.0	44.44 ghi	48.15 fghi	83.47 hi	94.40 abc
	25.0	37.26 ghij	0.00m	93.00 cde	100.00 a
	30.0	18.57 jkl	0.00 m	96.00 abc	100.00 a
	35.0	0.00 l	0.00 m	98.64 ab	100.00a
Mean		52.42	35.06	77.23	82.95
Moringa	1.0	74.11 abcd	61.73 abcde	68.26 mn	74.04 f
	5.0	57.39 cdefg	55.37 cdefg	77.96 jk	88.64 cd
	10.0	45.40 fghi	43.70 ghi	82.96 hij	95.71 ab
	15.0	46.51 efghi	42.04 hi	88.67 efg	97.13 a
	20.0	34.44 hij	26.11 kl	92.05 cdef	98.91 a
	25.0	0.00 l	0.00 m	99.01 ab	100.00 a
	30.0	0.00 l	0.00 m	100.00 a	100.00 a
	35.0	0.00 l	0.00 m	100.00 a	100.00 a
Mean		32.23	28.62	88.61	94.30
Control	0.0	84.64 ab	64.51 abcd	-	-
F. test		**	**	**	**

- ** indicates highly significant differences between means at 0.01 level of probability.
- Means in each column followed by similar letters are statistically insignificant at 0.05 level of probability.

Jojoba oil (at 30 and 35% concentrations) and moringa oil (at 30 and 35% concentrations). The results showed that jojoba oil at all concentrations used gave the highest percentage of oviposition deterrence indicating the general mean of 90.66% irrespective of tested concentrations. Statistical analysis of variance using F. test cleared that there are highly significant differences between the concentrations of the four plant oils.

3.3.4 Percentage reduction in F_1 adults

Results on reduction in F_1 adult emergence of the cowpea beetle, *C. maculatus* are presented in Table 3. The F_1 emergence of adult beetles was found to be reduced in oil treatments. The maximum reduction in F_1 adult emergence (100.00%) was observed in all tested plant oils at the concentrations 25, 30 and 35%. Generally, the tested plant oils can be descendingly arranged according to their effect on the reduction in F_1 adults as follows: 96.34%, 94.30%, 91.32% and 82.95% for jojoba, moringa, fenugreek and sweet almond oils, respectively. Statistical analysis appeared that there were highly significant differences between the plant oils respecting the percentage reduction in F_1 adult emergence at 0.01 level of probability.

These findings are in harmony with those recorded by several authors such as Carlos and Cardona [20] who stated that groundnut oil proved to have an ovicidal action against *C. maculatus*. The authors also, suggested that eggs mortality was caused by the physical properties of oil owing to coating and blocking respiration rather than specific chemical effect. Also, Raja *et al.* [21] reported that the leaf extract of *Azadirachta indica* and *Jatropha curcas* showed oviposition detterence and antifeedant activity as well as reduction of the adult emergence of *C. maculatus*. Rao and Sharma [22] observed the ovicidal effect of seed ethyl acetate and hexane extracts of custard apple on rice moth and revealed that these were the most effective effects in causing ova mortality. As well as, with those obtained by Chudasama *et al.* [23] who mentioned that among different aqueous extracts of plant materials, custard apple seed extract at 5% concentration showed the maximum percentage of oviposition deterrence and the maximum adult emergence of *C. maculatus*.

3.4 Infestation parameters

3.4.1 Percentage of weight loss

Considering the percentage of weight loss of cowpea seeds when treated with the tested plant oils, the results presented in Table 4 obviously demonstrate that statistical analysis of variance showed that the differences between these plant oils concerning this infestation parameter proved to be highly significant at 0.01 level of probability. The results showed that no seed loss was observed at the highest concentrations of all tested oils (25, 30 and 35% concentration), while the highest average percentage of weight loss (8.69%) was recorded in untreated seeds (control).

3.4.2 Percentage of infested seeds

As clearly shown from the results given in Table 4, the percentage of infested seeds which treated with four plant oils at different concentrations varied into the treatments showing a wide range from 0.00% for all tested plant oils at the concentrations 25, 30 and 35% to 56.32% for control treatment. The other tested concentrations showed intermediate percentage of infested seeds between the abovementioned infestation levels. Regardless of the presence of the wide range of differences between the tested oils at different concentrations respecting the percentage of infested seeds as a measure of infestation, statistical analysis of variance demonstrated that these differences indicated highly significant degree at 0.01 level of probability.

3.4.3 Number of holes per 25 g seeds

Results tabulated in Table 4 obviously showed that mean number of holes / 25 g seeds decreased by increasing the concentration of the plant oil used. The lowest one (0.00 hole per 25 g seeds) was recorded at the concentrations 25, 30 and 35% of all tested oils and the highest mean (96.33 holes per 25 g seeds) was recorded in untreated seeds (control). Statistical analysis of variance appeared that there were highly significant differences between the plant oils in respect to the number of holes per 25 g seeds.

Table 4: Effect of four plant oils on some infestation parameters of the cowpea beetle, *Callosobruchus maculatus* (F.) under constant conditions of 29 ± 1 ºC and 70 ± 5% R H.

Plant oil	Concentration (%)	Weight loss (%)	% of infested seeds	No. of holes/ 25 g seeds
Fenugreek	1.0	6.68 b	22.01 b	31.00 c
	5.0	3.95 def	10.76 d	17.00 de
	10.0	2.56 ghi	5.57 fg	9.00 efg
	15.0	1.79 hij	2.90 ghi	5.67 fg
	20.0	0.89 jklm	1.58 hi	2.00 fg
	25.0	0.00 m	0.00 i	0.00 g
	30.0	0.00 m	0.00 i	0.00 g
	35.0	0.00 m	0.00 i	0.00 g
Mean		1.98	5.35	8.08
Jojoba	1.0	2.81 fgh	11.29 d	16.33 de
	5.0	3.37 efg	3.62 gh	6.00 fg
	10.0	1.39 ijkl	1.86 hi	3.00 fg
	15.0	0.88 jklm	1.06 hi	1.33 g
	20.0	0.20 lm	0.53 i	0.67 g
	25.0	0.00 m	0.00 i	0.00 g
	30.0	0.00 m	0.00 i	0.00 g
	35.0	0.00 m	0.00 i	0.00 g
Mean		1.08	2.30	3.42
Sweet almond	1.0	8.49 a	35.02 a	47.33 b
	5.0	6.00 bc	24.79 b	33.33 c
	10.0	5.10 cd	17.83 c	25.00 cd
	15.0	3.49 efg	10.26 de	16.33 de
	20.0	1.65 hijk	2.68 ghi	5.00 fg
	25.0	0.00 m	0.00 i	0.00 g
	30.0	0.00 m	0.00 i	0.00 g
	35.0	0.00 m	0.00 i	0.00 g
Mean		3.09	11.32	15.87

Moringa	1.0	4.29 de	17.41 c	24.67 cd
	5.0	8.89 defg	7.45 ef	10.67 ef
	10.0	1.83 hij	2.86 ghi	4.33 fg
	15.0	0.91 jklm	1.85 hi	2.67 fg
	20.0	0.36 klm	0.77 hi	1.00 g
	25.0	0.00 m	0.00 i	0.00 g
	30.0	0.00 m	0.00 i	0.00 g
	35.0	0.00 m	0.00 i	0.00 g
Mean		2.04	3.79	5.42
Control	0.0	8.69 a	56.32 a	96.33 a
F. test		**	**	**

- ** indicates highly significant differences between means at 0.01 level of probability.
- Means in each column followed by similar letters are statistically insignificant at 0.05 level of probability.

These results are in agreement with those obtained by some investigators for instance, Pandey *et al.* [24] who found that essential oils based formulations exhibited efficiency as botanical fumigants in the protection of stored pigeon pea seeds up to six months by enhancing feeding deterrence and reducing seed damage as well as weight loss caused by *C. chinensis* and *C. maculatus*. Wahedi *et al.* [25] cleared that neem seed extract significantly prevented emergence of F_1 adults of *C. maculatus* and no subsequent weight loss done due pest. Also, Ibrahim and Aliyu [26] showed that the lowest mean number of holes was recorded in cowpea seeds treated with African nutmeg oil and moringa seed oil. Chudasama *et al.* [23] mentioned that minimum weight loss percentage was observed in the cowpea seeds treated with custard apple seed extract at 5% dose level which recorded 79.20%.

4. Conclusion

Four types of plant oils (fenugreek, jojoba, sweet almond and moringa) were evaluated for their effectiveness against adults of the cowpea beetle, *Callosobruchus maculatus* (F.) under constant conditions at 29 ±1 ºC and 70 ± 5% RH. The obtained results showed that the percentage of adult mortality increased by increasing both of concentration of the tested plant oil and exposure period. Generally, jojoba oil was the most effective plant oil against C. *maculatus* recording the highest percentage of adult mortality (56.67, 80.00 and 63.33%) regardless of the concentration after 24, 48 and 72 hr. post – treatment.

5. Acknowledgement

Deep thanks and appreciation are due to Prof. Dr. Saad Salem Mohammed Hassanien for the revision of the manuscript.

6. Referencies

1. Adam JI, Baidoo PK. Susceptibility of five cowpea (*Vigna unguiculata*) varieties to attack by *Callosobruchus maculatus* (Fab.) (Coleoptera: Bruchidae). J Ghana Sci. Assoc. 2008; 10:85-92.
2. IITA. International Institute of Tropical Agriculture. Annual Report, 1988 / 89, Ibadan, Nigeria. 1989.
3. Caswell GH. A review of the work done in Entomology Section, Institute Agricultural Research on pests of stored grains. Samaru Miscellaneous Paper. 1980; 99:12.
4. Caswell GH. Damage to stored cowpea in the Northen part of Nigeria. Samaru Journal of Agricultural Research. 1981; 1:154-158.
5. Ofuya TI, Gedland PF. Response of three populations of the seed beetle, *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae) to seed resistance selected cowpea [*Vigna unguiculata* (L.) Walp.]. Journal of Stored Product Research. 1995; 31:17-27.
6. Dauda Z, Maina YT, Richard BI. Insecticidal activity of garlic [*Alium sativum* (L.)] oil on *Callosobruchus maculatus* in post – harvest cowpea [*Vigna unguiculata* (L.) Walp.]. Journal of Biology, Agriculture and Healthcare. 2012; 2(3):28-35.
7. Parugrug AM, Roxas C. Insecticidal action of five plants against maize weevil, *Sitophilus zeamais* Motsch, (Coleoptera: Curculionidae). King Mongkuts Institute of Technology Ladkrabang. Sci. Technology Journal. 2008; 8(1):24-38.
8. Oparaeke AM, Dike MC, Amatobi CL, Hammand W. Preliminary study on dove (*Eugenia caryphyllata* Thumb: Myrtaceae) as a source of insecticide; Niger. J Agric. Ext. 2001; 13(2):78-81.
9. Oparaeke AM, Bunmi OJ. Insecticidal potential of cashew, *Anarcardium occidentale* (L.) for the control of the beetle, *Callosobruchus maculatus* (Coleoptera: Bruchidae) on Bambra groundnut, *Voandzeia subtrranea* (L.), Verde Arch. Phytopathol. Plant Protection. 2006; 39:247-254.
10. Obeng - Ofori D. Plant oils as grain protectants against infestations of *Cryptolestes pusillus* and *Rhizopertha dominica* in stored grain. Entomologia Experimentalis et Applicata. 1995; 77:133-139.
11. Udo IO. Efficacy of plant parts of dragon and wood – oil – nut trees against maize weevil (*Sitophilus zeamais* Motsch.) and cowpea weevil (Callosobruchus *maculatus* F.). Ph.D. Thesis, Rivers State University of Science and Technology, Port Harcourt, Nigeria. 2008, 164.
12. Singh P, Jakhmola SS. Efficacy of botanical extracts on biological activities of pulse beetle *Callosobruchus maculatus* (Fab.) on green gram. Trends in Biosciences. 2011; 4(1):25-30.
13. Little TM, Hills FJ. Statistical Methods in Agricultural Research. Available from U.C.D. Book Store, University of California, Davis. 1975, 241.
14. Fisher RA. Statistical Methods for Research Workers. Oliver and Boyed, Edinburgh and London. 1944.
15. Snedecor GW. Statistical Methods Applied to Experiments in Agriculture and Biology. The Iowa State College Press, Amer., Iowa. 1957; 5th Ed.
16. Duncan DB. Multiple range and multiple F. tests. Biometrics. 1955; 11:1-42.
17. Al - Jabr AM. Toxicity and repellency of seven plant essential oils to *Oryzaephilus surinamensis* (Coleoptera: Silvanidae) and *Tribolium castaneum* (Coleoptera: Tenebrionidae). Scientific Journal of King Faisal University. 2006; 7(1):49-60.
18. Bamaiyi LJ, Zarafi AB. Control of *Callosobruchus maculatus* (Fab.) (Coleoptera: Bruchidae) on stored cowpea with *Mahogany khaya senegalensis* (Devs.) seed products. Samaru J Agric. Res., 2006; 22:51-57.
19. Udo IO. Protectant effect of plant oils against cowpea

weevil (*Callosobruchus maculatus*) on stored cowpea (*Vigna unguiculata*). ARPN Journal of Agricultural and Biological Science. 2011; 6(12):58-61.
20. Carlos C, Cardona D. Control of ary seed weevils with cooking oil. J Agric. Puerto Univ. 1981; 65:295-298.
21. Raja N, Albert S, Ignacimuthu S, Ofuya TI, Dorn S. Role of botanical protectants and larval parasotoid *Dinarmus vagabundus* (Timberlake) (Hymenoptera: Pteromalidae) against *C. maculatus* (Fab.) (Coleoptera: Bruchidae) infesting cowpea seeds. Malaysian Applied Biology. 2000; 29(1):255-260.
22. Rao NS, Sharma K. Ovicidal effect of seed extracts of custard apple on *Corcyra cephalonica* (Stainton) and *Trogoderma granarium* (Everts.). Pesticide Research Journal. 2007; 19(1):4-6.
23. Chudasama JA, Sagarka NB, Satyakumari S. Deterrent effect of plant extracts against *Callosobruchus maculatus* on stored cowpea in Saurashtra (Gujarat, India). Journal of Applied and Natural Science. 2015; 7(1):187-191.
24. Pandey AK, Pooja S, Palni UT, Tripathi NN. Use of essential oils of aromatic plants for the management of pigeon pea infestation by pulse bruchids during storage. J Agric. Technol. 2011; 7(6):1615-1624.
25. Wahedi JA, David LD, Edward A, Mshelmbula BP, Bullus A. Efficacy of seed powder and extracts of *Azadirachta indica* Linn. (Meliaceae) at graded levels on adult *Callosobruchus maculatus* (Coleoptera: Bruchidae) in nubi, north – eastern Nigeria. International Journal of Science and Nature, 2013; 4(1):138-141.
26. Ibrahim ND, Aliyu SM. Evaluation of plant seed oil and bitter leaf powder for their repellency and control of cowpea beetle (*Callosobruchus maculatus* Fab.) (Coleoptera: Bruchidae) in stored cowpea. Research Journal of Agriculture and Environmental Management. 2014; 3(8):370-375.