

Efficacy of some plant oils against the rice weevil, *Sitophilus oryzae* (L.) and the red flour beetle, *Tribolium castaneum* (Herbst)

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Abstract

Laboratory bioassay tests were conducted to determine the efficacy of geranium, coriander and cumin oils against the adults of *Sitophilus oryzae* (L.) and *Tribolium castaneum* (Coleoptera), at 30 and 20 ± 1°C. The results indicated that the mortality of tested insects increased with increasing in concentration, exposure period and temperature. The complete mortality of *S. oryzae* adults was obtained at conc. 1.5 % (v/w) for the three tested oils, after 14 days exposure period at 30°C. Data also revealed that, the geranium oil was the most toxic for the studied insects at the two tested temperatures, and it gave LC₅₀ of 0.49, 1.72% at 30°C and 0.88, 1.89% at 20°C for the adults of *S. oryzae* and *T. castaneum* (after 3 days exposure period), respectively. The adults of *S. oryzae* were more sensitive to tested plant oils than the adults of *T. castaneum*. It can be concluded that geranium, coriander and cumin oils have a toxic activity against the two stored-product insects, *S. oryzae* and *T. castaneum*.

Key words: geranium, coriander and cumin, insecticidal activity, *Sitophilus oryzae*, *Tribolium castaneum*

Introduction

The loss in cereal grains and pulses during storage due to infestation by insect pests is a serious problem. Especially in the developing countries, one of the possible alternatives to synthetic pesticides is the screening of plants in search for alternatives pest control agents such as extracts of plants leaves, seeds, flowers, plant oils etc., in order to overcome and reduce the hazard occurring from the wide use of pesticides in the pest control. It is hoped that such agents would be more degradable in nature and with less adverse effects on mammals than the conventional synthetic insecticides (EL-Lakwah, *et al.*, 1997). Recently, natural plant products are presently in the focus of research efforts because of their mammalian safety and efficacy. Promising results against stored product pests with plant extracts, dusts, and plant oils as pest control agents were reported by some investigators (Darwish, 1992, 1997; El-lakwah *et al.*, 1992, 1993, 1994, 1995, 1996 (a, b) and 2009; Lee *et al.*, 2003; Al-Jabr, 2006; Halawa *et al.*, 2009; Zapata and Smagheha 2010; Suthisut *et al.*, 2011; Ben Jemâa *et al.*, 2012; Hassan *et al.*, 2013; Hernandez *et al.*, 2015)

The present study aimed to evaluate the efficacy of the plant oils of geranium, coriander and cumin against *Sitophilus oryzae* and *Tribolium castaneum* at 30 and 20 ± 1 °C in the laboratory.

Materials and Methods

Insects

Two stored product insect species, namely the rice weevil, *Sitophilus oryzae* (L.) (Curculionidae, Coleoptera) and the red flour beetle *Tribolium*

castaneum (Herbst) were obtained from the existing culture in the stored product pests Laboratory at the Plant Protection Department., Faculty of Agriculture, Benha University.

Rearing technique

The insects were reared in glass jars (approx. 250 ml) containing about 200 g of sterilized and conditioned wheat grains for *S. oryzae* (L.) or wheat flour for *T. castaneum*. The glass jars were covered with muslin cloth and fixed with rubber band. Insect cultures were kept under controlled conditions of 30 ± 1 °C and 65 ± 5 % R.H. at the rearing room of the laboratory. Wheat grains were treated by freezing at -18°C for 2 weeks before application to eliminate any possible infestation by any insect species. The moisture content of the grains was around 14%. Around 300 adults of each insect species (1-2 weeks old) were introduced into the jars for laying eggs under controlled conditions. Three days later, all insects were separated from the food and the jars were kept again in the rearing room. This procedure was repeated several times in order to obtain large number of the adults needed to carry out the experiments during this study.

Batches of 30 adults of *S. oryzae* and *T. castaneum* were used in all experiments.

Tested temperatures

All experiments were conducted under two temperatures 30 and 20 ± 1°C and 65 ± 5%.

Plant oils used

Geranium, coriander and cumin plant oils were bought from the guvadant Swaziland Company.

Geranium oil

The Major compounds are limonene, citronellol gerania and α - Terpineol.

Coriander oil

The major compounds are linalool, gerany acetate and terpinene.

Cumin oil

The major compounds are aldehydes- cuminic aldehyde pinene and α - Terpinol.

Bioassay tests

Twenty five milliliters of each pure oil was diluted with 50 ml acetone to obtain 50% (v/v) stock concentration which diluted to obtain 50, 40, 35, 30, 25, 20, 15, 10, 5, 2.5, 1.25 % (v/v) concentrations. One ml was taken from each concentration, and added to 10 g wheat grains to obtain concentrations 5, 4, 3.5, 3, 2.5, 2, 1.5, 1, 0.5, 0.25 and 0.125% (v/w). Thirty adult insects were added to wheat grains In case of *S. oryzae* and to crushed grains In case of *T. castaneum* and incubated at 30 ± 1 °C and 65 ± 5 % R.H. Three replicates were used for each treatment. For control only acetone was used for food treatment. Insects mortality was calculated after 1, 2, 3, 5, 7, 10 and 14 days from initial treatment to calculate the lethal concentration and the lethal time of each oils.

Data analysis

Data were analysed using probit analysis models (Finney, 1971) using a computer program of Noack and Reichmuth (1978).

Results and Discussion

1- Mortality effect of the tested plant oils against the adults of *Sitophilus oryzae* and *Tribolium castaneum* under 30 and 20 ± 1 °C at two tested temperatures and 65 ± 5 % R.H.

1.1 - *Sitophilus oryzae*

1.1.1. Geranium oil

The results of the effect of geranium oil on the adult mortality of *S. oryzae* at 30 and 20 ± 1 °C and 65 ± 5 % R.H. were presented in **Fig (1-5)**. The results showed that the mortality increased by increasing the plant oil concentration, period of exposure and temperature. At concentration 1.5% (v/w) the adult mortality of *S. oryzae*, after 1 day exposure period was 33.3 and 20.1% at 30 and 20 °C, respectively. While, the mortality increased after 14 days post treatment to reach 100% at both 30 and 20 °C. At 1% (v/w) the mortality was 25.8 and 16.6% after 1 day exposure period and increased after 14 days to 100 and 98.1% at 30 and 20 °C, respectively. At 0.5% (v/w) the mortality was 17.7 and 11.3% after 1 day exposure period and increased after 14 days post treatment to 98.2 and 84.4 % at 30 and 20 °C, respectively. At 0.25 % (v/w) the mortality was 5.5 and 1.1% after 1 day exposure period and increased after 14 days post treatment to 93.3 and 70.1% at 30 and 20 °C, respectively. At 0.125 % (v/w) the mortality was 1.1 and 0% after 1 day exposure period and increased after

14 days post treatment to 84.7 and 65.6 % at 30 and 20 °C, respectively.

1.1.2. Coriander oil

The data of the effect of coriander oil on the adult mortality of *S. oryzae* at 30 and 20 ± 1 °C and 65 ± 5 % R.H. were presented in **Fig (1-5)**. The results revealed that the mortality increased by increasing the plant oil concentration, period of exposure and temperature. At concentration 1.5% (v/w) the adult mortality of *S. oryzae*, after 1 day exposure period was 28.8 and 15.8% at 30 and 20 °C, respectively. While, the mortality increased after 14 days post treatment to reach 100% at both 30 and 20 °C. At 1% (v/w) the mortality was 20.2 and 13.3% after 1 day exposure time and increased after 14 days to 98 and 93.3% at 30 and 20 °C, respectively. At 0.5% (v/w) the mortality was 8.5 and 6.1% after 1 day exposure period and increased after 14 days post treatment to 85.5 and 70.1% at 30 and 20 °C, respectively. At 0.25 % (v/w) the mortality was 2.2 and 0% after 1 day exposure time and increased after 14 days post treatment to 80.1 and 63.6% at 30 and 20 °C, respectively. At 0.125 % (v/w) the mortality was 1.1 and 0% after 1 day exposure period and increased after 14 days post treatment to 77.7 and 59.1 % at 30 and 20 °C, respectively.

1.1.3. Cumin oil

The results of the effect of cumin oil on the adult mortality of *S. oryzae* at 30 and 20 ± 1 °C and 65 ± 5 % R.H. were presented in **Fig (1-5)**. The results showed that the mortality increased by increasing the plant oil concentration, period of exposure and temperature. At concentration 1.5% (v/w) the adult mortality of *S. oryzae*, after 1 day exposure period was 18.9 and 13.3% at 30 and 20 °C, respectively. While, the mortality increased after 14 days post treatment to 100 and 97.7 % at 30 and 20 °C, respectively. At 1% (v/w) the mortality was 15.5 and 9.9% after 1 day exposure time and increased after 14 days post treatment to 94.5 and 89.1% at 30 and 20 °C, respectively. At 0.5% (v/w) the mortality was 5.5 and 2.2% after 1 day exposure period and increased after 14 days post treatment to 87.9 and 81.1 % at 30 and 20 °C, respectively. At 0.25 % (v/w) the mortality was 1.1 and 0% after 1 day exposure period and increased after 14 days post treatment to 72.2 and 63.3% at 30 and 20 °C, respectively. At 0.125 % (v/w) the mortality was 1.1 and 0% after 1 day exposure period and increased after 14 days post treatment to 68.6 and 60.1 % at 30 and 20 °C, respectively.

1.2. *Tribolium castaneum*

1.2.1. Geranium oil

The data of the effect of geranium oil on the adult mortality of *T. castaneum* at 30 and 20 ± 1 °C and 65 ± 5 % R.H. were presented in **Fig (6-10)**. The results showed that the mortality increased by increasing the plant oil concentration, period of exposure and

temperature. At concentration 2.5% (v/w) the adult mortality of *T. castaneum*, after 1 day exposure period was 15.5 and 10.5 % at 30 and 20°C, respectively. While, the mortality increased after 14 days post treatment to 100 and 98.8 % at 30 and 20°C, respectively. At 2.25% (v/w) the mortality was 12.5 and 8.8 % after 1 day exposure period and increased after 14 days to 100 and 88.9% at 30 and 20°C, respectively. At 2 % (v/w) the mortality was 10.6 and 7.2% after 1 day exposure time and increased after 14 days post treatment to 94.4 and 78.8 % at 30 and 20°C for, respectively. At 1.75 % (v/w) the mortality was 8.7 and 5.5 % after 1 day exposure period and increased after 14 days post treatment to 90.1 and 73.3% at 30 and 20°C, respectively. At 1.5 % (v/w) the mortality was 6.6 and 4.4% after 1 day exposure period and increased after 14 days post treatment to 89.5 and 67.7% at 30 and 20°C, respectively. At 1.25 % (v/w) the mortality was 5.7 and 1.1% at after 1 day exposure period and increased after 14 days post treatment to 80.1 and 63.3 % at 30 and 20°C, respectively.

1.2.2. Coriander oil

The data of the effect of coriander oil on the adult mortality of *T. castaneum* at 30 and 20 ± 1°C and 65±5% R.H. were presented in **Fig (11-14)**. The results showed that the mortality increased by increasing the plant oil concentration, period of exposure and temperature. At concentration 5% (v/w) the adult mortality of *T. castaneum*, after 1 day exposure period was 10.3 and 5.5 % at 30 and 20°C, respectively. While, the mortality increased after 14 days post treatment to 100 and 87.7 % at 30 and 20°C, respectively. At 4% (v/w) the mortality was 8.8 and 2.2 % after 1 day exposure time and increased after 14 days post treatment to 88.8 and 77.9 % at 30 and 20°C, respectively. At 3.5 % (v/w) the mortality was 3.4 and 1.1% after 1 day exposure time and increased after 14 days post treatment to 76.7 and 55.3 % at 30 and 20°C, respectively. At 3 % (v/w) the mortality was 1.1 and 0 % after 1 day exposure period and increased after 14 days post treatment to 62.2 and 50.3% at 30 and 20°C, respectively.

1.2.3. Cumin oil

The data of the effect of cumin oil on the adult mortality of *T. castaneum* at 30 and 20 ± 1°C and 65±5% R.H. were presented in **Fig (6-10)**. The results revealed that the mortality increased by increasing the plant oil concentration, period of

exposure and temperature. At concentration 2.5% (v/w) the adult mortality of *T. castaneum*, after 1 day exposure period was 13.3 and 9.8 % at 30 and 20°C, respectively. While, the mortality increased after 14 days post treatment to 95.5 and 82.2 % at 30 and 20°C, respectively. At 2% (v/w) the mortality was 9.1 and 6.6% after 1 day exposure period and increased after 14 days post treatment to 92.2 and 80.1% at 30 and 20°C, respectively. At 1.75 % (v/w) the mortality was 6.1 and 5.5% after 1 day exposure period and increased after 14 days post treatment to 86.6 and 70.1 % at 30 and 20°C, respectively. At 1.5 % (v/w) the mortality was 4.3 and 0 % after 1 day exposure time and increased after 14 days post treatment to 70.7 and 55.5% at 30 and 20°C, respectively. At 1.25 % (v/w) the mortality was 1.1% and 0% after 1 day exposure period and increased after 14 days post treatment to 65.5 and 50.3 % at 30 and 20°C, respectively. At 1% (v/w) the mortality was 1.1 and 0% after 1 day exposure time and increased after 14 days post treatment to 57.7 and 48.3% at 30 and 20°C, respectively.

2. Toxicity parameters of the studied plant oils against the adults of *Sitophilus oryzae* and *Tribolium castaneum* at two tested temperatures and 65±5% R.H.

2.1. *Sitophilus oryzae*

The lethal concentrations (LC₅₀) of tested plant oils against the adults of *S. oryzae* at 30 and 20 °C and 65±5 R.H % . were presented in **Table (1)**

The results showed that at high temperature gave values less than at low temperature. The values of LC₅₀ at 30°C were 0.49, 0.77 and 1.06%, and at 20°C were 0.88, 1.31 and 1.53 % for geranium, coriander and cumin, respectively.

LC₉₀ values of geranium, coriander and cumin at 30°C were 1.06, 2.27 and 3.31%, and at 20°C were 2.98, 4.16 and 5.06 %, respectively.

2.2. *Tribolium castaneum*

The lethal concentrations (LC₅₀) of tested plant oils against the adults of *T. castaneum* at 30 and 20 °C and 65±5 R.H % . were presented in **Table (2)**

The results showed that at high temperature gave values less than at low temperature. The LC₅₀ values of geranium, coriander and cumin at 30°C were 1.72, 2.82 and 2.15%, and at 20°C were 1.89, 3.08 and 2.56 %, respectively.

LC₉₀ values of geranium, coriander and cumin at 30°C were 3.77, 3.94 and 2.24%, and at 20°C were 4.01, 5.22 and 6.94 %, respectively.

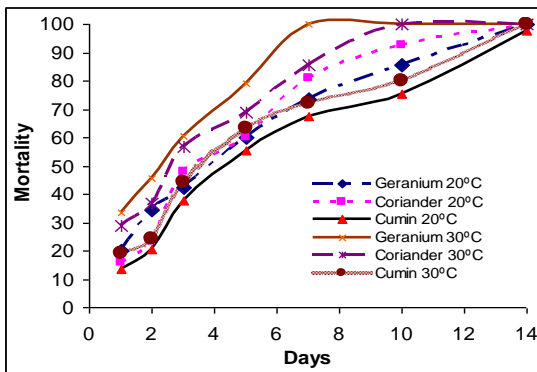


Fig. (1): Efficacy of tested plant oils (1.5%) against *S. oryzae* adults at 30 and 20°C.

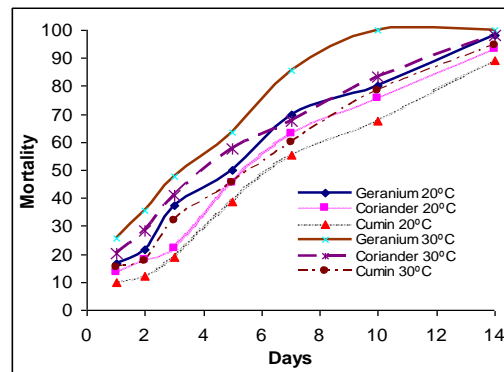


Fig. (2): Efficacy of tested plant oils (1%) against *S. oryzae* adults at 30 and 20°C.

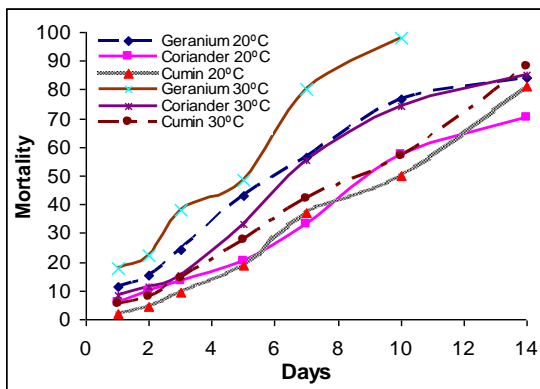


Fig. (3): Efficacy of tested plant oils (0.5) against *S. oryzae* adults at 30 and 20°C.

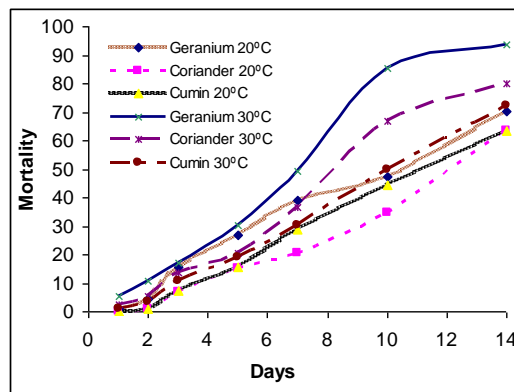


Fig. (4): Efficacy of tested plant oils (0.25%) against *S. oryzae* adults at 30 and 20°C.

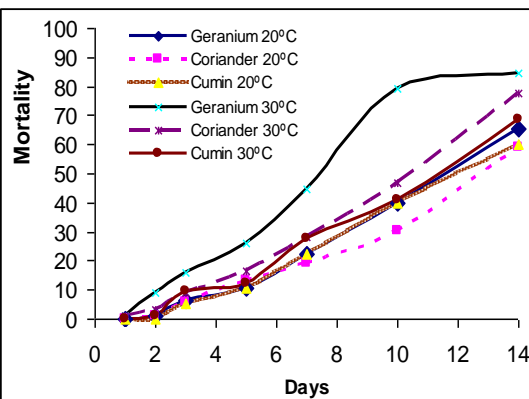


Fig (5): Efficacy of tested plant oils (0.125%) against *S. oryzae* adults at 30 and 20°C.

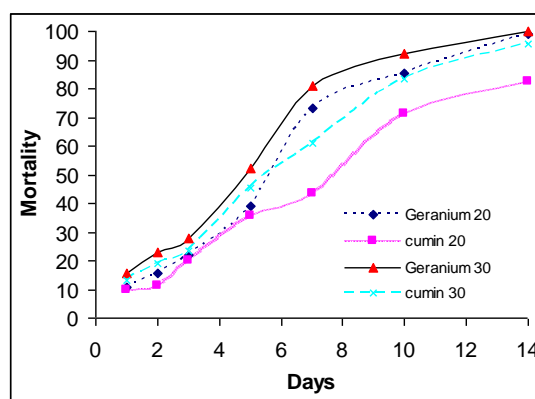


Fig (6): Efficacy of tested plant oils at (2.5 %) against *T. castaneum* adults at 30 and 20°C.

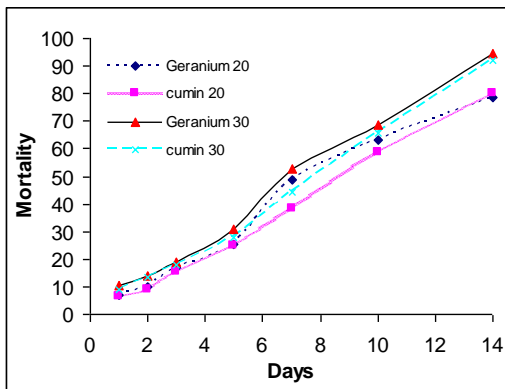


Fig (7): Efficacy of tested plant oils at (2 %) against *T. castaneum* adults at 30 and 20°C.

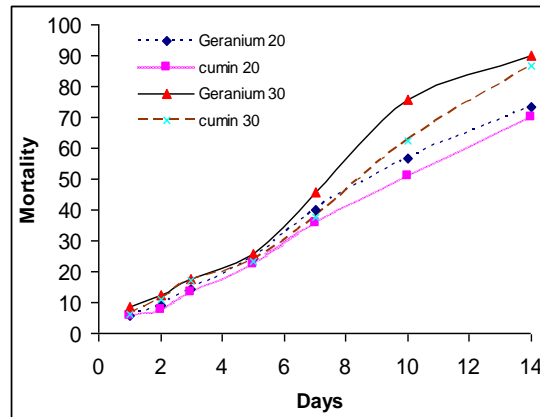


Fig (8): Efficacy of tested plant oils at (1.75 %) against *T. castaneum* adults at 30 and 20°C.

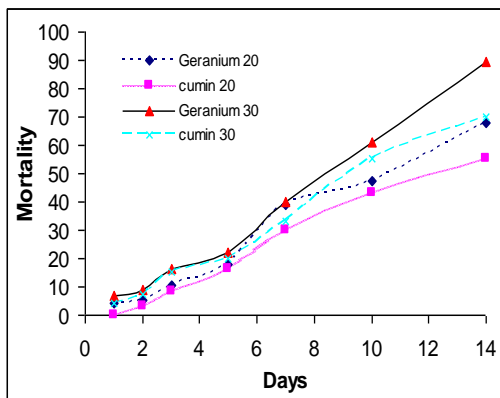


Fig (9): Efficacy of tested plant oils at (1.5 %) against *T. castaneum* adults at 30 and 20°C.

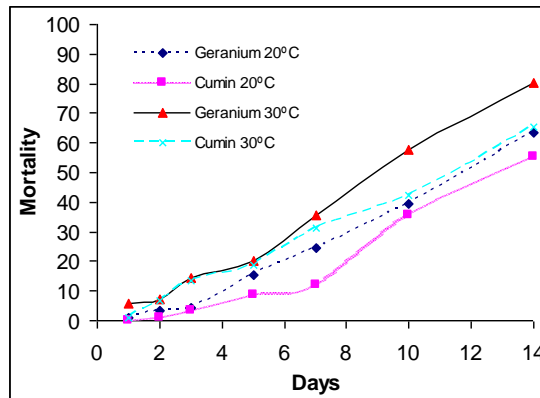


Fig. (10): Efficacy of tested plant oils at (1.25 %) against *T. castaneum* adults at 30 and 20°C.

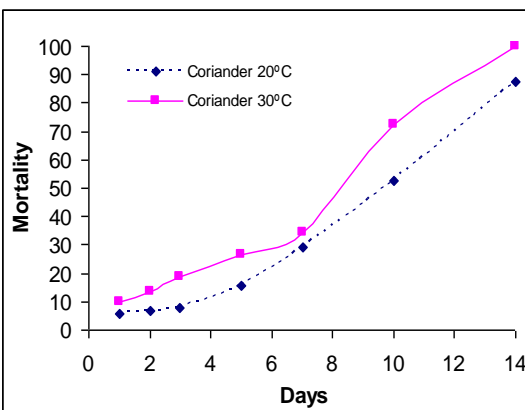


Fig. (11): Efficacy of coriander oil at (5%) against *T. castaneum* adults at 30 and 20°C.

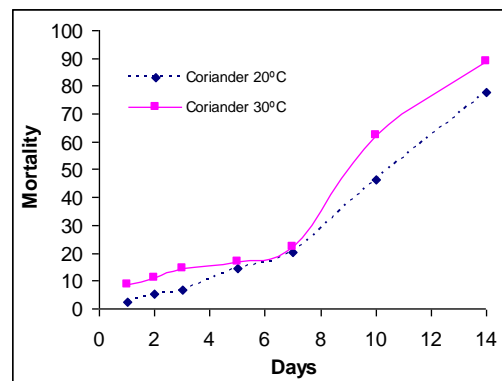


Fig. (12): Efficacy of coriander oil at (4%) against *T. castaneum* adults at 30 and 20°C.

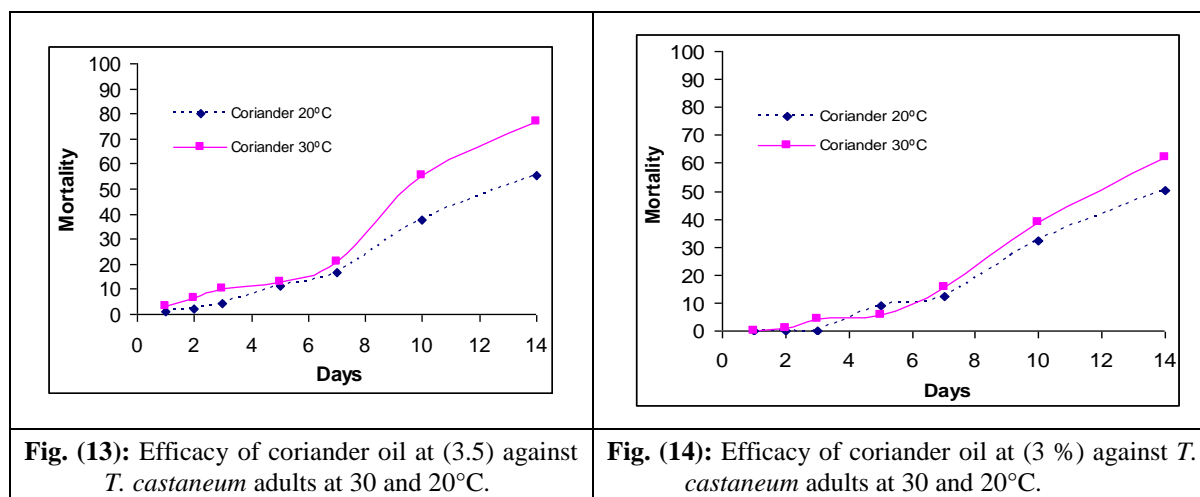


Table 1. Lethal concentration values and parameters of mortality regression line of geranium, coriander and cumin oils on *S. oryzae* adult at two tested temperatures

plant oil	Tempe.	Lethal concentrations(v/w%)of tested plant oils and Their 95% Confidence Limits		Slope \pm SD ¹	R ²
		LC ₅₀	LC ₉₀		
Geranium	30 °C	0.49 (0.39 – 0.95)	1.06 (1.01 – 2.35)	1.34 \pm 0.15	0.98
	20 °C	0.88 (0.71 – 1.17)	2.98 (2.02 – 5.05)	3.93 \pm 0.53	0.96
Coriander	30 °C	0.77 (0.64– 0.98)	2.27 (1.66 – 3.61)	1.45 \pm 0.16	0.99
	20 °C	1.31 (1.04 – 1.81)	4.16 (2.75 – 8.09)	1.34 \pm 0.17	0.97
Cumin	30 °C	1.06 (0.85- 1.44)	3.31 (2.25- 6.03)	1.37 \pm 0.61	0.98
	20 °C	1.53 (1.15 – 2.32)	5.06 (3.11 – 11.29)	1.29 \pm 0.17	0.95

1: Standard deviation

2: Correlation coefficient of regression line.

3: Mortality was recorded after 3 days of treatment for geranium, coriander and cumin

Table 2. Lethal concentration values and parameters of mortality regression line of geranium, coriander and cumin oils on *T. castaneum* adult at two tested temperatures .

plant oil	Tempe.	Lethal concentrations(v/w%)of tested plant oils and Their 95% Confidence Limits		Slope \pm SD ¹	R ²
		LC ₅₀	LC ₉₀		
Geranium	30 °C	1.72 (1.60 – 1.83)	3.77 (3.19 – 4.99)	3.77 \pm 0.52	0.95
	20 °C	1.89 (1.76 – 2.02)	4.01 (3.38 – 5.83)	3.93 \pm 0.53	0.96
Coriander	30 °C	2.82 (2.56– 2.99)	3.94 (3.77 – 4.27)	8.74 \pm 1.27	0.99
	20 °C	3.08 (2.72 – 3.28)	5.22 (4.74 – 6.21)	5.58 \pm 0.89	0.97
Cumin	30 °C	2.15 (1.91- 2.62)	3.69 (3.26 – 4.41)	2.29 \pm 0.41	0.96
	20 °C	2.56 (2.27 – 3.16)	6.94 (4.98 – 12.69)	2.97 \pm 0.45	0.95

1: Standard deviation

2: Correlation coefficient of regression line

3: Mortality was recorded after 14 days of treatment for coriander and 3days for geranium and cumin

Similar results were observed by **Azab, (2015); El-Lakwah et al., 2000 (a and b); 2002(a and b); Mohamed, (1999); Halawa, (1998)**. The data indicated clearly that adults were the most sensitive to the three tested oils, where as the *T.castaneum* was the least sensitive to the plant oils under study.

The obtained results during this study are in harmony with the findings of other investigators such as **Zamani et al., (2010); Sahaf et al., 2008; Wawrzyniak and Blazejewska 2002; Padin, 2000; Mohamed et al., (1999)**.

Conclusion

The findings of present study suggested that plant oils of geranium, coriander and cumin may be potentially used as eco- friendly pest control agents against insect pests of stored products.

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فاعلية بعض الزيوت النباتية ضد حشرتي سوسة الأرز و خنفساء الدقيق الكستانية

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1 قسم وقاية النبات - كلية الزراعة - جامعة بنها

2 معهد بحوث وقاية النباتات - مركز البحوث الزراعية - الدقى - الجيزة

أجرى هذا البحث لدراسة التأثير الإبادى للزيوت النباتية الشمر والكزبرة والكمون على حشرتي سوسة الأرز وخنفساء الدقيق الكستانية حيث أجريت تجارب التقدير الحيوى بإستخدام من أربع إلى خمس تركيزات للزيوت النباتية وكانت الإختبارات لمدة 14 يوم تحت درجتى حرارة هي 20 و 30 ± 1 درجة مئوية. وقد أشارت النتائج إلى زيادة نسبة الموت للحشرات بزيادة تركيز الزيت المستخدم أو بزيادة مدة التعرض للزيت أو بزيادة درجة الحرارة حيث أمكن الحصول على نسبة موت تام للحشرات الكاملة لسوسة الأرز بإستخدام تركيز 1.5 % من أى من الزيوت المستخدمة بعد 14 يوم من التعرض للزيت على درجة حرارة 30 درجة مئوية. كما أظهرت النتائج أن زيت الشمر هو الأكثر سمية لجميع الحشرات تحت الدراسة على درجتى الحرارة حيث كانت الجرعة النصفية LC₅₀ هي 1.72 و 0.49 % على درجة حرارة 30 ° م و 1.89 و 0.88 % على درجة حرارة 20 ° م في خنفساء الدقيق الكستانية بعد (14 يوم من المعاملة) وسوسة الأرز بعد (5 يوم من المعاملة) على التوالى كما كانت الحشرات الكاملة لسوسة الأرز هي الأكثر حساسية لكل الزيوت المختبرة. ويستنتج من ذلك أن كلاً من زيت الشمر والكزبرة والكمون لها تأثير سام ضد كل من حشرتي سوسة الأرز وخنفساء الدقيق الكستانية .