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EFFICACY OF CERTAIN VEGETABLE OILS AS WHEAT GRAIN PROTECTANTS AGAINST THE LESSER GRAIN BORER, *Rhyzopertha dominica* (F.)

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ABSTRACT

The efficacy of ten vegetable oils namely cottonseed, sesame, castor, sunflower, lettuce, olive, soybean, fenugreek, maize and black cumin as wheat grain protectants against the lesser grain borer, *Rhyzopertha dominica* was studied. In treated surface tests, olive oil was the most potent at both LC_{50} and LC_{90} levels. These values were 3.5 and 5.9 μl/Petri dish. When wheat grains were treated with vegetable oils, sunflower and black cumin oils were the most effective against *R. dominica* at LC_{50} and LC_{90} levels, respectively. All concentrations of the different oils when mixed with wheat grains, caused significant reductions in progeny emergence. Progeny emergence was eliminated at the higher concentration (12 ml/kg) for all the oils, with the exception of olive oil which gave 97.86% control. The egg stage of *R. dominica* was the most highly affected by oil treatments followed by larval and pupal stages. All the tested oils with the exception of sunflower and soybean protected wheat grains against these insects up to 120 days. The germination of wheat grains treated with vegetable oils was not affected throughout 120 days storage after treatment.

Key words: *Rhyzopertha dominica, storage protection, vegetable oils, wheat grain.*

1. INTRODUCTION

Grains of different kinds and many stored products are considered important food sources for people, animals and birds. The insect infestation of stored grains and their products is a serious problem. The lesser grain borer, *Rhyzopertha dominica* (F.) is considered to be an important pest in stored grains. Although an increasing number of plant oils have been screened for use in preventing post-harvest losses due to insects, most of this work has demonstrated action against bruchid pests of cowpea or other pulses (Messina & Renwick 1983, El-Sayed 1986, Doharey *et al.*, 1988, Begum & Quiniones 1990, Risha *et al.*, 1993, Adebayo & Gbolade 1994, and Rajapakse & Vanemden 1997). However, Sighamony *et al.* (1986) showed that oils of clove, cedarwood and karanja protected wheat against *Sitoplilus oryzae* and *Rhyzopertha dominica*. Schmidt and Risha (1990) demonstrated that adults of *Tribolium confusum* and *Rhyzopertha dominica* were completely tolerant when exposed to vapors from the essential oil of *Acorus calamus*. Xu *et al.*, (1993) found that 0.2% cassia oil kept stored wheat free from insect damage caused by *Sitophilus zeamais* and *Rhyzopertha dominisca*. Xu *et al.*, (1994) indicated that the essential oil from *Calusena dunniana* was very effective against the stored product insect pests; *Sitophilus zeamais* and other species including *Tenelrio molitor* and *Rhyzopertha dominica*. Therefore, the present work aimed to investigate the efficiency of ten vegetable oils namely cottonseed, sesame, castor, sunflower, lettuce, olive, soybean, fenugreek, maize and black cumin oils as wheat grain protectants against the lesser grain borer, *Rhyzopertha dominica* (F).

2. MATERIALS AND METHODS

2.1. Test insect

The original culture of *Rhyzopertha dominica* was started with batches of adults from a laboratory strain maintained at the Plant

Protection Research Institute (Agriculture Research Center, Ministry of agriculture, Cairo, Egypt). Stock culture of the test insect was obtained by rearing on wheat (Sakha 69) in an incubator maintained at 28 ± 2°C and 60 ± 5% R.H.

2.2 The oils

The vegetable oils used were cottonseed, sesame, castor, sunflower, lettuce, olive, soybean, fenugreek, maize and black cumin. These oils were obtained from the local market.

2.3 Dry film method

This technique was carried out to evaluate the toxicity of the vegetable oils to the adult insect in the absence of wheat. Different concentrations of each oil in acetone were spread onto the inner surface of Petri dishes (7 cm dim.) and left to dry. Twenty adults of *R. dominica* (4-7 days old) were placed in each of the treated Petri dishes, covered and kept in an incubator maintained at 28 ± 2°C and 60 ± 5% R.H. Control was treated with acetone only. Three replicates were made for each treatment. Mortality counts were recorded after 24 h. Adult percent moralities were corrected using Abbott's formula (1925). The corrected percentage mortality was statistically computed according to Finney (1971).

2.4 Mixing the oils with wheat grains

2.4.1 Adult stage treatment

To determine the efficacy of the tested oils for protecting wheat grains from *R. dominica* attack, the appropriate dosage of each kind of oil was pipetted on quantities of 50g each of wheat grains in 250 ml glass jars and mixed manually for 7 minutes to ensure even coating of grains. Then, the grains were infested with twenty adults of *R. dominica* (4-7 days old) and covered with muslin cloth. Untreated wheat grains were used as control. Three replicates were made for each treatment. Treated and untreated jars were held in the same mentioned conditions. Dead adults were recorded 7 days after exposure. After 28 days all dead and live insects were removed. The total number of adult progeny that emerged 70 days after treatment was recorded. Mortality percentages were calculated and corrected according to Abbott's formula (1925) and statistically computed according to Finney (1971).

2.4.2 Immature stage treatment

Wheat grains (150g) were infested with 4-7 day old *R. dominica* adults (120 adults). After 24 h., the adults were removed and the grains were divided into three equal portions, which were treated with the LC_{90} for adult stage of each oil. The first portion was treated immediately to determine the effect on the egg stage. The second portion was treated 15 days after oviposition to determine the effect on the larval stage. The third portion was treated 28 days after oviposition to test the effect of the oils on the pupal stage. Untreated grains were kept as control for all tests. Three replicates were made for each treatment. The jars were held under the same mentioned conditions. The number of adult progeny was scored 6 weeks later. Percentage of reduction in adult emergence was determined according to Finney (1971).

2.4.3 Assay of residual activity

In order to study the residual activity of the tested oils against *R. dominica* after different storage periods of wheat grains, 750 g. wheat grains were treated with LC_{90} values for adult insects of each tested oil and kept in glass jars covered with muslin. The wheat grains were divided into five groups and stored for different periods under laboratory conditions. Untreated wheat grains served as control. Three replicates were made for each treatment. After each storage period (15, 30, 60, 90 and 120 days), twenty adults of *R. dominica* (4-7 days old) were introduced into the treated grains. The infested grains were kept in the incubator under the same conditions. All adults were removed after 30 days. The total number of adult progeny, which emerged 40, 55 and 70 days after infestation were separated and recorded. Percent reduction in the emerged adults was determined according to Finney (1971).

2.4.4 Effect of oils on wheat grain germination

Germination test was carried out according to Qi and Burkholder (1981). All data were statistically analyzed according to

Snedecor and Cochran (1981).

3. RESULTS

3.1 Toxicity of vegetable oils to the adult stage (dry film test)

Data presented in Table (1) show the LC_{50},LC_{90} and slope values of the tested vegetable oils against *R. dominica*. Olive oil was the most potent at both LC_{50} and LC_{90} levels. These values were 3.5 and 5.9 µl/Petri dish. The descending order of toxicity at LC_{50} level was as follows: olive, lettuce, cottonseed, sesame, soybean and black cumin, sunflower, maize, fenugreek and castor. On the basis of LC_{90}, the order of efficiency was as follows: olive, cottonseed , maize, black cumin,sunflower, soybean , lettuce, sesame followed closely by

Table (1): LC_{50}, LC_{90} and slope values of mortality regression lines for *Rhyzopertha dominica* one day after exposure to tested oils.

Oil source	LC_{50} (ul/Petri dish)*	LC_{90} (µl/Petri dish)	Slope
Cottonseed	4.2	6.2	7.78
Sesame	4.3	8.0	4.59
Castor	5.4	8.9	5.82
Sunflower	4.5	7.4	5.98
Lettuce	3.8	7.9	4.08
Olive	3.5	5.9	5.86
Soybean	4.4	7.8	5.00
Fenugreek	5.2	8.0	6.66
Maize	5.1	6.6	11.56
Black cumin	4.4	6.7	6.97

*Diameter of Petri dish = 7 cm

fenugreek and castor. Upon comparing the slope values of the toxicity lines, it is evident that maize oil recorded the steepest line (11.56) and that of lettuce oil recorded as the flattest one (4.08). The slope values of the other toxicity lines ranged between 4.59 and 7.78. It could be seen that the slope of all regression lines for adult insects was steep. The slope value is known to be very important feature of regression lines that is helpful in determining the exact reaction of a population (Hoskins and Gardon, 1956). These results indicate that *R. dominica* was homogenous in response to the tested oils.

3.2 Toxicity of oil treatment of wheat grains to the adult stage

3.2.1 Adult mortality

Data in Table (2) show the LC_{50}, LC_{90} and slope values of the different tested oils against the adults of *R. dominica.* To compare the efficiency of the tested vegetable oils as insecticides against *R. dominica,* the conventional insecticide malathion was tested and chosen as reference standard. The tested oils could be arranged according to their LC_{50}'s in the following descending order; sunflower, fenugreek, black cumin, castor, maize, lettuce, sesame, olive, soybean and cottonseed.

Table (2): Comparative toxicity of different vegetable oils and one conventional insecticide to adults of *Rhyzopertha dominica* exposed 7 days to treated wheat grains.

Oil source	LC_{50} ml/kg	LC_{90} ml/kg	Slope	Toxicity index at	
				LC_{50}	LC_{90}
Cottonseed	11.00	15.00	9.85	19.27	34.66
Sesame	9.00	13.50	7.12	23.55	38.51
Castor	6.80	9.50	8.75	31.17	54.73
Sunflower	5.10	10.50	3.95	41.56	49.52
Lettuce	8.90	13.00	7.56	23.82	40.00
Olive	9.20	13.50	7.83	23.04	38.51
Soybean	10.00	13.25	11.21	21.20	39.24
Fenugreek	5.8	14.00	3.42	36.55	37.14
Maize	8.30	16.00	4.45	25.54	32.50
Black cumin	6.10	9.40	6.93	34.75	55.31
Malathion	2.12	5.20	3.25	100.0	100.0

On the basis of LC_{90}, the order of efficiency was as follows: black cumin, castor, sunflower, lettuce, soybean, sesame and olive, fenugreek, cottonseed and maize. Based on the slope values of the toxicity lines, it is clear that soybean oil showed the steepest toxicity line (11.21) and that of fenugreek oil showed the flattest one (3.42). The slope values of the other eight oils lie between that of the two mentioned oils (3.95 to 9.85). The toxicity index suggested by Sun(1950) was used to compare the relative toxicity of the tested oils. Regarding the toxicity index using malathion as reference insecticide at LC_{50} level, sunflower oil was 41.56%. The toxicity of the other nine oils ranged from 19.27 to 36.55% as toxic as malathion. At LC_{90} level, black cumin and caster oils were 55.31% and 54.73% as toxic as malathion. The toxicity index of the other oils ranged between 32.50% and 49.52%.

3.2.2 Adult progeny

Data in Table (3) show that each of the tested vegetable oils when mixed with wheat grains at each concentration caused a high reduction in progeny emergence. For example, sesame, castor, fenugreek and black cumin oils at the rate of 8 ml/kg of wheat grain caused reductions in progeny emergence which reached 98.15, 97.27, 96.99 and 94.80%, respectively. Also, progeny emergence was eliminated at the higher concentration (12 mg/kg) for all the tested oils with the exception of olive oil that gave 97.86% reduction in progeny. Statistical analysis revealed that there were insignificant differences between the rates of each oil used in the number of progeny produced with the exception of castor, sunflower and black cumin oils.

All the tested oils significantly reduced the number of *R. dominica* progeny emerged compared with the control. Also the vegetable oils completely inhibited progeny emergence of *R. dominica* at the highest concent`ration 14 ml/kg.

3.3 Effect of oils on immature stages

The effect of the tested oils at the rates of LC_{90}'s for the adult was studied on egg, larval and pupal stages of *R. dominica*. The number of progeny emerged and percentages of reduction in emergence were the criteria used to determine the effect of the oils on

Table (3): Effect of treating wheat grains with vegetable oils at different concentrations on *Rhyzopertha dominica* progeny emergence.

Oil source	Mean number of progeny and their reduction at the concentrations						Control
	6 ml/kg		8 ml/kg		10 ml/kg		
	Mean No.	% Red.	Mean No.	% Red.	Mean No.	% Red.	
Cottonseed	-	-	15.00	92.46	3.33	98.31	199.0
Sesame	-	-	3.33	98.15	1.67	99.07	180.0
Castor	15.67	92.10	5.33	97.27	1.67	99.48	210.0
Sunflower	-	-	-	-	26.00	86.92	210.0
Lettuce	19.00	89.83	12.33	93.40	7.00	96.25	187.0
Olive	20.00	89.30	15.67	91.62	12.33	93.82	187.0
Soybean	-	-	19.33	90.29	15.67	92.14	188.0
Fenugreek	14.33	92.79	6.00	96.99	0.00	100.00	188.0
Maize	20.00	89.94	14.67	92.67	2.67	98.65	183.0
Black cumin	14.67	92.63	10.33	94.80	0.00	100.00	183.0

L.S.D. at 5% of average number of progeny = 51.48

the immature stages of *R. dominica*. Data given in Table (4) indicate that when oil treatments were applied 1, 15 and 28 days after oviposition, different levels of reduction in adult emergence were observed. All oil treatments showed complete protection for grains having 0-1 day old eggs except sunflower oil which gave 82.26%. With grains having the larval stage, the same level of protection was achieved with cottonseed, sesame and soybean oils only, whereas the remaining oils produced different numbers of progeny. Treatments of grains having the pupal stage resulted in reducing the insect progeny from 19.67 adults in the control treatment to 5.33, 7.00, 9.00, 12.00, 12.67, 12.67, 16.00, 16.67, 17.00 and 17.33 individuals with lettuce, olive, soybean, sesame, cottonseed, fenugreek, castor, sunflower, maize and black cumin, respectively. The results indicate that the egg stage of *R. dominica* was highly affected by oil treatment followed by

Larval and pupal stages. Statistical analysis revealed that there were significant differences in the average number of progeny, which emerged in the tested oil and control treatments. Pupal treatments showed significant differences between lettuce oil and all the tested oils except olive oil.

3.4 Residual activity of oils

Wheat grains were treated with the tested oils at LC_{90} for *R. dominica* adults to study their residual activities. Data presented in Table (5) show that all tested oils prevented any emergence of progeny for up to 30 days of storage after treatment with the exception of castor, sunflower and soybean oils. After 60 days of storage, sesame, lettuce, fenugreek, cottonseed, castor, maize, black cumin, olive, soybean and sunflower oils at the rates of LC_{90} values induced 100.0, 100.0, 100.0, 99.85, 99.77, 99.09, 99.09, 98.57, 87.50 and 51.58% reduction in emergence, respectively. At 90 days after storage, the percentages of reduction reached 100.0, 100.0, 99.49, 99.40, 99.27, 96.23, 99.01, 100.0, 83.32 and 21.24% with the same oils, respectively. The respective values for 120 days storage were 100.0, 97.37, 96.38, 94.74, 97.70, 92.77, 83.83, 96.47, 54.01 and 10.0%. The efficiency of the oils slightly decreased with increasing the duration of storage except with sunflower and soybean oils. However, insignificant differences in percentage reductions of progeny were noticed for each oil at the different storage durations. It could be concluded that all the tested oils with the exception of sunflower and soybean oils protected wheat grains from *R. dominica* up to 120 days.

3.5 Effect of oils on wheat grain germination

The germination of wheat grains treated with the vegetable oils at the rate of LC_{90} for *R. dominica* was not affected by storage for 120 days after treatment (Table 6). Statistically, the results proved that there were no significant differences between the treated grains and untreated control as well as between the treatments with the different oils.

Table (4): Effect of the tested oils on eggs, larval and pupal stages of *Rhyzopertha dominica.*

Oil source	LC_{90} (ml/kg)	Effect of tested oils on immature stages (Average number of progeny and their percent reduction)					
		Egg stage		Larval stage		Pupal stage	
		Av. No. of progeny	% Reduction	Av. No. of progeny	% Reduction	Av. No. of progeny	% Reduction
Cottonseed	15.00	0.00	100.00	0.00	100.00	12.67	35.55
Sesame	13.50	0.00	100.00	0.00	100.00	12.00	38.97
Castor	9.50	0.00	100.00	16.67	16.28	16.00	19.44
Sunflower	10.50	3.33	82.26	17.67	13.09	16.67	15.25
Lettuce	13.00	0.00	100.00	2.00	89.65	5.33	72.86
Olive	13.50	0.00	100.00	3.00	85.05	7.00	64.44
Soybean	13.25	0.00	100.00	0.00	100.00	9.00	54.18
Fenugreek	14.00	0.00	100.00	2.33	88.15	12.67	35.59
Maize	16.00	0.00	100.00	1.00	95.24	17.00	13.50
Black cumin	9.40	0.00	100.00	1.67	91.23	17.33	11.83
Control	-	18.83	-	20.00	-	19.67	-
L.S.D. at 5%	-	1.75	10.27	2.53	14.91	4.21	17.71

Table (5): Effect of treated grains storage duration on the efficiency of the different vegetable oils as grain protectants against *R. dominica*.

Oil source	LC_{90} (ml/kg)	Duration of storage after treatment (days)									
		15		30		60		90		120	
		Av.No.of progeny	% Reduction	Av.No.of progeny	% Reduction	Av.No.of progeny	% Reduction	Av.No.of progeny	% Reduction	Av.No.of progeny	% Reduction
Cottonseed	15.00	0.00	100.00	0.00	100.00	0.33	99.85	1.33	99.40	11.00	94.74
Sesame	13.50	0.00	100.00	0.00	100.00	0.00	100.00	0.00	100.00	0.00	100.00
Castor	9.50	0.00	100.00	0.00	99.74	0.33	99.77	1.67	99.27	5.00	97.70
Sunflower	10.50	20.00	82.90	34.00	81.84	83.00	51.58	170.00	21.24	189.67	10.00
Lettuce	13.00	0.00	100.00	0.00	100.00	0.00	100.00	0.00	100.00	5.67	97.37
Olive	13.50	0.00	100.00	0.00	100.00	3.00	98.57	0.00	100.00	7.33	96.47
Soybean	13.25	9.67	91.74	14.00	92.63	22.67	87.50	36.67	83.32	95.00	54.01
Fenugreek	14.00	0.00	100.00	0.00	100.00	0.00	100.00	1.00	99.49	7.67	96.38
Maize	16.00	0.00	100.00	0.00	100.00	1.67	99.09	8.00	96.23	15.00	92.77
Black cumin	9.40	0.00	100.00	0.00	100.00	1.67	99.09	2.00	99.01	34.00	83.83
Control	-	119.00	-	186.67	-	183.00	-	214.67	-	211.00	-
L.S.D. at 5%	-	10.87	4.92	26.00	1.00	39.17	21.43	23.71	6.09	19.71	9.11

Table (6): Percent germination of wheat grains treated with LC_{90}s of the tested vegetable oils for *R. dominica* and stored for 30-120 days.

Oil source	LC_{90} ml/kg	% Germination after different periods of storage (days)			
		30	60	90	120
Cottonseed	15.00	100.0	100.0	98.33	100.0
Sesame	13.00	98.33	96.67	96.67	95.00
Castor	9.50	91.67	96.67	98.33	95.00
Sunflower	10.50	96.67	93.33	96.76	100.0
Lettuce	13.00	95.00	93.33	93.33	95.00
Olive	13.50	90.00	90.00	90.00	91.67
Soybean	13.25	95.00	96.67	95.00	96.67
Fenugreek	14.00	91.67	100.0	98.33	95.00
Maize	16.00	93.33	95.00	98.33	93.33
Black cumin	9.40	96.67	93.33	95.00	93.33
Control	-	95.00	98.33	100.0	98.33
L.S.D. at 5%	-	N.S.	N.S.	N.S.	N.S.

4. DISCUSSION

The results obtained showed that all the tested oils caused adult mortality of *R. dominica*. When wheat grains were treated with the different vegetable oils, sunflower and black cumin oils proved to be the most efficient against *R. dominica* at LC_{50} and LC_{90} levels, respectively. All the tested oils significantly reduced the number of progeny emerged as compared with the control. Also all the vegetable oils completely inhibited progeny emergence at the highest concentration (14 ml/kg). Trivedi (1987) mentioned that pyrethrin with sesame and groundnut oil cakes was the most effective against *R. dominica* followed by neem oil cake, cattle dung ash and lineseed oil cake. Also, Xu *et al*., (1994) showed that the essential oil from *Clausena dunniana* was very effective against *R. dominica.* It was found that the egg stage of *R. dominica* was the most highly affected by oil treatments followed by larval and pupal stages. Complete protection for wheat grains against this insect was achieved when oil treatments were applied one day after oviposition with the exception of sunflower oil, which gave 82.26% reduction in progeny. The oils probably affected the eggs and/or the larvae by chemical toxicity and/or physical properties by the mechanisms mentioned by Singh *et al.*, (1978), Messina & Renwick (1983) and Don-Pedro (1989). The present investigation revealed also that all vegetable oils used exhibited significant ovicidal action. These findings are in agreement with several workers (Qi & Burkholder 1981, El-Sayed 1986, Begum & Quiniones 1990, Schmidt& Risha 1990 and Risha *et al.,* 1993). Concerning the residual activity of the vegetable oils against *R. dominica*, the present study showed that all the oils with the exception of sunflower and soybean protected wheat grains against these insects up to 120 days. Sighanony *et al*., (1986) found that oils of clove, cedarwood and karanja at doses of 25-100 ppm provided protection to wheat against *R. dominica* for up to 30 days. Xu *et al*., (1993) found that 0.2% cassia oil kept stored wheat free from insect damage caused by *R. dominica* for up to 8 months.

The germination of wheat grains treated with tested vegetable oils was not affected throughout 120 days after treatment. These data agree with the findings of Schoonhoven (1978), Sighamony *et al.,* (1986), Doharey *et al*., (1988) and El-Borolosy *et al*., (1988).

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فاعلية بعض الزيوت النباتية كمواد واقية لحبوب القمح ضد حشرة ثاقبة الحبوب الصغرى

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ملخص

تم دراسة فاعلية عشر زيوت نباتية هي زيت بـذرة القطـن ، السمسـم ، الخروع ، تباع الشمس ، الخس ، الزيتون ، فول الصويا ، الحلبة ، الذرة وحبـة البركة كمواد واقية لحبوب القمح ضد حشرة ثاقبة الحبوب الصغرى . عند معاملة أطباق بيتري بالزيوت المختبرة كان زيت الزيتون أكثر فاعلية ضد الحشرة عنـد مستوى LC_{50} و LC_{90} . وكانت هذه القيم 3.5 ، 5.9 ميكروليتر / طبق بتري. عند معاملة حبوب القمح بالزيوت النباتية المختبرة كان زيت تباع الشمس وحبـة البركة أكثر فاعلية ضد حشرة ثاقبة الحبوب الصغرى عند مستوى LC_{50}, LC_{90}.
أعطت جميع تركيزات الزيوت النباتية المختبرة عند خلطها بحبوب القمح أعطت انخفاضا معنوياً في النسل الناتج . أدى استخدام التركيز العالي (12مـل/كجـم) للزيوت النباتية المختبرة إلى منع النسل الناتج لحشرة ثاقبة الحبـوب الصغـرى ماعدا زيت الزيتون أعطى خفضا يقدر بـ 97.86 % .كان طور البيض لحشرة ثاقبة الحبوب الصغرى أكثر تأثراً بالزيوت المختبرة يليه طور اليرقة ثم العذراء. وفيما يختص بالتأثير المتبقي للزيوت النباتية ضد حشرة ثاقبة الحبوب الصغـرى وجد أن جميع الزيوت المختبرة أعطت حماية جيدة لحبوب القمح حتى 120 يـوم فيما عدا زيت تباع الشمس وفول الصويا . لم يتأثر إنبات حبوب القمح المعاملـة بالزيوت المختبرة حتى 120 يوم بعد المعاملة.

المجلة العلمية لكلية الزراعة – جامعة القاهرة – المجلد (52) العدد الأول (يناير 2001):167-182.