Effectiveness of some plant oils and Malathon 1% dust against the coleopteran beetles the rice weevil Sitophilus oryzae(L). and the granary weevil Sitophilus granarius.

Ameer Mahmoud Mohamed Hwash [1]; Amany M. Rizk [2] ; Abdel-Aziz E.A n[2] and M. A. E

1- graduate student- University of Sadat City

2- Environmental studies and Research Inst., University of Sadat City, Egypt

.

ABSTRACT

The present study aimed to evaluate the toxic effects of four natural plant oils a.i.e. Thyme oil (Thymus vulgaris), Lemon grass oil (Cymbopogn citratus), Pulicaria oil (Pulicaria adenensis) and Chamomile flower oil (Matricaria chamomilla) against the adults of Sitophilus oryzae(L.) and Sitophilus granarius at the laboratory conditions. Mortality and reduction in if F_1 -progeny were assessed. Results showed high mortality values at various used concentration after 3 and 7 days from initial treatment. The S. oryzae showed moderately sensitive than S. granarius. Also , the inhibition in F_1-progeny at all oils had lower than the mortality. Toxicity of Malathion against S.oryzae and S. granarius were fast acting. For both insects, control mortality was extremely high and achieved 100% after 2 days only and 3 days for S. oryzae and S. granrius, respect respectively. The results suggested that these essential oils can be used as appropriate alternative strategy for control the S.oryzae and S. granarius.

Key words: Sitophilus granaries, Sitophilus oryzae(L) , Essential oils, contact toxicity

الملخص

أجريت هذه الدراسة لتقييم التأثير السام لبعض الزيوت النباتية وهي زيت الزعتر، زيت حشيشة الليمون زيت البابونج وزيت حشيشة الرعراع مقارنة بمبيد الملاثيون ١% مسحوق كمبيد موصي به وقد تم تقدير نسبة الموت وكذلك مقدار الإنخفاض في تعداد الجيل الأول لهذه الحشرات، وقد أوضحت النتائج أن كل الزيوت النباتية قد أعطت نسب موت مرتفعة عند مختلف التركيزات بعد ٣ ، ٧ أيام من المعاملة.

أيضاً أظهرت النتائج أن نسب الموت قد إرتفعت بزيادة التركيزات وزمن التعرض وكانت حشرة سوسة الأرز أكثر حساسية للزيوت من حشرة سوسة المخزن فيما عدازيت البابونج الذى أثبت أن حشرة سوسة المخزن أكثر حساسية من سوسة الأرز.

كذلك أوضحت النتائج أن مقدار الإنخفاض في تعداد الجيل الأول كان أقل من نسب الموت مع كل الزيوت وكذلك مختلف التركيزات.

أما في حالة المعاملة بالمبيد الموصي به وهو الملاثيون ١% مسحوق فكانت النتائج عالية جداً حيث أعطي نسبة موت ١٠٠% بعد ثلاثة أيام وكذلك أعطي نسبة خفض بنسبة ١٠٠% مع التركيزات العالية.

الكلمات الدالة : مخازن الحبوب- الزيوت الأساسية- سمية الاتصال.

INTRODUCTION

Moreno *et.al*., (2000),stated that the cereal grains are often infested by various stored product insects, which cause sever economic losses. For example food product commodities can be affected by insect pests during the storage period and visible contamination due to insect individuals or their remains may be present in the final product (*Riudavets et al.,2014*). The major source of food for humans and most domesticated animals. In many developing countries, overall post-harvest losses of cereals and legumes by pests such as insects during storage and microbial spoilage or contamination may make these totally inedible (*Neethirajan et al., 2007*).

The cereal grains are after infested by various stored product insects, which cause severe economic losses. For example, food product commodities can be affected by insect pests during the storage period, and visible contamination due to insect individuals or their remains may be present in the final product (Gur *et al*., 2014).

The plant products are often biodegradable to non-toxic products, are potentially suitable for use in integrated pest management and less detrimental environment (Udo, 2005).Also botanicals used as insecticides presently constitute 1% of the world insecticide market (Ayvaz et al., 2010).

Since the plant oils contain several bioactive chemical compounds which are toxic to stored product insects, are rich in phenols, flavonoids and terpenoids (Tsao *et al*., 1995; Lee *et al*., 2003).

The objective of this research was to evaluate efficacy of Thyme, Lemon grass, Chamomile, Oatare-Nature oils against tow stored-product insect species, *S. oryzae* and *S. granrius*.

The adults of rice weevil, *Sitophilus oryzae* (L.), and granary weevil *Sitophilus granaries* (Coleoptera: Curculionidae) in this study, were reared free of insecticidal contamination at the laboratory conditions of Stored Product Pests Research Department, Plant Protection Research Institute. The culture was maintained under the same conditions, insects were emplaced in glass jars (1000 gm.) containing 500 g. of sterilized wheat grain and 400-500 of *S. oryzae* or *S. granarius* insects. Jars was covered with muslin cloth. Adult insects were left for two weeks for egg laying inside the jar and kept in the rearing laboratory then were removed. The newly emerged adults (l-2weeks-old) were used for experiments

2. Bioassay methods:

2.1 Mixing with diet method:

This technique of grains treatment was the contact toxicity by mixing with medium according to the **El-Lakwah*et al.* (1992)**, to determine the insecticidal effect of the tested plant oils and Malathion powder against *S. oryazae* and *S. granarius*. These oils were applied at the rates of 0. 5, 1.0 and 1. 5mg.\kg , for thyme ,lemon grass , pulcaria and chamomil flower oil, respectively as well as the untreated control. Malathion a synthetic insecticide, had the rates

were: 0.25, 0.5, 0.75 and 1gm/kg W/W for comparison. For the plant oils, each concentration was dissolved in 1 ml acetone and the control treatment was carried using acetone only. Each concentration and untreated control was candied using acetone only. Each concentration and untreated control was in three replicates. Each concentration was mixed well with 20gm wheat grains in glass jar 250 ml and then was shaken thoroughly manually to ensure uniform coverage by the different treatment. For the plant oils, the treatments were left for suitable time until solvent evaporated. Before using them in experimentation. Twenty five of newly emerged adults of *S. oryzae S. granarius* (1-2 week –old) were added to treated grains jar respectively. The jars were covered with muslin cloth and kept under laboratory conditions. Mortality counts were recorded after 1,2,3, 4, 7 and 14 days *S. oryzae* and *S. granarius*. All the results were corrected with **Abbott's (1925)** as the following equation:

$$\%\ correct\ mortality = \frac{\%\ mortality\ of\ treated - \%\ mortality\ of\ control}{100 - \%\ mortality\ of\ control} x\ 100$$

The corrected percentages of mortalities were statistically computed according to the method of Finney

(1971). Computed percentage of mortality was plotted versus the corresponding concentrations using Ldp line software program obtain the toxicity regression lines.

RESULTS AND DISCUSSION

Results in Table (1) concerning the effect of Thyme oils at 0. 5, 1.00 and 1. 5 mg/gm against *S. oryzae,* and *S. granarius*. It showed that, the mortality percentage increased with increasing the oil concentration and exposure time. After one day the mortality between (21.33 – 34.67 and 20.0 – 32.0%) at 0. 5 and 1. 5 mg/g for *S. oryzae* and *S. granrius* respectively. But the seven days complete mortality both all insects for all concentrations. On the other hand, the reduction in F_1-progrny was lower than mortality in all concentrations.

The effects of Lemon grass oil on mortality and reduction in F_1-progeny of tested insect are summarized in Table 2. The data clearly reveal that Lemon grass oil was more toxic to adults of *S. oryzae* than *S. granrius*. The toxic effects of Lemon grass oil on the two species was concentration – and time dependent over the test period of two weeks. The highest recorded mortalities were found to be 100% and 80% after seven days exposure period at the lower concentration for *S. oryzae* and highest concentration to *S. granrius*.

Also, results in table 2 showed a pronounced adverse effect of Lemon oil on F_1-progency. Inhibition of F_1-progeny was lower than mortality values at the two higher Lemon grass concentrations. Reduction in F_1-progeny ranged from 40-58% and 39-58% at different concentrations of Lemon grass oil for *S. oryzae* and *S. granrius*, respectively.

The efficacy of pulicaria oil against *S. oryzae* and *S. granarius* are presented in Table 3. Showed that *S. oryzae* was more sensitive to pulicaria oil than the *S. granrius*. The toxic effects of pulicaria oil on the *S. oryzae* and *S. granarius* was concentration – and time- dependent over the test period of two weeks. The highest recorded mortalities were found to be 100% and 94.67% after two weeks exposure period at the highest tested concentration (1.5) of the oil for *S. oryzae* and *S. granarius*, respectively.

On the other hand, results in Table 3 showed a pronounced adverse effect of pulicaria oil on F_1-progeng. Inhibition of F_1-progeny was much lower than mortality values at the higher concentration for two species insect. Reduction in F_1-progeny ranged from 42-60%&39-57% at different concentrations of pulicaria oil for *S. oryzae* and *S. granaries*, respectively.

Effect of chamomil flower oil on adult mortalities of S. oryzae and S. granarius are presented in Table 4. These results showed that mortality was time dependent since the mortality ranged from 46.67-66.67 & 73.33-81.33% after seven days to *S. oryzae* and *S. granrius*, while, the mortalities was 96-98.67 % & 93.33 – 98.67 % after 2 weeks for the same insects, respectively. These result showed that the *S. granaries* was more sensitive than the *S. oryzae* after seven days, but the sensitively both oil insects was equal after two weeks.

Data in Table 4 showed that the reduction in F_1-progeny for *S. oryzae* and *S. granarius* ranged 59%, 58% at higher concentration for both *S. oryzae* and *S. granarius*, respectively. These results showed that lower than mortality.

These results agreed with **Abd-El-Aziz (2002)** found that the mortality of *C. maculatus* caused by extracts of *S. aromaticum* increased with the increase in concentration and exposure period with percentages of 100, 90, 70 and 44% for tested concentrations at 5 days from the initial treatment.

Reduction percent in emerged adults was 100% at all the tested concentrations of petroleum extract of swamp paper bark, while it ranged from 69% - 97.6%, 85.4% 100% and 51.5%

In the harmony with the current results, **El-Naggar *et al.* (2012)** mentioned that the reduction in F_1-progeny increased by increasing the concentration of the plant extract, the lowest percent (45.3%) of adult emergence of *Spodoptera littoralis* larvae at 10% concentration of *T. distichum* extract, while the highest percentage (72.15%) was at 0.625% concentration. The oil of *S. aromaticum* prevented adult emergence of the *S. oryzae* weevil at all concentrations as revealed by **Ileke *et al*. (2014).** Similarly, significant reduction against *S.zeamais*, *C.macultus* and *T. castaneum* at all levels by ethanolic extract of *E. aromatica* essential oil was reported by **Olotuah (2014)** and **Devi (2013)** found that hexane extracts of clove (LD_{50} values of 0.517, $\mu l/cm^2$) showed 92% mortality against *S. oryzae* and *C. maculatus* than ethanol one when mixed with wheat grains and cowpea seeds was reported by **Arab *et al*., (2004)**. Higher larval mortality percent was obtained by *Nigella sativa* followed by *T. distichum* against *S. granarius* for all the concentrations of the three tested oil extracts as mentioned by **Sabbour and Abdel-Raheem(2015)** ethanolic extract from *P. pseudocaryophyllus* leaves (Myrtaceae), did not have a significant effect on adult survival, F_1-progeny, or damage caused by *S.zeamais* when added to the diet **(Riberio*et al*., 2015)**.

Data presented in table (5) indicated that the Mortalities percentage (%, mean ± SD) of *S. oryzae* L. and *S. granarius* adults exposure to Malathion (mg/kg) effective compounds at 1, 2, 3, 4, 7 and 14 days after treatment. For both species, the treatment effect (Malathion , untreated control) was significant. For both insects, control mortality was extremely high and achieved 100% after 2 days only and 3 days for *S. oryzae* and *S. granarius*, respectively. However, after longer exposure times mortality of both species adults notably increased, reaching 84.00% and 100%, at 1.00 mg/kg after 2 days exposure intervals for *S. oryzae* and *S. granarius*, respectively. Generally, in this bioassay, complete control (100%) was achieved already after 3 days of exposure, regardless of the dose and the species.

Also, the inhibition in F_1-progeny increasing with increased the concentrations.

Table (6) indicated that the Thyme oil, exposure times required to cause 50% mortality (LT50) and 90% 90% (LT90) decreased as the concentration of oil after treatments increased. It ranged between 1.66 to 1.32 and 3.97 to 3.59 for *S. oryzae* , mean while, it marked 1.71 to 1.37 and 3.99 to 3.53 for S. granaries.

The slope of the time-mortality curves was decreased by increasing the concentration tested.

The obtained results showed clearly that the adults of *S. oryzae* were more susceptible to oils than *S. granarius* which were the least susceptible.

The same trend was showed in Tables 7,8,9 and 10 except in Lemon grass oil which gave an adverse effect, *S. granarius* adult was much more susceptible than *S. oryzae* adults.

REFERENCES

Abbott, W.S. (1925): a method of computing the effectiveness of an insecticide- J. Econ. Entomol., (18): 265-267.

Abd-El-Aziz, A.E. (2002): Effectiveness of petroleum ether extract of some plants alone and under controlled atmospheres of carbon dioxide against the cowpea beetle *Callosobruchus maculatus*(F.) Ann. Agric. Sci. Moshtohor, 40(2):1309-1319.

Arab,R.B.A.,Ell-All,S.M.A. and El-Rahman, S.A. (2004): Effected of certain plant extracts and one conventional insecticide pirimiphos-methyl on progeny, ovicidal and residual activities of two stored product pests. Egypt. J. Biol. Pest. Cont., 14(1):155-163.

Ayvaz, A.; O, Sagdic; S. Kardborklu and I. Ozturk (2010): Insecticidal activity of the essential oils from different plant against three stored-product insects. Journal of Insect Sconce, (10):1-13.

Devi, K.C. and Devi, S.C (2013): Insecticidal and oviposition deterrent properties of some spices against coleopteran beetle *Sitophilus oryzae*" J. Food. Sci. Technol., 50(3): 600-604.

El-Lakwah, F.A.,A.A. Darwish and Omnia, M.Khaled (1992): Effectiveness of dill seed powder *(anthumgraveolens)* on some stored product insects. Ann. Agric. Sci., Moshtohor, 34940 2031-2037.

El-Naggar, S.E. M., Hazaa, M.A.M. and Ibrahim, R.S.H. (2012): Growth inhibitory effects of Taxodiumdistichumextract on gamma irradiated cotton leaf worm *Spodoptera littordlis* (Boids). J. Read, Res. Appl. Sci., 5(4): 697-715.

Ilike,K.D.; Ogungbite, O.C. and Olayinka –Olagungu, J.O. (2014): Powders and extracts of Syzygium aromaticum and Anacardium occidentale as entomocides against the infestationof Sitophilus oryzae(L.) (Coleoptera: Curculionidae) on stored sorghum grains. African. Sci. J. , 22:267- 273.

Lee, S.; C.J. Peterson and J.R. Coats (2003): Fumigation toxicity of monoterpenoids to several stored product insects. J. Stored Prod. Res. 939):77-85.

Moreno – Martinez, E., S. Jimenez and M.F. Vazquez, (2000): Effect of *Sitophilus zeamais* and *Aspergillu schevalieri* on the oxygen level in maize stored hermetically. J. Stored Prod. Res., 36:25-36.

Olotuah, O.F. (2014): Bio-efficacy of oil extract of *Eugenia aromatic* in the control of storage insect pests. Int. J. Geol. Agric. Environ. Sci., 2(4):4-10.

Ribeiro, L.P.; Ansante, T.F.; Niculau,E.S.; Pavarini, R.; Silva,M. and Seffrin, R.C. (2015): Pimenta pseudocryophyllus derivatives: extraction methods and bioactivity against Sitophilus zeamais Motschulsky (Coleoptera: Curculionidae). Neotrop. Entomol. 44:634-642.

Riudavets, J., M.J. Pons, R. Gabarra, C.Castanes O. Alomar, L.F. Vega and S. Guri, (2014): The toxicity effects of atmospheres with high content of carbon dioxide with addition of sulphur dioxide on two stored. Product pest species: *Sitophilusoryzae* and *Triboliumconfusum*. J. Stored prod. Res., 57:58-62.

Tsa, R., S. Lee; P.J. Rice; C. Jensen and J.R. Coats (1995): fumigant toxicity of six essential oils to the immature stages and adults of *Tribolium conbusum.* Hellenic Plant protection J. (6): 29-39.

Udo, L.O. (2005): Evaluation of potential of some local spices as stored grain protectants against the maize weevil *Sitophilus zeamaize* Mots (Coleoptea :Curculionidae). J. Applied Sciences and Environmental Mangement, 9:165-168.

Table (1): Percentage mortality of adults Sitophilus oryzae and Sitophilus granaries after exposure for different periods to Thyme oil.

Insects	Con. (mg/g)	Corrected mortality (% , Mean ± SD)						Average No. of F_1. Progeny after 45 days	% reduction in F_1- progery
		1 day	2 days	3 days	4 days	7 days	14 days		
Sitophilusoryzae	0. 5	21.33±8.69	65.33±5.357	78.67±13.67	94.67±5.57	100±0.00	100±0.00	49	47.0
	1.00	32.00±8.69	69.33±3.65	82.67±11.15	96.00±3.65	100±0.00	100±0.00	42	45.0
	1. 5	34.67±8.39	73.33±6.67	84.00±3.65	97.33±3.65	100±0.00	100±0.00	21	86.0
Sitophilusgranarius	0. 5	20.00±10.54	62.67±7.61	78.67±7.31	86.67±4.71	100±0.00	100±0.00	60	45.0
	1.0	26.67±9.428	68.00±8.69	81.33±5.57	92.00±5.57	100±0.00	100±0.00	45	59.0
	1. 5	32.00±5.57	73.33±13.33	84.00±12.11	93.33±6.66	100±0.00	100±0.00	25	77.0

Table (2): Percentage mortality of adults *Sitophilus oryzae* and *Sitophilus granaries* after exposure for different periods to Lemongrass oil.

Insects	Con. (mg/g)	Corrected mortality (% , Mean ± SD)						Average No. of F_1. Progeny after 45 days	% reduction in F_1- progery
		1 day	2 days	3 days	4 days	7 days	14 days		
Sitophilusoryzae	0.5	14.67±14.45	56.00±7.61	70.67±5.96	78.67±9.89	100±0.00	100±0.00	78	40.0
	1.0	20.00±12.47	57.333±5.96	74.67±14.45	81.33±7.31	100±0.00	100±0.00	70	46.0
	1.5	22.67±10.11	60.00±18.25	77.33±12.11	90.67±8.94	100±0.00	100±0.00	54	58.0
Sitophilusgranarius	0.5	17.33±7.61	26.67±9.43	44.00±5.96	56.00±7.61	74.67±8.69	94.67±5.58	90	39.0
	1.0	22.67±10.11	34.67±5.58	48.00±8.69	58.67±10.95	78.67±9.89	96.00±5.96	85	43.0
	1.5	28.00±5.58	37.33±8.94	54.67±19.66	69.33±11.16	80.00±8.17	100±0.00	62	58.0

Table (3): Percentage mortality of adults Sitophilus oryzae and Sitophilus granaries after exposure for different periods to Pulicaria oil.

Insects	Con. (mg/g)	Corrected mortality (% , Mean ± SD)						Average No. of F_1. Progeny after 45 days	% reduction in F_1- progery
		1 day	2 days	3 days	4 days	7 days	14 days		
Sitophilusoryzae	0.5	14.67±5.58	30.67±5.96	42.67±7.61	49.33±5.96	80.00±6.67	100±0.00	55	42.0
	1.0	17.33±7.61	32.00±8.69	45.33±8.69	50.67±5.96	82.67±10.11	100±0.00	43	55.0
	1.5	20.00±12.48	38.67±12.82	46.67±16.99	53.33±16.99	86.67±8.17	100±0.00	38	60.0
Sitophilusgran	0.5	10.67±5.96	17.33±7.61	21.33±7.31	28.00±5.578	61.33±5.58	94.67±5.58	64	39.0
	1.0	14.67±7.31	25.33±5.58	34.67±2.98	52.00±5.58	73.33±4.71	94.67±5.58	56	47.0

	1.5	17.33±11.16	30.67±16.73	40.00±4.714	56.00±7.61	78.67±5.58	97.33±3.65	45	57.0

Table (4): Percentage mortality of adults Sitophilus oryzae and Sitophilus granaries after exposure for different periods to Chamomile flower oil.

Insects	**Con. (mg/g)**	**Corrected mortality (% , Mean ± SD)**						**Average No. of F_1. Progeny after 45 days**	**% reduction in F_1-progery**
		1 day	**2 days**	**3 days**	**4 days**	**7 days**	**14 days**		
Sitophilusoryzae	**0.5**	0.00±0.00	4.00±5.96	10.67±5.96	17.33±3.65	46.67±8.16	96.00±5.69	89	41.0
	1.0	0.00±0.00	5.33±5.56	16.00±5.96	26.67±6.67	58.67±8.69	97.33±3.65	83	45.0
	1.5	0.00±0.00	8.00±5.56	20.00±4.71	32.00±2.98	66.67±10.54	98.67±2.98	62	58.0
Sitophilusgranarius	**0.5**	2.66±3.65	8.00±2.98	20.00±8.16	34.67±7.31	73.33±4.71	93.33±4.72	95	42.0
	1.0	4.00±3.65	9.33±3.64	22.67±10.11	40.00±6.67	74.67±2.98	97.33±3.65	81	51.0
	1.5	8.00±10.95	13.33±10.54	30.67±10.11	42.67±7.61	81.33±5.57	98.67±2.98	69	59.0

Table (5): Percentage mortality of adults Sitophilus oryzae and Sitophilus granaries after exposure for different periods toMalathion 1% dust.

Insects	**Con. (mg/g)**	**Corrected mortality (% , Mean ± SD)**						**Average No. of F_1. Progeny after 45 days**	**% reduction in F_1-progery**
		1 day	**2 days**	**3 days**	**4 days**	**7 days**	**14 days**		
S .oryzae	**2.25**	76±11.15	100.0±0.00	100.0±0.00	100.0±0.00	100.0±0.00	100.0±0.00	5	89.0
	0.50	90.67±3.65	100.0±0.00	100.0±0.00	100.0±0.00	100.0±0.00	100.0±0.00	2	95.0
	0.75	90.67±7.61	100.0±0.00	100.0±0.00	100.0±0.00	100.0±0.00	100.0±0.00	-	100
	1.00	96.00±5.96	100.0±0.00	100.0±0.00	100.0±0.00	100.0±0.00	100.0±0.00	-	100
S.granarius	**2.25**	38.67±10.95	66.67±4.71	100.0±0.00	100.0±0.00	100.0±0.00	100.0±0.00	6	88.0
	0.50	48.00±9.88	69.33±7.61	100.0±0.00	100.0±0.00	100.0±0.00	100.0±0.00	3	94.0
	0.75	60.00±10.54	80.00±12.47	100.0±0.00	100.0±0.00	100.0±0.00	100.0±0.00	-	100
	1.00	66.67±10.54	84.00±16.73	100.0±0.00	100.0±0.00	100.0±0.00	100.0±0.00	-	100

Table (6): Lethal time values and confidence limits of thyme oil for the adults of of *S.oryzae and S .granarius* at the laboratory conditions.

Insects	Concent.	L_{t50}	L_{t90}	Confidence limits				Slope ± SD	R
				L_{t50}		L_{t90}			
				Lower	Upper	Lower	upper		
S.oryzae	0.05	1.66	3.97	1.23	2.24	2.94	5.36	3.39±0.29	0.984
	0.01	1.413	3.80	1.0	1.99	2.69	5.35	2.98±0.33	0.996
	0.15	1.32	3.59	0.93	1.87	2.53	5.09	2.96±0.33	0.987
S .granarius	0.05	1.71	3.99	1.27	2.29	2.98	5.36	3.47±0.28	0.992
	0.01	1.52	3.82	1.11	2.09	2.77	5.25	3.22±0.311	0.990
	0.15	1.37	3.53	0.98	0.98	2.53	4.93	3.12±0.32	0.984

Table (7) : Lethal time values and confidence limits of thyme pulicaria oil for the adults of *S.oryzae and S .granarius* at laboratory conditions.

Insects	Concent.	L_{t50}	L_{t90}	Confidence limits				Slope ± SD	R
				L_{t50}		L_{t90}			
				Lower	Upper	Lower	upper		
S.oryzae	0.05	3.79	19.29	2.45	5.85	12.10	30.74	1.81±0.55	0.99
	0.01	3.60	20.23	2.20	3.88	12.39	33.04	1.71±0.58	0.99
	0.15	3.23	20.07	1.93	5.40	12.00	33.59	1.61±0.61	0.98
S .granarius	0.05	4.85	25.08	3.12	7.55	16.13	38.99	11.79±0.55	0.99
	0.01	5.94	36.54	3.37	10.47	29.25	59.81	1.36±0.73	0.98
	0.15	4.48	34.72	2.63	7.65	20.37	59.19	1.44±0.11	0.99

Table (8): Lethal time values and confidence limits of Chamomile flower oil for the adults of *S.oryzae and S. granarius* at laboratory conditions.

Insects	Concent.	Lt_{50}	Lt_{90}	Confidence limits				Slope ± SD	R
				Lt_{50}		Lt_{90}			
				Lower	Upper	Lower	upper		
S.oryzae	25	6.26	12.20	4.88	8.02	9.52	15.63	4.49±0.22	0.97
	50	5.46	10.81	4.26	7.01	8.43	13.87	4.36±0.22	0.97
	75	5.31	12.37	3.96	7.11	9.23	16.57	3.49±0.22	0.99
S .grandrius	25	5.07	11.67	3.80	6.77	8.74	15.59	3.54±0.28	0.99
	50	4.65	9.74	3.57	6.06	7.47	12.71	3.99±0.25	0.99
	75	4.20	9.01	3.20	5.53	6.85	11.84	3.87±0.25	0.98

Table (9): Lethal time values and confidence limits of Lemon grass oil for the adults of *Sitophilusoryzaand Sitophilusgranarius* at laboratory conditions.

Insects	Concent	Lt_{50}	Lt_{90}	Confidence limits				Slope ± SD	R
				Lt_{50}		Lt_{90}			
				Lower	Upper	Lower	upper		
S.oryzae	0.05	1.97	4.63	1.47	2.63	3.49	6.27	3.41±0.29	0.98
	0.01	1.814	4.585	1.32	2.47	3.35	6.26	3.18±0.31	0.99
	0.15	1.74	4.34	1.26	2.38	3.16	5.95	3.16±0.31	0.99
S .grandrius	0.05	4.14	20.44	2.54	6.74	16.24	43.05	1.59±0.62	0.93
	0.01	3.44	20.86	2.01	5.86	15.74	45.84	1.43±0.69	0.98
	0.15	2.79	22.96	1.61	4.83	13.27	39.70	1.40±0.71	0.91

Table (10): Lethal concentration values and confidence limits of Malathion dust after one day for the adults of *S. oryzae and S.granarius* at laboratory conditions.

Insects	L_{C50}	L_{C90}	Confidence limits				Slope ± SD	R
			L_{C50}		L_{C90}			
			Lower	Upper	Lower	upper		
S.oryzae	0.085	0.59	0.04	0.18	0.26	1.22	1.57±0.63	0.918
S. grandrius	0.469	5.471	0.22	0.99	2.57	11.64	1.20±0.83	0.967