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# EFFECT OF SOME BOTANICALS OILS AGAINST *Sitophilus oryzae*, *Rhyzopertha dominica* And *Tribolium castaneum*

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## ABSTRACT

The present study was carried out to evaluate three oils (basil, chamomilla and nigella) and malathion as reference against three important insects of stored products,rice weevil , *Sitophilus oryzae*,Lesser grain borer, *Rhyzopertha dominica* and red flour beetles, *Tribolium castaneum* using the bioassay method, mixing with media. Results obtained demonstrated that the chemical insecticide malathion was the most efficient agent as compared with the other tested toxic materials. The basil oil was the most efficient against *S. oryzae* followed by chamomilla and nigella. The emergence of *S. oryzae* adults showed significant differences between the control and all treatments. For *R. dominica* the chamomilla oil was the most effeicient followed by basil and nigella. The loss of wheat weight showed significant differences between control and treatments. For *T. castaneum* the chamomilla oil had the most adversed effect on the all parameters studied. It reduced the number of progeny and loss % wheat grain, and increased the % reduction in progeny. The germination percentages decreased with increasing the concentration and exposure period.

## INTRODUCTION

The loss of food grains during storage due to various insect pests is a very serious problem. Therefore, it is main important to avoid these losses not only to save valuable, human food, but also to maintain seed quality, quantity and the economic value (El-Lakwah *et al*. 2000).

The environmental problems caused by overuse of pesticides have been the matter of concern for both scientists and public in recent years. It has been estimated that about 2.5 million tons of pesticides are used on crops each year and the worldwide damage caused by pesticides reaches $ 100 billion annually. The reasons for this are two fold: (1) the high toxicity and nonbiodegradable properties of pesticides and (2) the residues in soil, water resources and crops that affect public health. Thus, on the one hand, one needs to search the new highly selective and biodegradable pesticides to solve the problem of long term toxicity to mammals and, on the other hand, one must study the environmental friendly pesticides and develop techniques that can be used to reduce pesticide use while maintaining crop yields.

Malathion, an organophosphorous compound (OP), was used widely in the 1960s (Winks and Bailey, 1965) until the wide spread led to development of resistance in a range of species rendered this protectant largely ineffective (Champ and Dyte, 1976). New protectants have been registered since that time, and used to control a range of species with different susceptibilities to the new protestants but new resistance continued to develop (Collins *et al*., 1993).

Natural products are an excellent alternative to synthetic pesticides as a means to reduce negative impacts to human health and the environment.

Essential oils are defined as any volatile oil (s) that have strong aromatic components and that give distinctive odour, flavour or scent to a plant. These are the by-products of plant metabolism and are commonly referred to as volatile plant secondary metabolites. Essential oils are found in glandular hairs or secretory cavities of plant-cell wall and are present as droplets of fluid in the leaves, stems, bark, flowers, roots and / or fruits in different plants. The aromatic characteristics of essential oils provide various functions for the plants including (i) attracting or repelling insects, (ii) protecting themselves from heat or cold; and (iii) utilizing chemical constituents in the oil as defence materials. Many of the essential oils have other uses as food additives, flavourings, and components of cosmetics, soaps, perfumes, plastic, and as resins.

Side effects and toxic hazards have been observed in the environment. In view of this, the search for anti-insect chemicals naturally occurring in plants has received special attention in recent years. This is because these substances could be used to solve the serious problems of insect resistance to insecticides, management programs, pest resurgence and detrimental effects on non target organisms. The biorational insecticides, those based on natural products and synthesized analougues of naturally occurring biochemicals, are more acceptable than other conventional chemical pesticides; because of an assumed reputation for being environmentally innocuous, available and less hazardous to humans and non-target organisms (Mc Closky *et al*, 1993 and Prakash and Rao, 1997). There is now overwhelming evidence that many plant species exert diverse biological effect on insects, i.e killing, attracting, repelling, feeding deterring, growth inhibiting and sterilizing effects (Abbassy, 1969, 1974, 1981 and 1982; Meisner *et al* ., 1982 and Simmonds *et al*., 1996, Lopez *et al* ., 2008; Mansoor and Sattar, 2013).

Therefore , the present study was conducted to investigate the efficiency of three oils(basil, chamomilla and nigella) compared to the recommended compound malathion, against three important insects of stored products, *S. oryzae*, *R. dominica* and *T. castaneum* using mixing with stuff method with the respect to adult mortality and progeny reduction. Finally, this study investigated the effect of three oils on the germination of wheat grains.

## MATERIALS AND METHODS

**1-Materials:**

**Insects:**

Three important coleopteran stored grain pests were assessed in the current investigation, Lesser grain borer, *R. dominica* (F.) (Bostrychidae: Coleoptera), rice weevil, *S.oryzae* (L.) (Curculionidae: Coleoptera) and red flour bettle, *T. castaneum* (Herbst) (Tenebrionidae: Coleoptera). The original stock culture of the three insects were obtained from stored product pest laboratory, Plant Protection Research Institute , Sakha Agricultural Research Station.

**Tested toxicants :**

**Insecticide :** Malathion : (57% E.C.) 0,0 dimethyl –s-(1,2 dicarboxyethyl) ethylphosphorodithioate.

**Botanical oils :**

Botanical oils listed in Table (1) were obtained from Aro-Misr Co., Egypt. The oil concentrations used were 0.25 , 0.50 , 0.75 and 1.0% w/w.

**Table (1) : Listed Botanical oils.**

| Arabic name | English name | Scientific name | Part used | Source |
|---|---|---|---|---|
| الريحان | Basil | *Ocimum basilicum* | Leaves | Aro-Misr Co., Egypt |
| البابونج | Chamomilla | *Matricaria chamilla* | Flowers | Aro-Misr Co., Egypt |
| حبة البركة | Nigella | *Nigella sativa* | Seeds | Aro-Misr Co., Egypt |

**2.Methods:**

**Insect cultures**

***R. dominica* :**

Insects were reared on wheat grains, cleaned from dusts, husks and other inert materials and sterilized by heating at 60ºC for one hour, then grains were put in glass jars each containing 400g of wheat and provided with 100-200 adult insects. Jars were covered with muslin cloth secured with elastic rubber bands and placed under laboratory conditions of 30±2ºC and 65±5% R.H. The newly emerged adults (1-2 weeks old) were used for tests.

***S .oryzae*:**

*S. oryzae* (Egyptian strain) was obtained from the Department of Stored Products Pest Control, Plant Protection, Research Institute Sakha Kafr-El-Shiekh. This strain was continuously reared free of insecticidal contamination for several years at 30±2°C and 70±5 relative humidity (RH). The cultures were maintained under the same conditions in the Pesticide Department, Faculty of Agriculture, Kafr-El-Shiekh University, Egypt and 200–400 adults from the pervious culture were added in 1,000 ml glass jars containing 400 gram of wheat as a culture medium. The mouth of the jars were covered with muslin cloth. Then, 7–14 d old adults were used for experimental work.

***T. castaneum*:**

Insects were reared on a mixture of wheat grain mixed with wheat flour. Grain were cleaned and sterilizes and put in glass jars each containing 400gm (30% wheat flour) and provided with 100-200 adult insects. Jars were covered and placed under laboratory conditions of 30±2ºC and 65±5% R.H. The newly emerged adults (1-2weeks old) were used for different tests.

**Treatment with insecticide , malation :**

**Exposure of the adults of *S. oryzae*, *R. dominica*, and *T. castaneum* to treated media:**

Batches of whole wheat grain were weighed (20gm) and placed in glass jars (250ml) for *S. oryzae* and *R. dominica*, or 20g of cracked wheat grains for *T. castaneum* . The tested insecticide , (malathion) was diluted in water and added to the grains at rates which give the required concentrations (0.5, 1,2 and 4ppm) for malathion, jars were shaken by hand and grains were allowed to dry at room temperature. Twenty unsexed adults of each insect (1-2weeks old) were introduced to a jar containing treated grain, 3 replicates were set up for each treatment and control . Before introducing *T. castaneum* , part of wheat was ground to flower and returned to the jars. Mortality counts were recorded after 7 and 14 days and corrected by Abbott's formula (1925). The number of progeny was recorded after 2 months post-treatment. The reduction percentages in adult number after 2 months post-treatment were recorded and calculated according to the following equation of Tapondjou *et al*.( 2002).

**% IR = (Cn - Tn) 100/Cn, where,**

Cn is the number of newly emerged insects in the untreated (control) jar,

Tn is the number of newly emerged insects in treatments

Percentages of wheat weight loss were also recorded 2 months after treatment according to the equation of **Harris and Lindblad (1978).**

$$\% \text{ loss} = \frac{\text{Initial dry weight of seeds} - \text{seeds dry weight after 2 months}}{\text{Initial dry weight of seeds}} \times 100$$

**Treatment with botanical oils mixing with diet bioassay method:**

To carry out the treatments, batches of sterilized whole and cracked wheat grains (20g each) were cleaned and tempered to moisture of 12.5±0.5%. The oil toxicants tested at different concentrations of 0.25, 0.50, 0.75 and 1.0 w/w which were dissolved in acetone (2ml) and then mixed manually with whole or cracked wheat grains in wide-month glass jars (250 ml). After evaporation of acetone the treated whole or cracked wheat grains were infested by twenty newly adults (1-2 weeks-old) of *S. oryzae*, *R. dominica* and *T. castaneum*, separately. Whole and cracked wheat grain free of toxicants were used as control. Three replicates were kept at 30±1ºC and 65±5% R.H. for each treatment and control. Mortality percentages were recorded at 1 and 2 weeks exposure periods and corrected according to Abbott's formula (1925). The number of progeny was recorded 2 months after treatment and the reduction % progeny was calculated according to the equation of Tapondjou *et al*.( 2002).

**% IR = (Cn - Tn) 100/Cn, where,**

Cn is the number of newly emerged insects in the untreated (control) jar,

Tn is the number of newly emerged insects in treatments

The loss % in wheat weight was also calculated 2 months post-treatment according to the equation of Harris and Lindbled (1978):

$$\% \text{ loss} = \frac{\text{Initial dry weight of seeds} - \text{seeds dry weight after 2 months}}{\text{Initial dry weight of seeds}} \times 100$$

The germination tests were accomplished on prior treated wheat grains by toxicants tested according **Qi and Burkholder (1981)** with slight modification. After 60 days of treatment, sixty grain seeds of each treatment were divided into three replicates, placed on Petri-dishes containing cotton layer soaked with tap water and covered with tissue paper. germination percentages were recorded after 4 days.

**2.4. Statistical Analysis**

Data obtained from the experiments were statistically analyzed using one-way repeated measurement analysis of variance. Duncan's multiple range test Duncan (1955) were used to separate means using SAS program (Version 6.12, SAS Institute Inc., Cary, USA).

## RESULTS AND DISCUSSION

**1- Insecticidal activity of insecticide (malation) on adult insects *S. oryzae*, *R. dominica* and *T. castaneum*:-**

A laboratory experiment was carried out to evaluate one recommended chemical synthetic insecticide, malathion as reference against three important insects of stored grain,*S. oryzae*, *R. dominica* and *T. castaneum*. Results obtained in Table (2) show that rates of malation from 1-4 ppm completely prevented the emergence of adults of *S. oryzae* and followed that increase the reduction of progeny to 100%. In addition , the concentration of 0.5 ppm malathion caused 79% reduction in progeny. For *R. dominica* data in Table (2) refer the same trend with *S. oryzae* , but the *R. dominica* was more susceptible to chemical insecticide tested than *S. oryzae* . *T. castaneum* was more tolerant than the other tested insects, and the percentage of loss weight of wheat decreased in comparison with control In generally, *R. dominica* was the most susceptible to malathion followed by *S. oryzae* and *T. castaneum* . Many research workers investigated the effectiveness of malathion against some important of stored product insects (Nayak *et al*., 2005; Kljajia and Peric, 2007 and Athanassiou( a and b) *et al*., 2009).

**2-Effect of botanical oils admixed with wheat grain on the tested insects:-**

In this experiment three oils related to three different plant species were evaluated as stored grain protectants against three important insects of stored product, *S.oryzae, R.dominica* and *T.castaneum* using mixing with stuff method.

**Effect on *S.oryzae*:**

The results in Table (3)showed significant differences in activity between oils used on *S.oryzae* at one and two weeks after treatment. The basil oil was the most efficient followed by chamomilla and nigella with $LC_{50}$

values 0.05 , 0.07 and 0.11 w/w, respectively, at 2 weeks post-treatment. The emergence of *S.oryzae* adults showed significant difference between the control and all treatments and also within the treatments. The mean numbers of F1-progeny insects after 2 months were 580 adults in control while the corresponding numbers of the three tested oils of basil, chamomilla and nigella ranged from 10 to 197.

The reduction percentage in adults number after 2 months at the concentrations of 0.75 and 1.0% w/w for basil, chamomilla and nigella oils were (86.6 and 96.6%), (87.6 and 98.3%), and (82.8 and 91.9%) respectively. Derballa and Ahmed ( 2011)indicated that the higher efficacy of spearmint oil than powder against *S. oryzae* may be due to the oil's higher ability to penetrate into the insect's body

The results also cleared that there were significant differences in the loss % of wheat weight between control and the all tested plant oils, where the loss % values were 61% with control and ranged from 1 to 4.4% for the all concentrations of the tested oils.

**Effect on *R.dominica*:**

The results in Table(4) indicated that the chamomilla oil was the most efficient with $LC_{50}$ of 0.09 followed by basil and nigella with $LC_{50}$ values of 0.10 and 0.18 w/w after two weeks o f treatment.

The emergence of *R.dominica* had tha same trend with *S.oryzae* where there were significant differences between the control and all treatments and also within the treatments. The mean numbers of F1-progeny insects after 2 months was 471 adults in control, the corresponding numbers of basil, chamomilla and nigella oils ranged from 12 to 121 at the overall level of treatments . For the reduction percentages in adults number after 2 months, the chamomilla oil had the most effect with rate of 97.5 % reduction at 1.0 w/w followed by basil and nigella with rates of 96.2 and 91.7%, respectively. **A** reduction of adults emergence may have been achieved through a combination of high mortality of eggs and larvae immediately after eclosion and contact with spearmint oil **Lale and Abdulrahman( 1999).** The loss of wheat weight showed significant differences, control had 34% loss compared to basil, chamomilla and nigella treatments which reduced the %loss of wheat grain to levels of 1.7 to 5.4 % at the all concentrations of treatments compared to control.

**Effect on *T.castaneum*:**

The results obtained in Table (5) indicated that the chamomilla oil had the most adversed effect on the all parameters studied. It reduced the number of progeny and% loss of wheat grain, and increased the % reduction in progeny with percent of 94.5 at 1.0 w/w compared to basil and nigella which demonstrated 92.3 and 82.4 at the same concentration 1.0 w/w. The mentioned results in Tables (3-5) demonstrated the following points: chamomilla oil was the most effective agent compared to the remained oils following by basil and nigella oils.

1-There were high significant differences between control and the tested plant oils at the all concentrations for the all tested criteria, for example the tested oils reduced the adults emergence adults and the loss of grain .

2-*T.castanum* was less susceptible compared to the other two insects tested.

3-The differences between the effect of tested plant oils ascribe the different behaviour, the different physiological characters of the tested insects and the type of plants produced the oils tested (their chemical composition).

4-The results obtained highly affected by the concentration and the long of exposure period .

These results agree with that of several investigators. Abo-Arab *et al*. (1998) reported that *T.castaneum* was more tolerant than *S.oryzae* to *Nigella sativa* oils at level of 16 ml/kg grains and all three plant extracts at the concentrations of $LC_{99}$ completely prevented any emergence of adult *S.oryzae* for 6 months after treatments. Obeng and Reichmuth (1999) tested certain plant oils (coconut, sunflower, sesame and mustard ) at 10 and 5 ml/kg grains against *S.granarius* and *S.zeamais*. The mortality was significantly decreased with application time.

Kim.soonil *et al*. (2003) mentioned that the methanol extracts from 30 aromatic medicinal plant species and five essential oils gave best insecticidal efficacy against *S.oryzae* and *C.chinensis*. Raghvain and Kapadia (2003) mentioned that the neem and coconut oils at 10ml/kg seeds provided the complete protection of the seeds against *C.maculatus* for 6 months after treatment. Adedrie and Akinneye (2004) tested the powder and ethanol extract of *Tithania diversifolia* leaves at five different concentrations (0.0%, 1.0%, 1.5% and 2.0%) on *C.maculatus* mortality, oviposition and adults emergence, the leaf extract had higher bioactivity on oviposition, adult emergence and mortality of the insects . Cosimi *et al*. (2009) and Nerio *et al*. (2009) evaluated essential oil isolated from certain aromatic plants for toxic and repellent activity. They claimed that its constituents are potential alternatives to synthetic fumigants in the treatment of durable agricultural products . The oil of *Thymus persicus* was found to be toxic against *T. castaneum* and *S. oryzae* with LC50’s of 236.9 and 3.34 ll l-1 air, respectively Saroukolai *et al*.( 2010).

Fouad (2013) Concluded that essential oils of camphor (*Eucalyptus globules*), cinnamon (*Cinnamomum zelanicum*), clove (*Syzygium aromaticum*) and mustard (*Brassica rapa*) repelled the adults of *C.maculatus* when applied at 1%.

Gonzalez *et al*., (2014) reported that the germanium and bergamot produced contact toxicity during 4 and 2 weeks in *T.castaneum*, respectively. They found that the major compounds citronellol and geranial (26.14% and 23.19%,respectively). Three other terepenes were secondary important; linalool, citronellol formate and menthone.

**Effect of the tested treatments on the germination of wheat grain:**

The results in Table (6) showed significant differences in seed germination between oil treatments and control, and within concentrations. The germination percentages decreased with increasing the concentration and exposure period. The germination percentages at concentration 1.0% w/w was 87% for control after 2 months and (64.0%) , (48%) and (62%) in basil, chamomilla and nigella oil treatment, respectively. These results indicated that the all tested oils had a high detrimental effect on germination compared to control.

2-3

4-5

**Table (6) : Effect of the tests botanical oils on germination after 2 months of treatment.**

| Treatments | Concentration w/w % | Germination % |
|---|---|---|
| Basil | 0.25 | 83.0b |
| | 0.50 | 77.0cd |
| | 0.75 | 69.0f |
| | 1.00 | 64.0g |
| Chamomilla | 0.25 | 75.0de |
| | 0.50 | 63.0g |
| | 0.75 | 55.0h |
| | 1.00 | 48.0i |
| Nigella | 0.25 | 87.0a |
| | 0.50 | 80.0be |
| | 0.75 | 73.0e |
| | 1.00 | 62.0g |
| Control | 0 | 87.0a |

**Means followed by the same letters in the column are not significantly different (P<0.05)** .

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# تأثير بعض الزيوت النباتية ضد سوسة الأرز ، وثاقبة الحبوب الصغري و خنفساء الدقيق الصدئية

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أجريت هذه الدراسة بغرض تقييم ثلاثة من الزيوت النباتية وهي (زيت الريحان ، البابونج وحبة البركة) بجانب مبيد الملاثيون كمقارنة علي ثلاثة حشرات هامة من المواد المخزونة وهي سوسة الأرز ، ثاقبة الحبوب الصغري وخنفساء الدقيق الصدفية وذلك عن طريق خلطها مع البيئة الغذائية .

وأوضحت النتائج المتحصل عليها ان المبيد الكيماوي ملاثيون كان هو الأكثر تأثيراً علي الحشرات المختبرة بالمقارنة بالمركبات الآخري .

وأن زيت الريحان كان الأكثر تأثيراً علي حشرة سوسة الأرز يليه زيت البابونج ثم حبة البركة وكانت نسبة الخفض في الخلفة للزيوت الثلاثة المستخدمة وجد فيها فروق معنوية بينها وبين الكنترول .

أما بالنسبة لحشرة ثاقبة الحبوب الصغري أوضحت النتائج أن زيت البابونج الأعلي تأثيراً يليه الريحان ثم حبة البركة ووجد أنه بالنسبة للفقد في وزن الحبوب الناتجة من المعاملة ان هناك فروقاً معنوية بين التركيزات والكنترول لكل المعاملات المستخدمة .

أما بالنسبة لحشرة خنفساء الدقيق الصدئية وجد أن زيت البابونج كان الأكثر فاعلية يليه زيت حبة البركة – كما أن حشرة خنفساء الدقيق الصد ئية كانت أقل الحشرات المستخدمة تأثيراً بالزيوت النباتية .

أما بالنسبة للفقد في وزن الحبوب الناتجة من المعاملة فقد وجد أن هناك فروقاً معنوية بين التركيزات والكنترول لكل المعاملات المستخدمة علي الثلاث حشرات . أما نسبة الإنبات فقد انخفضت مع زيادة التركيزات .

**Table (2): Effect of insecticide, malathion on adults of *S.oryzae, R.dominica* and *T.castaneum* using mixing with media at different indicated periods (week).**

| Adult insects | Treatments | Conc. (ppm) | Mortality% | | $LC_{50}$ | | Slope value | | Confidence limits | | | | No. of emerged adults after 2 months | %reduction in F1 progeny | % Loss wheat grain weight |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 1 | 2 | 1 | 2 | 1 | | 2 | | | | |
| | | | | | | | | | Lower | Upper | Lower | Upper | | | |
| *S.oryzae* | Malathion | 0.5 | 48.0 | 72.0 | 0.40 | 0.06 | 1.26 | 0.97 | 0.23 | 0.56 | 0.003 | 0.16 | 89.0g | 79.00b | 5.3f |
| | | 1 | 69.0 | 90.0 | | | | | | | | | 0.0 | 100.00a | 3.19h |
| | | 2 | 79.0 | 88.0 | | | | | | | | | 0.0 | 100.00a | 2.00hi |
| | | 4 | 84.0 | 93.0 | | | | | | | | | 0.0 | 100.00a | 1.3i |
| | Control | 0 | 0 | 0 | - | - | - | - | - | - | - | - | 424.0a | - | 68.5a |
| *R.dominica* | Malathion | 0.5 | 50.0 | 77.0 | 0.39 | 0.21 | 1.45 | 2.36 | 0.24 | 0.52 | 0.10 | 0.31 | 102.89c | 67.6d | 3.2ef |
| | | 1 | 72.0 | 88.0 | | | | | | | | | 0.0 | 100.00a | 2.6fg |
| | | 2 | 81.0 | 95.0 | | | | | | | | | 0.0 | 100.00a | 1.5hi |
| | | 4 | 88.0 | 95.0 | | | | | | | | | 0.0 | 100.00a | 1.1hi |
| | Control | 0 | 0 | 0 | - | - | - | - | - | - | - | - | 318.0a | - | 72.0a |
| *T.castaneum* | Malathion | 0.5 | 27.0 | 58.0 | 2.3 | 0.22 | 0.75 | 1.06 | 1.58 | 4.40 | 0.12 | 0.36 | 11.7h | 93.7b | 7.1f |
| | | 1 | 38.0 | 69.0 | | | | | | | | | 11.0h | 94.1b | 4.1gh |
| | | 2 | 46.0 | 86.0 | | | | | | | | | 0.0 | 100.0a | 2.3hij |
| | | 4 | 53.0 | 90.0 | | | | | | | | | 0.0 | 100.0a | 1.2j |
| | Control | 0 | 0 | 0 | - | - | - | - | - | - | - | - | 185.0a | - | 39.4a |

**Means followed by the same letters in the column are not significantly different (P<0.05)**

**Table (3): Effect of botanical oils on adults of *S.oryzae* using mixing with media at different indicated periods (week).**

| Treatments | Conc. w/w% | Mortality% | | $LC_{50}$ | | Slope value | | Confidence limits | | | | No. of emerged adults after 2 months | %reduction in F1 progeny | % Loss wheat grain weight |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 1 | 2 | 1 | 2 | 1 | | 2 | | | | |
| | | | | | | | | Lower | Upper | Lower | Upper | | | |
| Basil | 0.25 | 62.0 | 74.0 | 0.10 | 0.05 | 1.01 | 1.05 | 0.07 | 0.15 | 0.02 | 0.08 | 106e | 81.7h | 2.9bc |
| | 0.50 | 67.0 | 79.0 | | | | | | | | | 96.0f | 83.4fg | 1.9bc |
| | 0.75 | 77.0 | 87.0 | | | | | | | | | 78.0g | 86.6e | 1.2bc |
| | 1.00 | 81.0 | 91.0 | | | | | | | | | 20.0i | 96.6b | 1.0c |
| Chamomilla | 0.25 | 67.0 | 71.0 | 0.10 | 0.07 | 1.31 | 0.98 | 0.04 | 0.17 | 0.04 | 0.13 | 114.0d | 80.3i | 3.0bc |
| | 0.50 | 71.0 | 77.0 | | | | | | | | | 93.0f | 84.0f | 2.6bc |
| | 0.75 | 82.0 | 87.0 | | | | | | | | | 72.0g | 87.6d | 1.9bc |
| | 1.00 | 87.0 | 93.0 | | | | | | | | | 10.0j | 98.3a | 1.0c |
| Nigella | 0.25 | 52.0 | 58.0 | 0.15 | 0.11 | 0.63 | 0.86 | 0.08 | 0.28 | 0.07 | 0.18 | 197.0b | 66.0k | 4.4b |
| | 0.50 | 60.0 | 62.0 | | | | | | | | | 177.0c | 69.5j | 3.6bc |
| | 0.75 | 62.0 | 71.0 | | | | | | | | | 100.0ef | 82.8g | 2.9bc |
| | 1.00 | 72.0 | 82.0 | | | | | | | | | 47.0h | 91.9c | 1.9bc |
| Control | 0 | 0 | 0 | - | - | - | - | - | - | - | - | 580.0a | - | 61.0a |

**Means followed by the same letters in the column are not significantly different (P<0.05)**

**Table (4): Effect of botanical oils on adults of *R.cominica* using mixing with media at different indicated periods (week).**

| Treatment | Conc. w/w% | Mortality% | | LC50 | | Slope value | | Confidence limits | | | | No. of emerged adults after 2 months | %reduction in F1 progeny | % Loss wheat grain weight |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 1 | 2 | 1 | 2 | 1 | | 2 | | | | |
| | | | | | | | | Lower | Upper | Lower | Upper | | | |
| Basil | 0.25 | 63.0 | 76.0 | 0.19 | 0.10 | 1.28 | 1.00 | 0.07 | 0.86 | 0.03 | 0.16 | 102.0c | 78.3h | 3.8bc |
| | 0.50 | 71.0 | 80.0 | | | | | | | | | 78.0f | 83.4f | 3.5cd |
| | 0.75 | 79.0 | 88.0 | | | | | | | | | 29.0j | 93.8b | 2.9cde |
| | 1.00 | 83.0 | 90.0 | | | | | | | | | 18.0k | 96.2a | 1.9de |
| Chamomilla | 0.25 | 64.0 | 73.0 | 0.10 | 0.09 | 1.13 | 1.63 | 0.06 | 0.13 | 0.05 | 0.13 | 92.0d | 80.5g | 3.3cde |
| | 0.50 | 75.0 | 81.0 | | | | | | | | | 67.0g | .8e85 | 2.9cde |
| | 0.75 | 80.0 | 89.0 | | | | | | | | | 21.0k | 95.5a | 2.0de |
| | 1.00 | 87.0 | 92.0 | | | | | | | | | 12L | 97.5a | 1.7e |
| Nigella | 0.25 | 55.0 | 59.0 | 0.23 | 0.18 | 1.30 | 0.97 | 0.19 | 0.32 | 0.12 | 0.33 | 121.0b | 74.3i | 5.4b |
| | 0.50 | 60.0 | 66.0 | | | | | | | | | 87.0e | 81.5j | 4.0bc |
| | 0.75 | 65.0 | 70.0 | | | | | | | | | 56.0h | 88.1d | 2.9cde |
| | 1.00 | 70.0 | 84.0 | | | | | | | | | 39.0i | 91.7c | 2.4cde |
| Control | 0 | 0 | 0 | - | - | - | - | - | - | - | - | 471.0a | - | 34.0a |

**Means followed by the same letters in the column are not significantly different (P<0.05)**

**Table (5): Effect of botanical oils on adults of *T.castaneum* using mixing with media at different indicated periods (week).**

| Treatments | Conc. w/w% | Mortality% | | LC50 | | Slope value | | Confidence limits | | | | No. of emerged adults after 2 months | %reduction in F1 progeny | % Loss wheat grain weight |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 1 | 2 | 1 | 2 | 1 | | 2 | | | | |
| | | | | | | | | Lower | Upper | Lower | Upper | | | |
| Basil | 0.25 | 40.0 | 46.0 | 0.51 | 0.27 | 1.72 | 1.11 | 0.46 | 0.70 | 0.20 | 0.39 | 367.0c | 25.7j | 11.4d |
| | 0.50 | 44.0 | 58.0 | | | | | | | | | 191.0g | 61.3f | 8.6e |
| | 0.75 | 55.0 | 65.0 | | | | | | | | | 91.0i | 81.6d | 4.8gh |
| | 1.00 | 67.0 | 74.0 | | | | | | | | | 38k | 92.3b | 2.6hi |
| Chamomilla | 0.25 | 58.0 | 71.0 | 0.12 | 0.08 | 0.89 | 1.35 | 0.01 | 0.22 | 0.01 | 0.14 | 300.0e | 39.3h | 9.5de |
| | 0.50 | 67.0 | 82.0 | | | | | | | | | 181.0h | 63.4e | 7.6ef |
| | 0.75 | 71.0 | 87.0 | | | | | | | | | 67.0j | 86.4c | 4.0ghi |
| | 1.00 | 77.0 | 90.0 | | | | | | | | | 27L | 94.5a | 2.0i |
| Nigella | 0.25 | 34.0 | 44.0 | 0.56 | 0.29 | 1.31 | 1.20 | 0.36 | 0.67 | 0.19 | 0.38 | 397.0b | 19.6k | 25.3b |
| | 0.50 | 40.0 | 58.0 | | | | | | | | | 352.0d | 28.7i | 16.2c |
| | 0.75 | 55.0 | 67.0 | | | | | | | | | 208.0f | 57.9g | 8.6e |
| | 1.00 | 62.0 | 81.0 | | | | | | | | | 87.0i | 82.4d | 6.0fg |
| Control | 0 | 0 | 0 | - | - | - | - | - | - | - | - | 494.0a | - | 37a |

**Means followed by the same letters in the column are not significantly different (P<0.05)**