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# The potential use of indigenous plant materials against *Callosobruchus chinensis* L. and *Callosobruchus maculatus* L. (Coleoptera, Bruchidae) in stored legumes in Sri Lanka

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**ABSTRACT**

Pulse beetles *Callosobruchus chinensis* and *Callosobruchus maculatus* are the most serious pests in stored legumes in majority of tropical countries. Attention has been given to the possible use of plant products or plant derived compounds as promising alternatives to synthetic insecticides in controlling insect pests of stored products. Various indigenous plant species in different forms such as crude ethanol (CE) extracts, vegetable oils, dry powders and combinations of plant materials with insecticides and effect of their concentration were tested against *Callosobruchus* spp. in laboratory conditions. The highest bioactivity (90 – 100% mortality) was manifested by the crude ethanol extracts of *Azadirachta indica* (Neem), *Anona reticulata* (Anona) and *Ocimum sanctum* (Maduruthala/sacred bail) among the crude ethanol extracts tested. Oils of *O.sanctum* at 1.5 µL and *A.reticulata* at 3.0 µL completely inhibited oviposition and adult emergence. Clove powder was the most effective among the four powders tested for adult mortality followed by root dust of papaya. Among the plant powders tested, Maduruthala (*O. sanctum*) was the most effective for suppressing oviposition significantly followed by Getathumba (*Leucas zeylanica*). Our experiments also revealed enhanced toxicity and persistence of the insecticide in causing significant mortality to *Callosobruchus* spp. when combined with vegetable oils. Further, these results revealed that the potential applicability of some indigenous plant materials as stored grain protectants. The modes of action of these substances are not yet known and further studies must be carried out especially to clarify how it is involved in the physiology of reproduction.

**Key words:** Botanicals, *Callosobruchus* spp., mortality, oviposition

## INTRODUCTION

The post-harvest losses and quality deterioration caused by storage pests are major problems throughout the world. Pulse beetle is the most serious pest in stored legumes in majority of tropical countries. The use of methyl pirimiphos ether as a 0.25% solution sprayed on the storage bags containing seeds for consumption or as a 2% dust where seeds are used as planting material is the current method of control (Anonymous, 1986). Although synthetic insecticides have been successfully used to protect stored grains from insect infestations, their indiscriminate and massive use have created serious problems (Sighamony *et al.*, 1980), residues in food grains (Fishwick, 1988), environmental pollution (WMO, 1995), and development of resistant strains (Zettler, 1982; Zettler and Cuperus, 1990; Yusof and Ho, 1992). Reducing the moisture content of seeds to less than 10% by weight through proper drying could significantly reduce the pulse beetle infestation. But this is not practiced in Sri Lanka as pulses are sold by weight rather than volume (Anonymous, 1986). Finding safe alternatives to synthetic insecticides to protect stored grains and grain products from insect infestations are highly desirable. Botanical insecticides have advantages over synthetic insecticides. Recently, attention has been given to the possible use of plant products or plant derived compounds as promising alternatives to synthetic insecticides in controlling insect pests of stored products (Rajapakse *et al.*, 1998; Rajapakse *et al.*, 2002; Rajapakse and Ratnasekera, 2009). The present paper reports findings of pesticidal activity of indigenous plant species on oviposition, hatchability, mortality, repellency, growth and development of next generation progenies of *Callosobruchus maculatus* L and *Callosobruchus chinensis* L in stored grain legumes in Sri Lanka.

## MATERIALS AND METHODS

A series of experiments were conducted at the laboratories of the Department of Agricultural Biology, Faculty of Agriculture, University of Ruhuna, Sri Lanka between 1990-2005. The ambient temperature and the relative humidity during the experimental period were 27-30$^0$C and 70%-80%, respectively.

**Rearing of the test insects**

Mass culture of *C. chinensis* was maintained using the procedure described by Strong *et al.* (1968). Adults emerged from this culture were used for the bioassay within 48 hrs of emergence. The remaining insects were used to start a new culture so that cultures with emerging adults are available continuously. A similar procedure was adapted to culture *C. maculatus.*

**Preparation of seed**

Seeds of green gram (variety MI 35) and cowpea (variety MI-5) obtained from the Field Crop Research and Development Institute, Mahailuppallama, Sri Lanka were used as a feed of pulse beetle in each study. Seeds were cleaned and disinfected by keeping them at 0$^0$C for 14 days prior to use.

**Experiment 1: Effect of crude ethanol extract of plants**

Crude ethanol (CE) extracts of twenty plant species belonging to different families were selected for the study (Table 1) based on the following characteristics: relative absence of insect damage, taxonomic closeness to families known to possess biologically active compounds, usage of plants as pesticides in rural agriculture, traditional knowledge as reported by extension workers. Beetles were sprayed directly with 1 mL of different concentration of a crude extract under Potters Precision tower at a pressure of 2.5 kg/cm$^2$. The controls were sprayed with water. Each experiment was replicated 10 times. Mortality was recorded every 24 hrs for 5 days and corrected by Abbot's formula (Busvine, 1972).

**Experiment II: Effect of plant oils on pulse beetle**

Different volumes (0.5, 1.5, 3 µL) of *O. sanctum, A. reticulata* and *A. indica* oil were made up to 30 µL with re-distilled acetone in a covered Petri dish (9cm diameter) by shaking the Petri dish for a few seconds and immediately the seeds were introduced into it. The solution was used to coat uniformly

**Table 1.** Toxicity of the ethanol extracts of the leaves of 20 plants to *C. maculatus* and *C. chinensis*

| Plant Species | Corrected mortality (%) | | | | | |
|---|---|---|---|---|---|---|
| | Day 1 | | Day 2 | | Day 3 | |
| | *C.c* | *C.m* | *C.c* | *C.m* | *C.c* | *C.m* |
| *Capsicum frutescens* | 35±1.0 | 40±2.6 | 45±1.2 | 48±3.1 | 60±6.6 | 60±6.7 |
| *Myristica fragrans* | 00 | 00 | 00 | 00 | 00 | 00 |
| *Piper nigrum* | 35±1.2 | 40±1.8 | 48±2.1 | 50±2.7 | 55±2.1 | 60±6.5 |
| *Citrus reticulata* | 10±0.8 | 12±1.0 | 10±1.0 | 08±0.7 | 12±1.1 | 14±1.0 |
| *Cymbopogan citratus* | 50±3.5 | 60±5.2 | 50±4.6 | 60±4.3 | 65±3.7 | 67±4.9 |
| *Artocarpus heterophyllus* | 05±0.5 | 08±0.7 | 12±1.0 | 11±1.0 | 15±1.1 | 17±1.1 |
| *Gliricidia sepium* | 00 | 00 | 00 | 00 | 00 | 00 |
| *Eugenia caryophyllata* | 50±4.8 | 60±5.1 | 60±4.8 | 60±4.0 | 71±5.6 | 70±6.2 |
| *Ricinus communis* | 00 | 00 | 00 | 00 | 00 | 00 |
| *Dillenia retusa* | 40±2.8 | 44±3.0 | 50±3.7 | 56±3.8 | 50±4.2 | 58±4.7 |
| *Azadirachta indica* | 50±3.5 | 60±4.2 | 60±4.0 | 65±4.6 | 80±6.7 | 90±7.2 |
| *Cajanus cajan* | 00 | 00 | 00 | 00 | 00 | 00 |
| *Cassia occidentalis* | 06±0.4 | 09±0.6 | 12±0.8 | 13±1.1 | 15±1.3 | 18±1.5 |
| *Anona reticulata* | 80±5.7 | 80±5.6 | 80±6.3 | 90±6.0 | 90±6.8 | 91±7.1 |
| *Mangifera indica* | 00 | 00 | 00 | 00 | 00 | 00 |
| *Eupatorium odoratum* | 00 | 00 | 00 | 00 | 00 | 00 |
| *Ocimum sanctum* | 80±5.9 | 80±6.1 | 80±6.6 | 90±7.0 | 100±0 | 100±0 |
| *Capsicum annum* | 30±1.8 | 35±2.1 | 43±3.8 | 50±4.6 | 48±3.9 | 45±3.2 |
| *Dioscorea polygonoides* wild | 00 | 00 | 00 | 00 | 00 | 00 |
| *Hibiscus rosainensis* | 00 | 00 | 00 | 00 | 00 | 00 |

C.c. - *C. chinensis*, *C.m- C. maculates,* Values indicate the mean ± Standard Error

**Table 2.** The effect of plant oils on egg deposition and adult emergence of *C. maculatus* (Values indicate the mean ± Standard Error)

| Oils | Dose{(µl)/ 50 seeds | Mean no. of Eggs | Mean no. of adults (emergence) | Damaged seeds (%) |
|---|---|---|---|---|
| *Ocimum sanctum* | 0.5 | 8.2 ±2.1 | 7.0 ± 2.7 | 14.0 ± 2.5 |
| | 1.5 | 00 | 00 | nd |
| | 3.0 | 00 | 00 | nd |
| *Anona reticulata* | 0.5 | 10.1 ± 2.0 | 9.4 ±2.1 | 16.0 ±2.1 |
| | 1.5 | 5.2 ± 2.1 | 3.4 ± 1.6 | 9.0 ± 2.2 |
| | 3.0 | 00 | 00 | nd |
| *Azadirachta indica* | 0.5 | 10.2 ± 2.1 | 11.2 ± 2.2 | 14.0 ±1.1 |
| | 1.5 | 6.8 ± 1.1 | 3.2 ±1.6 | 6.0 ± 1.4 |
| | 3.0 | 2.8 ± 0.9 | 2.1 ± 1.1 | 6.0 ± 0.9 |
| Control | | 76.6 ± 4.8 | 56.8 ± 2.6 | 59.4 3.8 |

n.d. = no determination

on 50 seeds of the cowpea. After 10 min when the acetone dried up, the seeds were transferred into 150 mL translucent plastic cups with firm cover, and 5 males and 5 females of freshly emerged *C. maculatus* (0-24 hrs) were introduced. The seeds were coated with ordinary acetone in the control treatment. There were four replicates for each treatment and all the cups were incubated at ambient temperature for 18 days. Egg count, the number of emerged adults and other parameters were determined.

**Experiment III: Bioactivity of dry plant powders**

In this study dry powder form of various parts of indigenous plant species commonly available in home gardens in Sri Lanka were tested for their pesticidal properties against pulse beetle with three different dosages. There were ten replicates for each treatment.

**Experiment IV: Effect of vegetable oils and insecticides**

The effect of vegetable oils alone and in combination with the insecticide on adult emergence of *C. chinensis* was examined in this study. Ten replications for each treatment were maintained.

**Data Analysis**

Separation of the means was performed using the Duncan's Multiple Range Test (DMRT) at 5% level. All value were presented by means with standard error.

## RESULTS AND DISCUSSION

**Experiment I**

Extracts of *Myristica fragrans*, *Gliricidia sepium*, *Ricinus communis, Cajanus cajan, Mangifera indica, Eupatorium odorantum, Dioscorea polygonoides,* and *Hibiscus rosasinensis* showed no toxicity while those of *Citrus reticulata, Artocarpus heterophyllus* and *Cassia occidentalis* had little toxicity. *Capsicum annum* and *Dillenia retusa* plant extracts were slightly toxic. *C. frutescens* and *Piper nigrum* were moderately toxic while those of *Eugenia caryophyllata* caused fairly high toxic plants to the beetle mortality. The highest bioactivity was manifested by the extracts of *Azadirachta indica*, *Anona reticulata* and *Ocimum sanctum.*

**Experiment II**

Data obtained with these 3 plant oils indicated that oils of *O.sanctum* at 1.5 µL and *A.reticulata* at 3.0 µL completely inhibited oviposition and adult emergence (Table 2). A mean of 8.2 eggs were laid on seeds treated with *O. sanctum* oils at 0.5 µl and a comparable number of emerged adults were recorded. *A. indica* oils did not inhibit oviposition completely at any of the 3 doses tested. This indicated that the volatile oils of *O. sanctum* and *A. reticulata* effectively protected stored cowpea from infestation by *C. maculatus* and insecticidal activities of these two plants used traditionally for preserving cowpea appear to reside in the ethanolic extracts. It was found that insecticidal activity of *O. sanctum* observed is due to the presence of linalool in the leaves. Schoonhoven (1978) indicated that 100 mL of selected

**Table 3.** Mortality of *Callasobruchus* spp. admix with various doses of plant powder

| Treatment | Dose (g) | Mortality |
|---|---|---|
| **Control** | 00 | 2.087$^{ef}$ |
| **Flour** | 00 | 2.800$^{d}$ |
| **Papaya roots** | 0.250 | 3.350$^{bc}$ |
| | 0.500 | 3.750$^{bc}$ |
| | 1.000 | 4.800$^{a}$ |
| | 1.250 | 3.850$^{b}$ |
| **Clove leaves** | 0.250 | 4.917$^{a}$ |
| | 0.500 | 4.917$^{a}$ |
| | 1.000 | 4.917$^{a}$ |
| | 1.250 | 4.800$^{a}$ |
| **Cinnamon leaves** | 0.250 | 2567$^{de}$ |
| | 0.500 | 2.700$^{de}$ |
| | 1.000 | 3.133$^{cd}$ |
| | 1.250 | 2.567$^{de}$ |
| **Ginger rhizome** | 0.250 | 2.767$^{d}$ |
| | 0.500 | 3.690$^{bc}$ |
| | 1.000 | 3.900$^{b}$ |
| | 1.250 | 1.650$^{f}$ |

Means with same letter are not significantly different according to DMRT

vegetable oils effectively protected cowpea against pulse beetle *Zabrotes subfasciatus.* Plant oils used in this study were more efficient than the vegetable oils reported by Messina and Renwick (1983) and Pereira (1983). The non-bitter state of plant oil used is an added advantage over neem oil which is known for its bitter taste.

**Experiment III**

Clove powder was the most effective treatment among the four powders tested for adult mortality followed by root dust of papaya (Table 3). The distribution of bioactive compounds often varies in different plant parts. Neem kernel has more azadirachtin than leaves and other tissues (Kossou, 1989) while leaves of *N. tabacum* have six times more bioactive compounds than root, stalk or inflorescences. (Rao and Chakraborty, 1982).

Ivbijaro and Agbaje (1986) reported high bruchid mortality in cowpea seeds treated with *Piper quineense* powder at 1.0 and 1.5 per 20g. Su (1977) showed that cause of high mortality of adults exposed to high doses of *Piper quineense* could be due to either stomach toxicity or contact toxicity. The adult mortality caused by clove powder may be due to its chemical compounds as reported by Su (1977) on *Piper quineense.*

Among the plant powders tested, *O. sanctum* was the most effective treatment for suppressing oviposition significantly (Table 4) followed by *L. zeylanica*. *Ocimum* species are known to be important sources of a repellent and toxicant against major insect pests. The repellency of eugenol extracted from the leaves of *O. suave* (Wild) against *Sitophilus zeamais* (Mots) in laboratory bioassays has already been reported (Hassanali *et al*., 1990). Weaver *et al*., (1991) reported the efficacy of milled dried leaves of *O. canum* (Sims) for the protection of edible beans against damage by *Zabrotes subfasciatus* (Bohem). There was also evidence of oviposition attractancy with some of the powders as evident in Table 4 with turmeric at 0.25 concentration. The other plant powders tested did not significantly affect hatchability (Table 5).

**Experiment IV**

The effectiveness of vegetable oils in controlling bruchid infestation was well documented (Galob and Webley, 1980). All the vegetable oils tested in this study caused significantly

**Table 4**. Mean oviposition of *Callasobruchus spp.* after 1 DAT and 3 DAT on cowpea seeds admixed with various dose of plant powders

| Botanicals used | Dosage (g) | Mean oviposition (1 DAT) | Mean oviposition (3 DAT) |
|---|---|---|---|
| **Control** | 0.00 | 45.133$^{cde}$ | 101.330$^{fgh}$ |
| **Flour** | 0.00 | 42.250$^{cdef}$ | 102.650$^{fgh}$ |
| **Citronella** | 0.25 | 47.000$^{cde}$ | 120.000$^{cde}$ |
| | 0.50 | 35.000$^{efgh}$ | 110.000$^{defg}$ |
| | 0.75 | 22.000$^{ghi}$ | 76.000$^{j}$ |
| | 1.00 | 54.000$^{bc}$ | 148.000$^{b}$ |
| **Lemon grass** | 0.25 | 42.000$^{cdef}$ | 113.000$^{def}$ |
| | 0.50 | 66.667$^{b}$ | 94.667$^{h}$ |
| | 0.75 | 66.000$^{b}$ | 147.500$^{b}$ |
| | 1.00 | 53.000$^{bcd}$ | 129.000$^{c}$ |
| **Turmeric** | 0.25 | 85.000$^{a}$ | 180.000$^{a}$ |
| | 0.50 | 54.000$^{bc}$ | 96.000$^{gh}$ |
| | 0.75 | 65.000$^{b}$ | 124.000$^{cd}$ |
| | 1.00 | 37.000$^{defg}$ | 108.000$^{efgh}$ |
| **Gatathumba** | 0.25 | 40.000$^{cdef}$ | 79.000$^{j}$ |
| | 0.50 | 26.000$^{fghi}$ | 50.000$^{j}$ |
| | 0.75 | 21.000$^{ghi}$ | 57.000$^{j}$ |
| | 1.00 | 35.000$^{efgh}$ | 76.000$^{j}$ |
| **Maduruthala** | 0.25 | 22.000$^{ghi}$ | 76.000$^{j}$ |
| | 0.50 | 19.000$^{hi}$ | 55.000$^{j}$ |
| | 0.75 | 15.000$^{i}$ | 35.000$^{k}$ |
| | 1.00 | 25.667$^{fghi}$ | 42.000$^{jk}$ |
| **Cinnamon seed** | 0.25 | 45.000$^{cde}$ | 109.000$^{efgh}$ |
| | 0.50 | 26.000$^{fghi}$ | 72.000$^{j}$ |
| | 0.75 | 31.667$^{efgh}$ | 104.000$^{fgh}$ |
| | 1.00 | 42.000$^{cdef}$ | 56.000$^{j}$ |

Means with same letter are not significantly different at 5% level.

**Table 5.** Mean number of hatched eggs accumulated after 5 and 10 DAT on cowpea seeds admixed with various doses of plant powders.

| Botanicals used | Dosage (g) | (5 DAT) | (10 DAT) |
|---|---|---|---|
| **Control** | 00 | $44.050^{cdef}$ | $83.05^{h}$ |
| **Flour** | 00 | $38.300^{defgh}$ | $102.00^{f}$ |
| **Citronella** | 0.25 | $29.000^{efghijk}$ | $104.00^{f}$ |
| | 0.50 | $21.000^{ghijk}$ | $125.00^{de}$ |
| | 0.75 | $54.000^{bcd}$ | $90.00^{gh}$ |
| | 1.00 | $46.000^{cde}$ | $140.00^{bc}$ |
| **Lemon grass** | 0.25 | $56.000^{bcd}$ | $120.00^{e}$ |
| | 0.50 | $90.333^{a}$ | $131.00^{cd}$ |
| | 0.75 | $64.500^{b}$ | $155.50^{a}$ |
| | 1.00 | $61.667^{bc}$ | $154.00^{a}$ |
| **Turmeric** | 0.25 | $40.000^{defg}$ | $149.00^{ab}$ |
| | 0.50 | $26.000^{fghijk}$ | $80.00^{hi}$ |
| | 0.75 | $29.000^{efghijk}$ | $90.00^{gh}$ |
| | 1.00 | $22.667^{ghijk}$ | $89.00^{gh}$ |
| **Gatathumba** | 0.25 | $34.000^{efghi}$ | $62.00^{jk}$ |
| | 0.50 | $28.000^{efghijk}$ | $69.00^{jk}$ |
| | 0.75 | $14.000^{jk}$ | $89.00^{gh}$ |
| | 1.00 | $31.667^{efghij}$ | $60.00^{k}$ |
| **Maduruthala** | 0.25 | $26.000^{fghijk}$ | $84.00^{h}$ |
| | 0.50 | $14.667^{ijk}$ | $70.00^{ijk}$ |
| | 0.75 | $12.000^{k}$ | $40.00^{i}$ |
| | 1.00 | $16.000^{ijk}$ | $48.00^{i}$ |
| **Cinnamon seed** | 0.25 | $31.000^{efghijk}$ | $91.00^{gh}$ |
| | 0.50 | $20.000^{hijk}$ | $72.00^{ij}$ |
| | 0.75 | $29.000^{efghijk}$ | $98.00^{fg}$ |
| | 1.00 | $30.000^{efghijk}$ | $134.00^{cd}$ |

Means with same letter are not significantly different at 5% level.

($P<0.05$) higher mortality compared with the untreated control (Table 6). The combination of groundnut oil and ½ dose of pirimiphos methyl was the most economic combination that caused significantly higher mortality (Table 7). Differences in effectiveness among oils tested alone were relatively small but groundnut oil was found to be most effective. The current recommended rate of pirimiphos methyl recorded 100% mortality and with decreasing the dosage the mortality rates were also decreased. However, all the vegetable oils tested caused significantly higher mortality than ¼ dosage of pirimiphos methyl.

The vegetable oils tested produced no significantly differences in insect mortality suggesting a similarity in action. The mode of action of vegetable oils in causing mortality in insects is reported to be anoxia (Ivbijaro *et al*., 1984). This outcome suggested that the use of less dosage should be discouraged. A similar observation on pirimiphos methyl 2% dust effective with *Sitophilus granarius* L. in wheat suggested that under dosage will cause emerging resistant strains (Tembo and Murfitt, 1995). Mortality was dose dependant one. This experiment revealed the enhanced toxicity and persistence of the insecticide in causing significant mortality to *Callosobruchus* spp. when combined with vegetable oils. Oils increase the absorption of insecticide (Ahmed and Gardiner, 1967) or increased the rate of penetration of the insecticide (Benezet and Forgash, 1972) into the insect. This experiment showed that dust formulation of pirimiphos methyl can be used at low dosage if combined with vegetable oils.

Overall, the possession of highly bioactive compounds of plants such as *O. sanctum, A. indica* and *A. reticulata* which

**Table 6.** The effect of vegetable oils and pirimiphos methyl treatments against *C. maculatus* adults.

| Treatments | Dosage | Mean (1 DAT) | % mortality (7 DAT) |
|---|---|---|---|
| **Control** | | $0.000^{g}$ | $2.700^{g}$ |
| **Pirimiphos methyl** | Full dose | $100.000^{a}$ | $100.000^{a}$ |
| | ¾ dose | $90.367^{c}$ | $95.300^{b}$ |
| | ½ dose | $73.267^{e}$ | $85.700^{e}$ |
| | ¼ dose | $65.000^{f}$ | $81.000^{f}$ |
| **Groundnut oil** | 10ml/kg | $95.000^{b}$ | $85.700^{e}$ |
| **Coconut oil** | 10ml/kg | $91.000^{c}$ | $92.000^{c}$ |
| **Soybean oil** | 10ml/kg | $85.000^{d}$ | $87.700^{d}$ |

Means with same letter are not significantly different at 5% level.

are grown widely in Sri Lanka offer an opportunity for developing them as alternatives to hazardous pesticides. Ketoh *et al.* (2000) reported that *C. schoenanthus* oil contained up to 61% of piperitone and 23.4% careen-2 as major constituents. *Cymbopogan citratus* (gevanial 34.6% and neral 50.9%) and *C. nardus* (Citronnellal, Citronnellol, Geraniol and Occidentalol) oils were the major components (Ketoh *et al.,* 2000).

The mode of action of oils is partially attributed to interference in normal respiration, resulting in suffocation (Schoonhoven, 1978). However, factors other than oxygen starvation probably also play a role in their mode of action (Shaaya and Ikan, 1978). It is also thought that oils exert some lethal action on developing embryos or first instar larvae by the reduction in rate of gaseous exchange due to a "barrier" effect and/or direct toxicity by penetrated oil fractions (Don Pedro, 1989). Phenomena such as the inhibition of oogenesis in *A. obtectus* have already been described as a secondary effect of the host-plant stimuli. Modifications of the microenvironment of the oviposition site can lead to a blockage of oogenesis and egg retention in the lateral oviducts (Huignard, 1969). Further studies are yet to be undertaken to elucidate the active ingredients, mode of action, and their interactions to understand their resourceful use in village storage crop protection.

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**Table 7.** The effect of vegetable oils/pirimiphos methyl combination treatments against *C. maculatus* adults.

| Treatments | Mean (1 DAT) | % mortality (7 DAT) |
|---|---|---|
| Groundnut oil (10ml/kg) + Pirimiphos methyl (3/4) | $99.333^{a}$ | $100.000^{a}$ |
| Groundnut oil (10ml/kg) + Pirimiphos methyl (1/2) | $95.000^{ab}$ | $100.000^{a}$ |
| Groundnut oil (10ml/kg) + Pirimiphos methyl (1/4) | $73.333^{de}$ | $78.000^{c}$ |
| Coconut oil (10ml/kg) + Pirimiphos methyl (3/4) | $98.300^{a}$ | $98.700^{a}$ |
| Coconut oil (10ml/kg) + Pirimiphos methyl (1/2) | $91.310^{ab}$ | $91.300^{b}$ |
| Coconut oil (10ml/kg) + Pirimiphos methyl (1/4) | $65.700^{e}$ | $68.300^{d}$ |
| Soybean oil (10ml/kg) + Pirimiphos methyl (3/4) | $85.000^{bc}$ | $87.310^{b}$ |
| Soybean oil (10ml/kg) + Pirimiphos methyl (1/2) | $78.300^{cd}$ | $85.000^{b}$ |
| Soybean oil (10ml/kg) + Pirimiphos methyl (1/4) | $56.703^{f}$ | $65.000^{d}$ |

Means with same letter are not significantly different at 5% level.

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