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Efficacy of certain plant oils as grain protectants against the rice weevil, *Sitophilus oryzae* (Coleoptera: Curculionidae) on wheat

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ABSTRACT

The present study was carried out to evaluate the toxicities of celery, camphor and garlic oils against the rice weevil, *Sitophilus oryzae* adults through laboratory tests by treating wheat grains with such plant oils. Mortality increased with increasing of both concentration and exposure period. The most effective oil was camphor (LC_{50} = 0.84 and LC_{95} =2.85 ml/Kg wheat), followed by the celery oil (LC_{50} = 0.89 and LC_{95} =3.84 ml / Kg wheat) and garlic oil (LC_{50} =1.27 and LC_{95} =10.81 ml / kg). All oils at LC_{50}'s caused a significant decrease in the mean number of eggs laid by females as compared to the control and completely inhibited adult emergence.

Key words: Rice weevil, *Sitophilus oryzae,* plant oils wheat protectants

INTRODUCTION

The rice weevil, *Sitophilus oryzae* (L.) has been reported as one of the severe pests of cereal grains and their products (Baloch, 1992) causing loss in weight and leading to quality deterioration and fungal growth in harvested cereals (Park *et al*., 2003).

In Egypt, the annual loss in wheat due to stored insects is estimated as equivalent to half a million tons of which 12% is caused by the rice weevil alone (Ministry of agriculture and land reclamation report, Egypt, 2007).

The control of rice weevil and other pests of stored products by the use of chemical insecticides have serious drawbacks, such as the environmental pollution, insect's resistance, high mammalian toxicity and increasing cost of application. This had led to search for more safe and less expensive alternative chemicals such as plant oils. Oils are safe to mammals, easily obtained, can be integrated with other pest management measures and eliminate the risk associated with hand mixing of insecticides. Thus, oils can play an important role in the protection strategy of stored products.

This study evaluates the efficiency of three plant oils as possible protecting agents of wheat grains against infestation by the rice weevil, *Sitophilus oryzae.*

MATERIALS AND METHODS

Sitophilus oryzae

Adults (1-2 week old) used in this study were obtained from a laboratory colony, established and maintained on wheat grains under constant laboratory conditions of 25 ± 1°C temperature and 65 ± 5% RH in Stored Products Department, Plant Protection Research Institute, Agriculture Research Center, Dokki, Giza, Egypt.

Plant Oils

Three locally available oils namely celery (*Apium graveolens*), camphor (*Cinnamomum camphora*) and garlic (*Allium sativum*) were tested in this study. A stock solution of each oil was prepared by mixing 1 ml in 10 ml of petroleum ether. Series of dilutions from such stock solution were prepared.

Treatment of Wheat Grains

Samples of disinfected wheat grains of ten grams each were separately placed in a glass tube (1 inch dia × 3 inch depth) and mixed with 1 ml of the oil concentration to achieve the desired test concentrations in ml/Kg wheat. The tubes were shaken vigorously and the solvent was allowed to evaporate for 30 minutes by using an electric fan.

Exposure of Adults to Treated Wheat Grains

After introducing the adults into the tubes containing the treated grains, the tubes were covered with muslin cloth secured with elastic bands and kept in the incubator under constant conditions (25 ± 1ºC, 65 ± 5 % RH).

The Insecticidal Efficiency of Tested Oils

A group of 25 adults were introduced into each tube containing treated grains. At least five oil concentrations which gave 20% to about 97% mortality were evaluated. Control tubes contained grains treated with the solvent only were also included. The control and treatments were replicated three times. Insect mortalities were calculated after 3, 5, 7 and 14 days post exposure. Mortality percentages were corrected by the formula of Abbott (1925) and probit analysis (Finney, 1971) was used to estimate the LC_{50} and LC_{95} after 3 days of exposure

Effect of Tested Oils on Egg Production and Adults' Emergence

Three replicates each of five adult couples were placed in tubes containing grains treated with LC_{50} of each oil and, covered with muslin and kept in the incubator. After 15 days, the insects were removed and the number of deposited eggs was counted (Howe, 1952). Tubes containing eggs were incubated and observed regularly for adult emergence.

Statistical Analysis

Means (±SE) were calculated and compared by the One-way ANOVA. If ANOVA shows significant inequality of the means, they were compared by Duncan multiple range test at 5% probability level. The SPSS software (Version 10 for windows, SPSS Inc., Chicago, IL) was used for statistical analysis.

RESULTS AND DISCUSSION

The insecticidal efficiency of the three plant oils:

Results (Figure 1) indicate that a gradual increase in the mortality rate of *Sitophilus oryzae* adults with increasing oil concentrations and the exposure period, i.e., mortality is directly related to oil concentration and exposure period. In consistence with such results, Arannilewa *et al*. (2006) reported an increase in adult mortality with increasing the days of exposure in all concentrations of four medicinal plant oils against the maize weevil, *Sitophilus zeamais* in the laboratory. Also, Arabi *et al*. (2008) reported that mortality of *Sitophilus oryzae* was increased with the increase of the concentrations of oils that contain camphor and 1, 8-cineole and increased the time of exposure. Similar findings were also obtained by Ahmed (2006) who observed complete mortality of *Oryzaephilus surinamensis* by camphor oil at concentration of 0.5% and increase of mortality with increasing the time of exposure.

The difference observed among the mortalities due to these three oils may be due to the differences in their volatilities. Liu and Ho (1999), Huang, *et al*. (2000) found that, mostly monoterpenes are very active on insects due to their active volatiles.

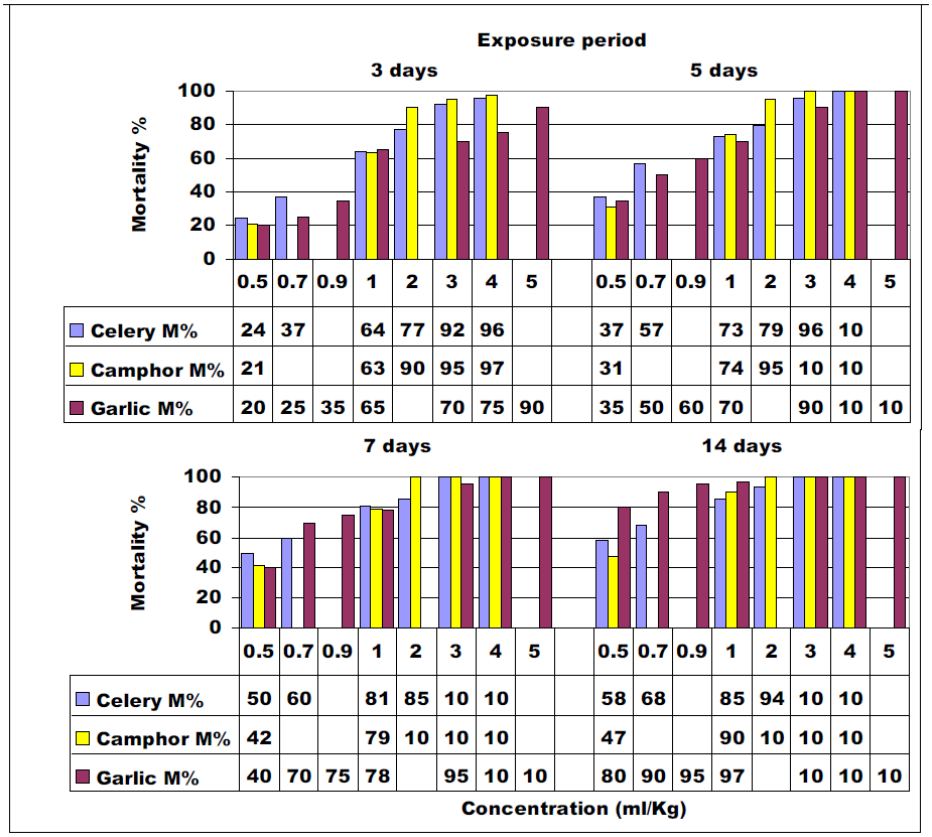

Fig. 1: Corrected mortality percentages of *Sitophilus oryzae* adults after exposure for different periods on wheat grains treated with different concentrations of three plant oils.

The calculated LC_{50}'s and LC_{95}'s (Table 1) after 3 days of adult exposure indicated that Camphor oil is the most effective (LC_{50} = 0.84 and LC_{95} = 2.85 ml/Kg wheat), while the garlic oil was the least effective (LC_{50}= 1.27 and LC_{95} =10.81ml/kg wheat). Thus the three oils can be arranged according to their median lethal concentrations in the following ascending order: camphor oil < celery oil < garlic oil. However, Adedire and Ajayi (1996) reported that Garlic oil may be a very potent because of its strong choky odors and which may have excreted a toxic effect by disturbing normal respiratory activity of the weevils, thereby resulting in asphyxiation and subsequent death. Richards (1978) reported that essential oils of plant origin are highly lipophilic and therefore have the ability to penetrate the cuticle of insects. By this method the plant material apart from its odor, may have also acted as a contact poison. However, the mode action of oils still needs further studies (Don-pedro, 1989).

Table 1: Estimated lethal concentrations (LC_{50} and LC_{95}) of the three plant oils against *Sitophilus oryzae* adults exposed to treated wheat grains for three days.

Oil	**LC_{50} (ml/Kg)**	**LC_{95} (ml/Kg)**	**Slope ± SE‡**
Celery	0.89	3.84	2.60 ± 0.20
Camphor	0.84	2.85	3.12 ± 0.25
Garlic	1.27	10.81	1.77 ± 0.14**

‡** ($P < 0.01$), χ^2 test

Effect of tested oils on egg deposition and adults' emergence

The three oils had significant decrease (F = 116.55 *d.f.* = 1, 3; $P \leq 0.01$) in the female fecundity (eggs /female) as compared to the control (Table 2). At LC_{50}'s level, camphor, celery and garlic oils treatments of adults yielded 0.40, 0.93 and 1.20 eggs/ female, respectively, i.e., the camphor oil caused the highest reduction (95.95%) in the number of deposited eggs followed by celery, (90.58 %) while the least reduction was that of the garlic oil (87.84%) as compared to that of control (9.87 eggs/ female). This is directly related to the efficiency of the three tested oils, i.e., the least effective oil (garlic) gave the highest yield. However the difference in egg yield among the three oils was not significant (Duncan's test, $P \leq 0.05$).

Table 2: Effect of LC_{50} of the three plant oils on egg production and adult emergence of *Sitophilus oryzae.*

Oil	Mean ± SE/ female‡	
	No. of eggs	No. of emerged adults
Celery	0.93 ± 0.18^{A}	0
Camphor	0.40 ± 0.12^{A}	0
Garlic	1.20 ± 0.31^{A}	0
Control	9.87 ± 0.75^{B}	7.60 ± 0.30^{bcd}

‡ Means with the different letters are significantly different ($P \leq 0.05$), Duncan's test)

The present study gives evidence on the impact of the three tested oils on adult oviposition. It was demonstrated that some essential oils are able to halt the egg incubation (Liu and Ho, 1999) or to kill the hatched larvae (Huang *et al*., 2000).

The three oils completely inhibited adult emergence. The suppression of F_1 adult emergence was likely to be caused by toxicity of the oils to eggs or younger larvae as concluded by Arannilewa *et al*. (2006) for four medicinal plants against the maize weevil, *Sitophilus zeamais*. The authors suggested that the reduction in oviposition and the suppression of adult emergence may be due to that the oils on application covered the outer layer (testa) of the grains, thereby serving as food poison to the adult; or due to its penetration into the endosperm and germ layers, thereby suppressing oviposition and larval development.

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ARABIC SUMMARY

فاعلية بعض الزيوت النباتية كمواد واقية لحبوب القمح ضد حشرة سوسة الأرز *Sitophilus oryzae* على القمح

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تم تقييم فعالية ثلاثة زيوت نباتية وهى: زيوت الكرفس، الكافور و الثوم مذابة فى الاثير البترولى ضد الحشرة الكاملة لسوسة الأرز. اظهرت النتائج إلى وجود علاقة طردية بين النسبة المئوية لموت الحشرات وكلا من تركيزالزيوت وزمن تعريض الحشرات. وبناء على قيم التركيز نصف المميت 50 % (LC_{50})والمميت 95% (LC_{95})، تم ترتيب الزيوت الثلاثة تصاعديا تبعا لسميتها كالتالى :- الكافور< الكرفس< الثوم . وبهذا يكون زيت الكافورالاكثر كفاءة.

وقد تم دراسة تأثيرالتركيز نصف المميت (LC_{50}) للزيوت الثلاثة على عدد البيض والخلفة فى الجيل الأول. وقد أظهرت النتائج إنخفاض ملحوظ فى عدد البيض كما لم يسجل خروج أى خلفة من الجيل الأول بالمقارنة مع الكنترول.