Insecticidal Activity of Pyridalyl, Spinosad Alone and Combined with Vegetable Oils on Growth Development and Reproductive Performance of *Callosobruchusuchus maculates* (F.)

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Abstract: The variations in efficacy of pyridalyl or /and spinosad either alone or combined with three vegetable oils (corn, sunflower and sesame) at mixing ratios of 99/1, 95/5 and 90/10(insecticide /oil) were evaluated on growth development and reproductive performance of cowpea beetle *Callosobruchus maculates* (F.). The results showed that the activity of pyridalyl or/and spinosad either alone or combined with the three vegetable oils was significantly increased, particularly at the highest concentration tested (1000_{ppm}) ,and that spinosad in combination with the three oils and in particular with sesame oil was significantly more effective in reducing number of deposited eggs, and F1 emerged adults whereas pyridalyl /corn and pyridalyl/ sunflower combinations were more effective than corresponding mixtures of spinosad in suppressing Hatchability percent. On the other hand spinosad/ oil combinations increased remarkably the duration of development period more then pyridalyl oil combinations. As for testing oils separately, sesame oil was more effective in reducing % hatchability and cowpea seeds weight loss %.while corn and sunflower oils significantly increased the duration of development period .However spinosad alone reduced each of number of deposited eggs and number of F1emerged adults more than pyridalyl. In general, using spinosad in mixtures with vegetable oils particularly at 100,500 and1000 $_{ppm}$ is quite effective, yielding minimum negligible weight loss in treated cowpea seeds.

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1. Introduction

The cowpea bruchid, *Callosobruchus maculatus* (Fabricius) is a major insect pest of stored legumes, in Africa and Asia .).The larval development of the insect occurred inside seeds of several leguminosae species (Ouedraogo *et al.,*1996). *C. maculatus* is a cosmopolitan field to store pest and ranked as the principal post –harvest pest of cowpea, *Vigna ungiculata* (Walp.) (Jackai and Daoust, 1986).It causes substantial quantitative and qualitative losses manifested by seed perforation, and reductions in weight market value and germinability of seeds (Sekou *et al.,*2001).The use of pesticides is one means of preventing some losses during storage. However, the choice of pesticides for storage pest control is very limited because of the strict requirements imposed for the safe use of synthetic insecticides on or near food. The continuous use of chemical pesticides for control of stored-grain pests has resulted in serious problems such as insecticide resistance (Pacheco *et al.,*1990; Sartori *et al.,*1990). Furthermore, the efficacy of insecticides against storage pests varies greatly after treatment (Suchita *et al.,*1989; Pinto *et al.,*1997).However; widespread environmental hazards have created the need for effective biodegradable pesticides (Elhag, 2000) instead for using of highly coasted synthetic insecticides.

In ancient times, oils obtained from locally available plants were used for stored grain protection against insects attack. In recent years, attention has been given to use of vegetable oils as stored grain protectants againsts (Verma and Pandy, 1978; Pandey *et al.,* 1981; Messina and Renwick, 1983; Pierrad 1986; Ahmed *et al.,*1988; Hall and Harman, 1991; Pacheco *et al.,*1995 Shaaya *et al.,*1997).Oils extracted from plants have been extensively used in tropical countries for crop protection (Singh *et al.,*1978;Dabire Â,1993;Ragapakse and Van Emden,1997).The mode of action of these oils is yet to be confirmed (Tembo and Murfitt,1995). But most appear to cause death of insect egg, larva or adult by suffocation (Hewett, 1975; Ivbijaro *et al.,*1984; Don perdro, 1989).The fact that most studies on the use of plant oils as proctectants of stored grain against insects have shown their action to be mainly against eggs and early larval stages restricts their use .The same author indicated that vegetable oils used alone were less effective than commercial insecticides and suggested the possibility of using vegetable oils in combination with synthetic insecticide in simple mixture as a mean of making their use more attractive and effective. In line with this hypothesis, earlier studies by Ahmed and Gardiner (1967) showed that dilute Malathion in oil was more effective than concentrated Malathion tropically applied on the desert locust.

Recently, Tembo and Murfitt (1995) also showed that wheat treated with vegetable oils combined with pirimiphos-methyl at half the recommended dose was effective as pirimiphos-methyl at the recommended dose against *S.granarius* (L.).

Accordingly., the present study was aimed at evaluating the efficacy of combining vegetable oils (corn, sunflower and sesame oils) and reduced- risk insecticides(spinosad and pyridalyl) that can be recommended as alternatives low cost technique of minimizing post-harvest losses of cowpea grain from the cowpea weevil *C. maculatus* infestation.

2.Materials and Methods

1: Test insect:

Cowpea beetles, *Calosubruchus maculatus* used in this study were obtained from the Department of Stored-Product Pests ,Plant Protection Research Institute, ARC, Dokki, where a standard culture has been maintained without exposure to insecticides for several years on cowpea seeds *V.unguiculata* L. and incubated in an environmental controlled conditions at 28±2C° and 65±5% RH. The cowpea seeds used for both insect culture and experiments were previously sterilized by freezing at -18C° for one week to kill off any prior insect infestation, then were stored in sealed polyethylene bags in refrigerator at 5C° until required for experiment (Abo Elghar *et al.,* 2003).

2:Insecticides and vegetable oils:

The naturally derived insecticide spinosad (Spinto 24%SC)and the newly developed insecticide pyridalyl (pleo,51812 50% EC),in addition to three locally produced plant oils named sunflower, corn and sesame oils were included in tests either alone or in binary mixtures with the fore- mentioned insecticides. The oils were obtained as refined oils from the local market.

3: Cowpea seeds:

Cowpea seeds used in this study were obtained with moisture content of approximately 13% as described by Mian and Mulla (1982) which is consistent with that normally required for storage. At this moisture level, the growth of fungi and other micro-organisms is almost completely suppressed (Leahey and Curl, 1982).

4: Preparing treatments:

For assessing the activity of each insecticide tested either separately or in binary mixture with vegetable oil, stock aquous solution of either the insecticide or and the oil alone or in mixture were prepared fresh daily on the basis of active ingredient. The tested mixing ratios of each mixture were 99:1, 95:5 and 90:10 (insecticide/oil).Serial dilutions of the stock of each treatment were prepared in distilled water to obtain the tested concentration i.e.10, 50,100,500 and 1000 ppm.

5:Treatment of cowpea seeds:

To treat the cowpea seeds, 80 g of seeds were placed in 1-1b glass jar. Ten milliliters of aqueous dispersion of the test compound(oil or insecticide or their mixture) at the concentration necessary to give the required deposit (mg Al/kg) was pipetted onto the seed surface and mixed thoroughly by shaking for ca 10 min (Onolemhemhem 2001)The treated seeds were spread over trays covered with polyethylene sheeting and left overnight to dry. A similar sample (80g) of untreated seeds were submerged in water to be use as control .The next day three samples of 20g/each of the treated seeds were transferred to Petri dishes (11 cm diameter).

6: Bioassay procedures:

Ten sexed pairs of *C. maculatus* adults (0-24h old) were released in each glass Petri dish (replicate) (11cm diameter) containing 20gm treated cowpea seeds and were allowed to lay eggs for 3 days .On the 4 the day adults were removed, and the number of eggs deposited on treated seeds in each dish were counted, to indicate the indirect effectiveness of the test treatments on adult fecundity. Three replicates per concentration / treatment were prepared. At the 9th day post- treatment the number of unhatched eggs was recorded and corrected for control response according to Abbott formula (Abbott, 1925) and accordingly hatchability percent was calculated.

The Petri –dishes containing infested- treated cowpea seeds were kept in the laboratory until the total emergence of adults of the 1st generation. The *C. maculatus* adults were counted daily from the beginning of the first insect emergence until 2 weeks later (Ouedraogo *et al.,* 1996).Also the developmental period was estimated from the time of egg laying up to the appearance of first adult .

7:Cowpea seeds weight loss:

After the emergence of adults, seeds were weighed after excluding the frass and dust. The weight loss was calculated according to Khare and Johari (1984) using the following equation:Weight loss % =

(Initial dry weight - final dry / Initial dry weight) ×100

8: Data analysis:

Mortality (unhatched) percentages of deposited eggs were corrected for natural mortality according to Abbott(1925) equation .The tested parameters includes : number of eggs laid/ female, hatchability percentage, number of emerged F1 adults, mean developmental period (days) and weight loss% of cowpea seeds. Data collected were subjected to statistical analysis of variance (ANOVA) test using a computer software SAS (SAS Institute 2000).

3. Results and Discussion

1. Effect of oils seperatly

1.1. Effect of oils on oviposition and hatchability:

Data in Table(1) indicate that all tested concentration of the three oils used in the study significantly inhibited the females *C. maculatus* from laying eggs on treated cowpea seeds, recording reduction ranged 88.82- 98.49; 80.31- 98.58; and 86.96- 98.13% for corn oil, sunflower oil and sesame oil, respectively at concentrations range of 10-1000 $_{ppm}$

The results were comparable with findings of Srivastava *et al.*(1988) who reported that eucalyptus oil effectively prevented the oviposition of insects and that of Mulatu and Gebremedhim (2000) who showed that the oils *A.indica* . *Milletiaie ferruginea* and *Chrysonthemun cineraraefolium* were highly effective in partially or completely preventing egg lying and pulse beetly F1 emergence from the laid eggs.

Further more, the viability (%hatching of the eggs) was significantly reduced compared with untreated check. However there were no significant differences between the lowest concentrations (10_{ppm}) and untreated control, while the higher concentration 50, 100, 500, and 1000 $_{ppm}$ showed significant differences, recording % hatchability of 90.73-79.06; 92.91-77.55; and 84.34-68.16% at 50-1000_{ppm} for corn oil, sunflower oil and sesam oil, respectively in comparison with untreated control (99.80%).The hatching rate of eggs decreased dramatically as the concentrations of oils increased. However highly significant were recorded in hatchability percentages between treated (50-1000_{ppm}) and untreated as well as between the concentrations. In general sesame oil showed strong indirect ovicidal effect on the eggs hatchability% than the other two oils recording 68.16% at 1000_{ppm} compared significantly by 77.55% and 79.06% for sunflower, and corn oil, respectively.

The eggs mortality and failure to hatch on the seeds treated with oil has been attributed to either the toxic component of the oil and also to the physical properties which cause changes in surface tension and oxygen tension within the eggs (Singh , 1978). Also, oil extracts of plants reduce oviposition rate and suppress adult emergence of bruchids and also reduce seed damage rate (Tapondjou *et al.,* 2002, Swella and Mushobozy, 2007).

1.2. Effect of oils on progeny emergence:

The mean number of F1emerged adults differed significantly between the oils-treatments and untreated, while there were mostly no significant differences between all treated concentrations (10-1000_{ppm}).The lowest mean number of F1 emerged adults was recorded significantly in sunflower oil treatments 1.33-5.67 adults at (1000-10_{ppm}) compared with a significantly the highest mean number of 206.67 adults recorded in untreated. Ahmed *et al.* (1999) found that the neem and sesame oils completely inhibited the survival of immature stages of *C.chinesis* as well as adult emergence and appeared to be most promising as seed protectant against the insect.

In explanation the oil coating the seed may prevent *C. maculatus* eggs to firmly attach to the seed coat which can inhibit larval penetration into seed (Adebowale and Adedire, 2006) and this can prevent adult emergence. Similarly Low-Ogbomo and Egharvbe (2006) found lower adult weevil emergence (6.3%) in grain treated with vegetable oils compared with 88.2% for untreated grain. Also castor oil among other five studied plant oils, acted as a surface protectants against *C. maculatus* population growth by reducing the seed damage rate and the number of F1 adults that emerged (Rahman and Talukder ,2006).

1.3. Effect of oils on developmental period:

The duration of development from egg to adult was significantly affected in oils treatments compared with untreated check. The longest duration(34 days) was recorded in corn oil at 1000_{ppm} whereas the shortest duration was reached in sesame oil (26.67 days) at 10_{ppm} and corn oil (27.67 days) at 10_{ppm} as well as in untreated (27.33days).

1.4. Effect of oils on weight loss:

The data presented in table (1) indicate that the loss weight percent in oil treatment was significantly low compared with untreated control. The weight loss reached 12.67-0.67%; 15.8 - 8.37%; 13.5-2.37% in corn oil, sunflower oil and sesame oil, respectively at 10-1000_{ppm} concentration. Corn oil seemed to be most effective in protecting cowpea seed and resulting significantly in the least loss weight percent particularly at concentrations 500 and1000_{ppm}.

The low grain damage in oil treatments might be due to the decrease in number of adult emergence that results in less weight loss and less kernel damage

(Vijaya and Khader, 1990 and Pimentel,1990). Recently Swella and Mushobozy(2007)observed that coconut oil provided the best protection of natural products against *C. maculatus* .Furthermore, previous studies indicated that saturated oil such as castor and palm oil are known to remain on the seed surface, hence giving a better control of bruchid (Hall and Harman,1991;Akintobi and Adebisi,2001). However, highly unsaturated lipids penetrate the testas and accumulate on the cotyledon surface, whereas saturated lipids solidify on the seed surface. They do not penetrate the seed and thus remain on the surface where they coat well the bruchid eggs surface cutting off oxygen supply to the eggs embryo causing suffocation and hence death of eggs(ovicidal effect).

2. Effect of insecticides seperately.

2.1. Effect of insecticides on fecundity and eggs hatchability:

The results (Table 2) showed a significant reduction% in the number of eggs laid by each adult female on cowpea seeds treated with pyridalyl or spinosad, the reduction reached 70.74-88.65% for pyridalyl and 76.86-96.09% for spinosad, at concentration range of 10-1000$_{ppm}$ respectively. Hatching rate of the eggs in all concentrations of pyridalyl and also at 100,500 and 1000$_{ppm}$ of spinosad differed significantly than untreated check pyridalyl treatments were significantly more effective than spinosad treatments at 10 and 50 $_{ppm}$ .The lowest percentage of hatchability (54.82%) was recorded at the highest conc. (1000$_{ppm}$) of pyridalyl.

In agreement spinosad affected and suppressed the eggs to adult emergence of *Rhyzopertha dominica* and *Plodia interpunctella* insects (Huang and Subramanyam, 2004).The spinosad has also an effect on the *Deudorix livia* eggs hatchability percent (Temerak and Sayed, 2001).

2.2. The effect of insecticides on F1 emerged adults:

As for the mean number of F1 emerged adults it differed significantly between the treated by either pyridalyl or spinosad and untreated (F=51.42) check where there were no significant differences between all tested concentrations. The lowest mean number of F1 emerged adults was significantly recorded in 500, 1000 $_{ppm}$ of spinosad and 1000$_{ppm}$ of pyridalyl, compared to the highest mean number recorded in untreated check. Previous results of Fang *et al.*(2002) revealed that spinosad killed all exposed *R. dominica* adults and significantly suppressed progeny production by 84-100%. Also spinosad was extremely effective against *Plodia interpunctella* on wheat and suppressed the egg to adult emergence by 93 %(Huang and Subramanyan. 2004).

2.3. Effect of insecticides on development duration:

The duration of life cycle, egg to adult, in pyridalyl and spinosad showed significant differences between the untreated and the treated concentrations. Moreover, results indicated a significant difference in development period between the treatments. The duration of developmental period was shortened significantly (26.67 day and 27.0 day) for pyridalyl and spinosad at lowest concentration (10$_{ppm}$) while the duration at the highest concentration (1000$_{ppm}$) was longer (31.0and 30.67 days) for pyridalyl and spinosad, respectively. In agreement Mohamed *et al.* (2004) indicated that the larval duration of *Agrotis ipsilon* differed between the spinosad- treated and untreated.

2.4. Effect of insecticides on weight loss:

Weight loss of the seeds caused by *C. maculatus* internally feeding was significantly low in all concentrations of pyridalyl (13.67- 4.33%) and spinosad (17.0-6.67%) treatments compared to the untreated seeds (44%). On the other hand there are negative relations between the concentration and weight loss percentage, with more seed protection occurs in the high concentration. These results agree with Mohamed *et al.* (2009) .Indicating that the weight loss was reduced drastically in avermectin treatments and recording high protection of the legume seed against *C.maculatus*. Previous studies by Vijaya and Khader (1990) and Pimentel (1990) indicated that the low grain damage in oil treatments might be due to the decrease in number of emerged adults that results in less weight loss and less kernel damage.

3- Combined action of insecticides and different oils on *C. maculatus*:

3.1. Effect of combinations on oviposition and hatchability:

The results (Table3) showed that mean number of eggs laid / female exposed to insecticide / oil combinations was significantly reduced than untreated .All combinations were more effective at 90/10 (insecticide/oil) mixing ratio, having reduction percent of 98.45% followed by 96.13 at 95/5 and 85.46% at 99:1 ratio for pyridalyl+ corn oil at the high concentration (1000$_{ppm}$) . Combinations of other oils with insecticides at different concentrations performed similarly. In general, it obvious that combination of spinosad were more effective than those of pyridalyl regardless the combined oil and also that those of sesame oil was more effective when combined with both insecticides than the other two oils.

As for the effect of combination on hatchability

(Table 4) it was obvious that the lowest hatchability percent or/and the highest unhatched percent was demonstrated at concentration of 1000_{ppm} in all combinations. Combinations of pyridalyl with corn oil or sunflower oil resulted in lower% hatchability than when spinosad was combined with the same oils. On contrary mixing spinosad with sesame oil resulted in % hatchability lower than pyridalyl / sesame oil combination. In general hatchability was reduced remarkably in combinations at mixing ratio of 90:10 (insecticide/ oil) than the two other mixing ratios (95:5 and 99:1).Similar performance was recorded for both insecticides in combinations with the three tested oil at different concentrations.

3.2. Effect of combinations on F1 progeny emergence:

Oil / insecticide combinations significantly reduced F1 progeny emergence (Table5). The mean number of emerged progeny (F1 adults) recorded for the untreated was 206.67 adults. The mean number after combinations treatments was significantly decreased as the tested concentrations increased .The results showed that spinosad combined with oils were more effective than pyridalyl / oil combinations and also that insecticide/sunflower combinations were more effective than insecticide with other oil and recording a lower number of F1 adults.

3.3. Effect of combinations on development duration:

The results showed that treatment with insecticide/oil combinations exhibited variable effects on development duration of *C. maculatus* from egg to adult (Table 6).The development duration was 27.33 day for untreated control. Development duration was significantly longer for spinosad / sesam combinations recording 34.33, 35.67 and 36 day at 1000 $_{ppm}$ when combined at 99:1, 95:5 and 90:10 spinosad / sesame oil, respectively. Similar performance was achieved in combinations of sunflower oil and corn oil. In general pyridalyl/ sunflower oil combinations recorded the shortest duration recording 25, 25 and 25.33 day for 1000 $_{ppm}$ at mixing ratios of 99:1, 95:5 and 90:10 respectively

3.4. Effect of combinations on seed weight loss:

Weight loss% of the seeds caused by *C.Maculatus* feeding internally was significantly low in all combinations treatments compared to untreated seeds (44%). However, the weight loss decreased clearly as the concentration of combinations increased, indicating a negative relation between the concentrations and the weight loss percentage and more seed protection. It was obvious that combinations of sesame oil and sunflower oil with spinosad at 90:10 ratio for concentrations of 100,500 and 1000 $_{ppm}$ showed no weight loss indicating complete protection of treated seeds. Generally spinosad/ oil combinations were significantly more effective than pyridalyl/ oil combinations particularly at mixing ratio 90/10(Ins. /oil).

Tembo and Murfitt (1995) observed that vegetable oil (groundnut, rape seed and sunflower) at 10 ml-1 kg when were tested alone and in combination with pirimiphos- methyl at 1/2, 1/3 or 1/4 recommended dosage against *Sitophilus granarius* (L.) caused significant mortality compared to control, (untreated grain).Also, Sridevi and Dhingra (1996, 1999, 2000) evaluated the variation in the efficacy of deltamethrim formulated alone and in combination with five non-toxic vegetable oils, viz., sesame, karanj (*Pongmia pinnata*) ,neem and citronella (Cymbopogon nardus) oil in four ratios (1:1, 1:2, 1:4, 1:8) against the adults of susceptible and resistant strains of *T. castaneum* by direct spray and film residue methods and observed that all the vegetable oils proved additive when combined with deltamethrin except neem oil which showed antagonistic effect against the s- strain of *T. castaneum* .

Generally, based on results obtained by the present study it was observed the use of vegetable plant oils has demonstrated a potent activity against *Callasobruchus maculate* (F.)which can be useful in short listing the oil as an alternative source of botanical pesticide .On the other hand the application of insecticide/ oil mixture may minimize insecticide usage and hence reduce health hazards to applicators and reduce the amount of insecticide used to protect stored products. Furthermore, the use of reduced rate of oils when combined with insecticide will make their utilization more economical and attractive. However treatment of grains with vegetable oil/ insecticide mixtures could have important practical applications in parts of the world where insecticides are expensive or where vegetable oils are readily available.

In addition, one of the main advantages is that plant oils are more readily biodegradable; they may be easily and cheaply produced by farmers and small scale industries as crude or partially purified extracts. Though, application of plant oils to common bean seeds for storage is an inexpensive and effective technique leading to acceptance of this technology by farmers. Also, it could be very useful as components of integrated storage pest management in reducing post harvest losses experienced by resource- poor farmers.

Table (1) : Effect of vegetable oils on fecundity, hatchability, development period, F1 emerged adults, and food consumption of *C.maculatus* fed on treated cowpea.

Conc. ppm	No. of deposite Egg/female (% Reduction)	Hatchability %	F1 emerged adults	Development period(days)	Weight loss(%)
Untreated	376 a	99.80a	206.67a	27.33hi	44a
Corn oil					
10	42 b (88.82)	92.92abc	72.33b	27.67ghi	12.67bc
50	20 b (94.68)	90.73bcd	28.67cd	30cd	5cde
100	11.33 b (96.98)	90.50bcd	27cd	31.67b	4.67cde
500	8.67 b (97.69)	.79.06e	21.67cd	32b	1.33e
1000	5.67 b (98.49)	84.06bcde	16cd	34a	0.67e
Sunflower oil					
10	44 b (80.31)	93.33ab	5.67d	28fgh	15.80b
50	35 b (90.69)	92.91abcd	4.67d	29def	13.47bc
100	15 b (96.01)	92.08bcde	2d	29.67de	13.22bc
500	6.33 b (98.31)	77.55e	1.33d	30cd	11.43bcd
1000	5.33 b (98.58)	84.76bcde	1.33d	31bc	8.37bcde
Sesame oil					
10	49 b (86.96)	93.51 ab	34.33 c	26.67 i	13.50 bc
50	34 b (90.95)	84.34 cde	23 cd	27.67 ghi	10.13 bcde
100	20 b (95.68)	83.34 de	20.67 cd	28 fgh	7.07 bcde
500	17 b (95.47)	78.15 e	3 cd	28.67 efg	6.63 bcde
1000	7 b (98.13)	68.16 f	1.67 d	29.67 de	2.37 de
F-value	29.96	9.32	39.51	33.22	11.36
LSD(0.05)	47.31	7.58	23.25	0.99	8.6

Table (2) : Effect of Pyridalyl and Spinosad on fecundity, hatchability, development period, F1 emerged adults, and food consumption of *C.maculatus* fed on treated cowpea.

Conc. ppm	No. of deposite egg /female (% Reduction)	Hatchability (%)	F1 emerged adults	Development period(days)	Weight loss(%)
Untreated	376 a	99.80a	206.67a	27.33hi	44a
Pyridalyl					
10	110 b (70.74)	78.39 d	28.67 bcd	26.67 h	13.67 bcd
50	80 bc (78.72)	71.95 d	28.67 bcd	28 efg	8.33 def
100	74 bc (80.13)	70.48 d	18.33 bcd	29 cde	6 f
500	62.67 bc (83.33)	68.78 d	9 cd	29.67 bc	4.67 f
1000	42.66 bc (88.65)	54.82 e	7.33 d	31 a	4.33 f
Spinosad					
10	87 bc (76.86)	93.25 ab	37.33 b	27 gh	17 b
50	57.33 bc (84.75)	88.19 abc	34.33 be	28.33 def	15 bc
100	30.67 c (91.84)	81.46 bcd	15.33 bcd	29.33 bc	12 bcde
500	28 c (92.55)	76.13 cd	3 d	30 abc	9.33 cdef
1000	14 c (96.09)	68.99 d	1.67 d	30.67 ab	6.67 ef
F-value	21.59	10.53	51.42	17.85	37.53
LSD(0.05)	62.99	11.51	23.78	1.02	5.35

Table (3): Mean number of eggs and percentage reduction in oviposition of *C. maculatus* by different insecticide / oil combinations.

Conc. ppm	No. of deposite Egg / female (% Reduction)					
	Corn oil		Sunflower oil		Sesame oil	
	Pyridalyl	Spinosad	Pyridalyl	Spinosad	Pyridalyl	Spinosad
Untreated	376 a	376 a	376 a	376 a	376 a	376 a
99:1 (Ins. / oil)						
10	195.67 b(47.96)	105 b(72. 07)	220 b(41.48)	126.33 b(66.40)	66 b(82.44)	40 b(89.36)
50	145.33bcd (61.34)	65 bc (82.71)	179 bc (52.39)	72 bcde (80.85)	57.33 b (84.75)	28 b(.92.55)
100	104 cde (72.34)	39 cd (89.62)	139 cde (63.03)	45 def (.88.03)	51.67 b (86.25)	22 b (94.14)
500	51.67 efg (85.46)	35 cd (90.69)	117 cdef (68.88)	30 ef (92.02)	38.67 b (92.37)	18.67 b(95.03)
1000	51.67 efg (85.46)	15 cd (96.01)	90 defgh (76.06)	16 ef (95.74)	20.33 b (94.59)	14.67 b (96.09)
95:5 (Ins. / oil)						
10	169.67 bc (54.87)	99 b (73.67)	149 bcd (60.37)	104 bc (72.34)	59.67 b (84.13)	26 b (93.08)

50	103.33 cde (72.51)	69 bc (81.64)	98 defg (73.93)	63 cde (83.24)	51.67 b (86.25)	20.67 b (94.68)
100	80.33 defg (78.63)	35 cd (90.69)	67.33 defg (82.09)	42 def (88.82)	51.67 b (86.25)	20 b (94.68)
500	48 defg (87.23)	18 cd (95.21)	45 fgh (88.03)	20 ef (94.86)	37.33 b(90.07)	18 b (95.21)
1000	7 g (96.13)	15 cd (92.81)	27 gh (92.81)	10 f (97.34)	13.33 b (96.45)	8.97 b (97.61)
90:10 (Ins. / oil)						
10	153.33 bcd (59.22)	95 b (74.73)	139 cde (63.03)	99 bcd (73.67)	54.67 b (85.46)	20 b (94.68)
50	88.33 def (76.50)	29 cd (92.28)	60 efgh (84.04)	49 cdef (60.37)	13 b (96.54)	16 b (95.74)
100	60 defg (84.04)	21 cd (94.41)	34 gh (90.95)	19 ef (94.94)	8.67 b (97.69)	14.67 b (96.09)
500	13.33 fg (96.45)	13 cd (96.54)	28 gh (92.55)	14 ef (96.27)	4 b (98.93)	6.67 b (98.22)
1000	4 g (98.45)	6 d (98.40)	13.67 g (96.36)	4 f (98.93)	4 b (98.93)	6 b (98.40)
F-value	15.43	27.79	13.68	25.07	22.84	27.76
LSD(0.05)	68.23	48.77	72.11	51.75	52.96	49.06

Table (4): Percentage hatchability of eggs deposited by *C. maculatus* in different insecticide / oil combinations.

Conc. ppm	Hatchability %					
	Corn oil		Sunflower oil		Sesame oil	
	Pyridalyl	Spinosad	Pyridalyl	Spinosad	Pyridalyl	Spinosad
Untreated	99.80 a	99.80 a	99.80 a	99.80 a	99.80 a	99.80 a
99:1 (Ins. / oil)						
10	98.03 a	96.86 ab	92.6 ab	98.88 a	97.87 a	80 b
50	95.56 ab	95.94 b	90.26 abc	96.64 ab	96.95 a	78.77 bc
100	80.46 abc	93.86 bc	89.1 abc	95.63 ab	88.56 a	76.67 bc
500	78.87 abc	91.92 cd	83.94 abcd	90.72 abc	79.18 cde	68.92 bcd
1000	68.96 abc	81.68 gh	66.39 defg	81.30 fg	74.43 def	62.20 bcde
95:5 (Ins. / oil)						
10	96.05 ab	95.47 bc	90.21 abc	96.97 ab	96.99 a	67.81 bcd
50	81.38 abc	94.35 bc	84.43 abc	94.23 abc	81.35 bcd	67.78 bcd
100	80.29 abc	91.55 cde	80.11 abcd	88.81 cde	73.32 def	59.43 cdef
500	76.80 abc	84.81 fg	72.74 cdef	83.72 efg	71.16 efg	55.42 def
1000	62.81 bc	79.65 h	67.29 defg	79.38 g	68.36 fg	47.99 efg
90:10 (Ins. / oil)						
10	88.09 abc	95.21 bc	65.34 efg	88.79 cbe	82.73 bc	43.82 efgh
50	82.80 abc	88.98 de	65.01 efg	87.21 def	72.72 ef	40.69 fgh
100	78 abc	87.92 ef	58.32 fg	84.69 defg	72.11 ef	35.33 gh
500	68.89 abc	80.55 h	52.70 g	81.51 fg	67.97 fg	29.64 gh
1000	59.95 c	75.92 i	29.14 h	72.72 h	63.24 g	28.33 h
F-value	3.37	33.57	10.50	13.89	22.07	11.36
LSD(0.05)	19.13	3.56	16.21	6.09	7.35	17.28

Table (5) : Mean number of *C. maculatus* F1 adult emergence under different insecticide / oil combinations.

Conc. ppm	No. of Emerged adults					
	Corn oil		Sunflower oil		Sesame oil	
	Pyridalyl	Spinosad	Pyridalyl	Spinosad	Pyridalyl	Spinosad
Untreated	206.67 a	206.67 a	206.67 a	206.67 a	206.67 a	206.67 a
99:1 (Ins. / oil)						
10	113.67 b	72 b	83.33 b	63.33 b	150 b	79 b
50	73.67 bc	52 cd	52.33 bcd	38.33 c	115 cd	63 c
100	56 de	33.33 e	42 bcde	32 c	53.33 e	35.67 d
500	48.33 de	30.67 ef	40.33 cde	16 d	48.67 e	27.33 def
1000	23.33 efg	14.67 gh	36.33 cde	5.67 ef	30 efg	14 efgh
95:5 (Ins. / oil)						
10	103.33 bc	60.67 c	83 b	12.67 de	123.33 c	39 d
50	71 cd	48.33 d	52.33 bcd	6 ef	96 d	19 efgh
100	53.67 de	31.67 ef	24.67 cde	5.67 ef	43.67 ef	11.33 gh
500	10 fg	13.33 hi	18.33 de	5.33 ef	35.67 ef	9.33 gh
1000	6.33 g	8.67 hi	3.33 e	3.67 f	18.33 fgh	6 gh
90:10 (Ins. / oil)						
10	55.67 de	56.33 cd	65.67 bc	7 ef	9.67 gh	28.33 de
50	52.33 de	23 f	40.33 cde	5 ef	5.33 gh	21efg
100	36.33 defg	11.67 hi	22.67 de	4 f	4.33 gh	13 fgh
500	6.67 g	8.68 hi	12.67 de	2.67 f	2.33 h	7.67 gh
1000	2.67 g	4.67 i	2 e	1.67 f	2 h	4.67 h
F-value	16.67	262.64	14.42	419.13	59.95	117.17
LSD(0.05)	36.96	8.65	36.99	7.18	23.51	13.28

Table (6): Mean development period days of *C.maculatus* under different insecticide/oil combinations

con.ppm	development period(days)					
	Corn oil		Sunflower oil		Sesame oil	
	Pyridalyl	Spinosad	Pyridalyl	Spinosad	Pyridalyl	Spinosad
Untreated	27.33 a	27.33 j	27.33 cd	27.33 k	27.33 f	27.33 j
99:1 (Ins. / oil)						
10	22.67 f	29.33 hi	27.33 cd	30.33 j	27.33 f	29.67 i
50	24.33 e	30.67 gh	27 de	31 ij	28.33 de	31.33 gh
100	25 e	30.67 gh	26.33 e	32.33 fgh	29 cd	32.33 ef
500	25.33 de	31 fg	25.33 f	33.33cde	29.67 bc	33.33 cd
1000	26.33 cd	31.67 ef	25 f	34.33 ab	30 ab	34.33 b
95:5 (Ins. / oil)						
10	24.33 e	30 hi	29.33 a	30.33 j	27.33 f	30.67 h
50	25 e	31 fg	28 bc	31.67 hi	28.67 d	31.67 fg
100	26.33 cd	32 de	27.33 cd	33 def	29.67 bc	33 de
500	27.33 bc	33 c	26.33 e	33.67 bcd	30 ab	34.67 b
1000	28.33 b	33.33 bc	25 f	35 a	30.67 a	35.67 a
90:10 (Ins. / oil)						
10	24.33 e	31.33 efg	29.66 a	32 gh	27.67 ef	32.fg
50	25.33 de	32.67 cd	28.33 b	32.67 efg	28.33 de	33.33 cd
100	28 b	33.33 bc	28 bc	33.67 bcd	29 cd	34 bc
500	28.33 b	34 ab	27.33 cd	34 bc	30.33 ab	34.67 b
1000	29.33 a	34.33 a	25.33 f	35 a	30.67 a	36 a
F-value	32.52	37.62	27.20	53.66	17.07	62.67
LSD(0.05)	0.96	0.87	0.80	0.76	0.83	0.83

Table (7): Percentage weight loss of cowpea seeds treated with different insecticide/oil combinations.

	Weight loss (%)					
	Corn oil		Sunflower oil		Sesame oil	
	Pyridalyl	Spinosad	Pyridalyl	Spinosad	Pyridalyl	Spinosad
Untreated	44 a	44 a	44 a	44 a	44 a	44 a
99:1 (Ins. / oil)						
10	22 bc	13.83 b	26 b	17 b	20.87 b	8b
50	19.95 bc	11.30 b	20.50 bc	16.17 b	14.65 bcd	5.50 bcd
100	17.50 bcd	9.90 b	13.50 cde	15.50 b	12.47 bcde	4.67 cd
500	13.45 cdef	7.18 b	12 cdef	8.93 bcd	9.29 cdef	3.67 cde
1000	4.50 def	3.95 b	6.33 defg	7.87 bcd	3.50 ef	2.50 def
95:5 (Ins. / oil)						
10	27.1 b	12.25 b	16.33 bcd	15.63 b	15.43 b	6.33 bc
50	16.90 bcd	11.08 b	11.67 cdef	13.47 bc	11.10 cde	2.50 def
100	15.33 bcde	6.18 b	7.33 defg	9.20bcd	9.33 cdef	0.83 ef
500	13.15 cdef	6.58 b	7.33 defg	8 bcd	6.47 cdef	0.67 ef
1000	2.80 ef	3.20 b	4.50 efg	5.67 cd	2.87 ef	0 f
90:10 (Ins. / oil)						
10	14.13 bcde	10b	10.33 cdefg	12.10 bc	9.58 cdef	1.17 ef
50	12.25 cdef	7.50b	7.17 defg	4 cd	5.20 cdef	0.50 f
100	6 def	5 b	6.67 defg	0 d	6.33 cdef	0 f
500	3 ef	4.50 b	2 fg	0 d	5.18 def	0 f
1000	0 f	2.98 b	0 g	0 d	0.20 f	0 f
F-value	7.23	17.62	10.55	12.85	11.74	123.51
LSD(0.05)	11.70	6.64	9.56	8.47	8.61	2.77

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