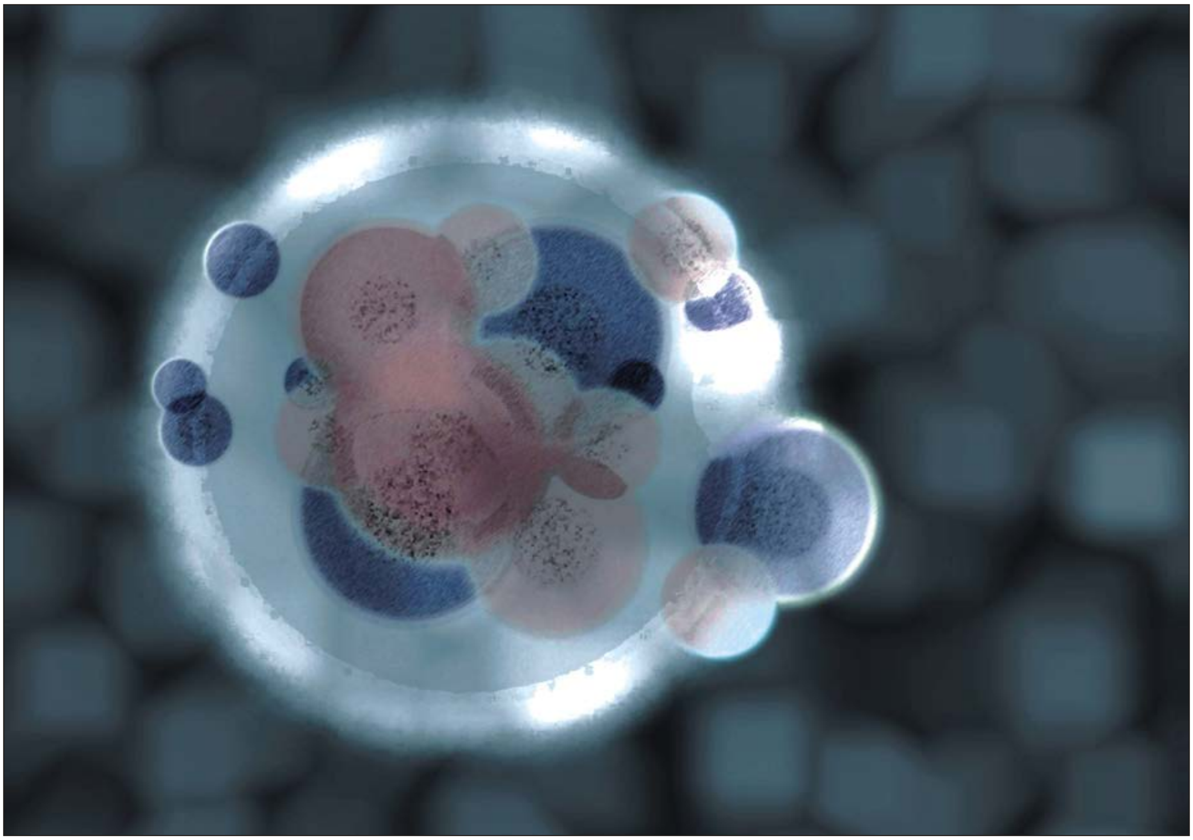

Journal of Biological Sciences

ISSN 1727-3048

Journal of Biological Sciences 9 (2): 175-179, 2009
ISSN 1727-3048

Insecticidal Efficacy of Castor and Hazelnut Oils in Stored Cowpea Against *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae)

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Abstract: *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae) is a primary pest of cowpea and other legumes worldwide, both in fields and in stored seeds. Castor oil at 5, 6, 7, 8 and 9 mL kg^{-1} and Hazelnut at 2.8, 4.4, 6, 7.6 and 9.2 mL kg^{-1} were tested against *C. maculatus* in cowpea. All bioassays were conducted at 27±1°C and 65±5% r.h and mortality was counted after 24, 48 and 72 h of exposure. After the 72 h mortality count, all adults were removed and the vials were left at the same conditions for further 35 days to assess progeny production. The increase of dose and exposure interval increased mortality. After 72 h of exposure, mortality received to 80.83% on Hazelnut oil at high rate (9.2 mL kg^{-1}). Mortality in the case of Castor oil was higher than Hazelnut and received to 86.66% at 9 mL kg^{-1}. The lowest LC_{50} value on 72 h was observed in the Hazelnut (6.57 mL kg^{-1}). In contrast, the lowest LC_{95} value on 72 h was observed in the Castor (10.94 mL kg^{-1}). Complete suppression in progeny production was achieved on cowpea treated with Castor oil at 9 mL kg^{-1} but in the all case, the percentage of reduced progeny received up to 90%. In conclusion, treatment of grain with vegetable oil could have important practical implications for parts of the world where pesticides are expensive or in short supply.

Key words: *Callosobruchus maculatus*, cowpea, castor oil, hazelnut oil

INTRODUCTION

Cowpea, *Vigna unguiculata* Walpers, is an important food legume and an essential component of cropping systems in the drier regions and marginal areas of the tropics and subtropics. With their high protein content cowpeas are a natural supplement to cereal, root and tuber staples in the human diet (Cherry *et al*., 2005). The beetles of the family Bruchidae are closely associated with the plant family Leguminosae and many species are important primary insect pests of stored legumes (Rajapakse and Van Emden, 1997).

Callosobruchus maculatus (F.) (Coleoptera: Bruchidae) is a primary pest of cowpea and other legumes worldwide, both in fields and in stored seeds (Singh and Van Emden, 1979). Attack on stored grain by *C. maculatus* significantly reduces the quantity and quality of seeds destined for both human consumption and sowing purposes. The development of a single larva in a grain can lead to weight losses of 8-22% (Credland *et al*., 1986).

Residual insecticides have been used routinely for many years to control insect pests in stored grain. These insecticides are primarily organophosphorous and pyrethroid compounds and the residues from this single application can often prevent insects from establishing in stored grain. However, use of residual insecticides is becoming less desirable because of the resistance in major insects, regulatory restrictions on use of insecticides, awareness of environmental pollution, the increasing cost of storage insecticides, erratic supplies, worker safety and consumer desire for a pesticide-free product, has led to pest management specialists reappraising natural products (Arthur, 1996; Lorini and Galley, 1999). Control of *C. maculatus* currently relies on the use of chemical insecticides (Jackai and Adalla, 1997).

Plant products have played an important role in the traditional methods of protection against crop pests and disease vectors (Poswal and Akpa, 1991). In ancient times, oils obtained from locally available plants were used for stored grain protection against insect attack. In recent years, attention has been given to the use of vegetable

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oils as post harvest grain protectants against insects (Perieira, 1983; Don-Pedro, 1989; Bekele *et al.*, 1995; Rajapakse and Van Emden, 1997; Obeng-ofori *et al.*, 2000; Obeng-ofori and Amiteye, 2005). The mode of action of these oils is yet to be confirmed, but most appear to cause death in the insect egg, larvae or adult by suffocation (Don-Pedro, 1989). The action of vegetable oils is due to suffocation, but in other cases, oils can act as antifeedants or even act as Insect growth regulators (IRGs) by affecting metamorphosis (Weaver and Subramanyam, 2000).

The objectives of the present study were to assess the efficacy of two vegetable oils, Castor (*Ricinus communis* L.) and Hazelnut (*Corylus avellana* L.) against *C. maculatus* on stored cowpea.

MATERIALS AND METHODS

Insect rearing: The initial stock culture of *C. maculatus* was obtained from Department of Plant Protection, Agricultural Faculty, Urmia University, Urmia, Iran. Cowpea grains of the variety Kamran cleaned and disinfested by storing at -12°C for a week. Insect cultures were maintained in glass jar (1 L) filled with 200 g of clean and disinfested cowpea grains. Each jar was then infested with 200 adults of *C. maculatus* of mixed sex and age and covered with nylon mesh secured with rubber bands. Infested grains were incubated at 27±1°C and 65±5% relative humidity (r.h.) with a natural photoperiod. After 72 h, the parental adults were removed by sieving and the cowpea grains were kept at the same conditions. Progeny emergence was checked daily and new adults were kept in separation jar containing cowpea grains.

The oils: Vegetable oils (from Castor, *Ricinus communis* L. and Hazelnut, *Corylus avellana* L.) were obtained from a local supermarket.

Bioassay: On the basis of preliminary tests, the oils were applied at five rates in a logarithmic series (Robertson and Preisler, 1992): 2.8, 4.4, 6, 7.6 and 9.2 mL kg^{-1} for Hazelnut and 5, 6, 7, 8 and 9 mL kg^{-1} for Castor. Mortality was counted after 24, 48 and 72 h of exposure. Five lots of 0.5 kg of cowpea were prepared and placed in separate cylindrical jars and treated with appropriate rate. All jars were shaken manually for approximately 5 min to achieve equal distribution of the oils in the entire grain mass. Four samples, of 50 g each, were taken from each jar as replication. Thirty 0-24 h old adults were used for each replication. All experiments carried out in 27±1 °C and 65±5% r.h. After the 72 h mortality count, all adults (dead and alive) were removed from the vials and the vials were left in the incubators at the same conditions for further 35 days to assess progeny production.

Statistical analysis: The mortality counts were corrected by using Abbott's (1925) formula. Percentage of reduction in progeny production was determined by the [(No. progeny in control No. progeny in treatment)/No. progeny in control×100] formula (Aldryhim, 1990). To equalize variances, mortality percentage of adults and percentage of reduction in progeny production were transformed using the square root of the arcsin. The data were analyzed using Analysis of Variance (SAS, 2000). Means were separated by using the Tukey Multiple Range Test at p = 0.05. The dose required to kill 50% of the insects (LC_{50}) was estimated using probit analysis (SPSS, 1999).

RESULTS

Adult's mortality: For Castor oil, all main effects as well as all associated interaction were significant at the $p<0.0001$ level (rate: df =4, 59; F = 107.82; exposure: df = 2, 59; F = 37.33; rate×exposure: df = 8, 59; F =2.9). Although, for Hazelnut oil, all main effects as well as all associated interaction were significant at the $p<0.0001$ level (rate: df = 4, 59; F = 76.27; exposure: df = 2, 59; F = 11.18; rate×exposure: df = 8, 59; F = 3.61). Adult's mortality of *C. maculatus* on control treatment was very low (2.83%). Mortality percentage was increased with increase of rate and exposure interval in both oils. At the 72 h exposure interval, the highest mortality levels for castor oil were recorded at 9 mL kg^{-1}, where 86.66% (Fig. 2). In contrast, for hazelnut, the highest mortality levels were recorded at 9.2 mL kg^{-1}, were 80.83% (Fig. 1).

The lowest and highest LC_{50} values on 72 h were observed in the Hazelnut and Castor (6.57 and 7.05 mL kg^{-1}, respectively). In contrast, the lowest and highest LC_{95} values on 72 h were observed in the Castor and Hazelnut (10.94 and 14.13 mL kg^{-1}) (Table 1).

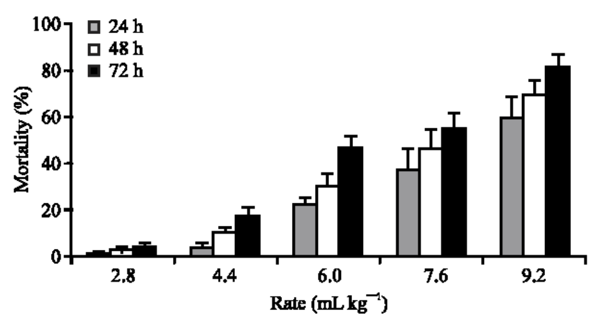

Fig. 1: Mean adult mortality (%+SE) of *C. maculatus* adults, on cowpea treated with Hazelnut oils at after 24, 48 and 72 h of exposure

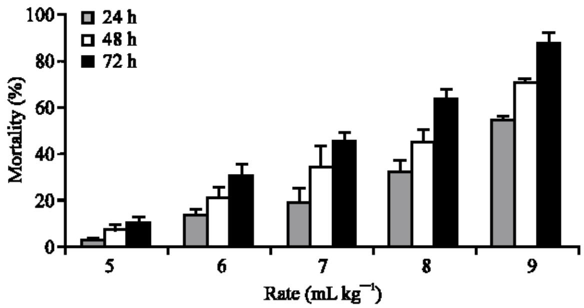

Fig. 2: Mean adult mortality (%+SE) of *C. maculatus* adults, on cowpea treated with Castor oils at after 24, 48 and 72 h of exposure

Table 1: The lethal dose for 50% (LC_{50}) of *C. maculatus* adults in cowpea treated with oils on 72 h

Oil	LC_{50} (mL kg^{-1})	LC_{95} (mL kg^{-1})	Probit parameters±SE Intercept	Slope	p-value	χ^2-value
Castor	7.05	10.94	-2.32±0.59	8.63±0.69	0.176	4.93
Hazelnut	6.57	14.13	0.96±0.32	4.94±0.40	0.164	5.11

Table 2: Mean percentage of reduction (±SE) in progeny production (F1) of *C. maculatus* in cowpea treated with Castor and Hazelnut oils

Oil	Dose (mL kg^{-1})	Mean±SE
Castor	5.0	98.75±0.43b
	6.0	99.74±0.12ab
	7.0	99.84±0.05ab
	8.0	99.94±0.05ab
	9.0	100.00±0.00a
Hazelnut	2.8	93.85±2.37b
	4.4	98.44±0.46a
	6.0	99.06±0.24a
	7.6	99.79±0.08a
	9.2	99.94±0.05a

Means followed by the same letter(s) in the row are not significantly different (Tukey Multiple Range test at p = 0.05)

Progeny production: The application of oils highly significantly reduced progeny production in the cowpea treated with both oils and the main effect was significant in Castor (rate: df = 4, 19; F = 6.93; p = 0.0023) and Hazelnut (rate: df = 4, 19; F = 4.43; p = 0.0045). In both oil and all rates, the percentage of reduction in progeny production received up to 90%, even in low rate. The highest progeny reduction observed in the cowpea treated with Castor oil at the rate of 9 mL kg^{-1} (100%) (Table 2).

DISCUSSION

In this study, vegetable oils; Castor and Hazelnut applied at different rates, caused considerable mortality of *C. maculatus* compared to untreated controls but the Castor oil can provide better control of *C. maculatus*. Dead insects from oil-treated grain showed signs of rapid immobilization with their legs flexed and clinging to either the grain or the container surface. This observation highlights the need for screening for more plant materials for use in the management of this pest.

Several earlier studies have demonstrated the effectiveness of different vegetable oils in protecting grains against major stored-product insect pests (Shaaya *et al*., 1976; Don Pedro, 1987, 1989; Obeng-ofori, 1995). Singh *et al*. (1978), Messina and Renwick (1983), Pandey *et al*. (1983), Pereira (1983) and Don-Pedro (1989) have shown that oil coating is effective in controlling *C. maculatus* and present result are accordance with them results. Although, the mode of action of vegetable oils is not clearly understood, it has been suggested by Don-Pedro (1989) that insect death caused by oils is due to anoxia or interference in normal respiration resulting in suffocation (Schoonhoven, 1978). The oils could also act as antifeedants or modify the storage micro-environment thereby discouraging insect penetration and feeding (Obeng-ofori, 1995).

Pacheco *et al*. (1995) used refined soybean and crude castor oils and these were evaluated for the control of infestations of *C. maculatus* and *C. phaseoli* (Gyllenhal) in stored chickpea (*Cicer arietinum* L.). They observed that both oils inhibited population growth of the two insect species as compared to untreated seeds. Castor oil was more effective than soybean oil. In our experiments, also the Castor oil was more effective than Hazelnut because of higher mortality (86.66% in 9 mL kg^{-1} for Castor in contrast of 80% in 9.2 mL kg^{-1} for Hazelnut).

Rajapakse and Van Emden (1997) demonstrated that corn, groundnut, sunflower and sesame oil reduced oviposition by three bruchid species: *C. maculatus*, *C. chinensis* and *C. rhodesianus* by over 70% at a concentration of 10 mL kg^{-1} cowpea seeds. In our experiments, the percentage of reduction in progeny production received up to 90% in both oils even at low rates (93.85% in 2.8 mL kg^{-1} for Hazelnut and 98.75% in 5 mL kg^{-1} for Castor) and complete reduction in progeny production observed in cowpea treated with 9 mL kg^{-1} of Castor oil that received to 100%. Credland (1992) has explained the ovicidal effect of oils on bruchids in terms of asphyxiation by occluding a funnel which is probably the major route of gas exchange between a thin area of the chorion and the outside.

In conclusion, the results of this study show that Castor and Hazelnut oils, when added to cowpea, affords good protection to the grain by killing various life stages of *C. maculatus* via contact, antifeedant and possibly stomach action. Further research into the bioactivity of these two oils and its constituents against other stored product insects is needed before commercial application can be considered. The application of oils may minimize insecticide usage and hence reduce health hazards to applicators and reduce the amount of insecticides used to protect stored products. The mode of action of vegetable oils needs to be studied in more detail to promote the development of more potent fractions for use as grain protectants. Treatment of grains with vegetable oils could have important practical applications in the parts of the world where insecticides are expensive, in short supply or where vegetable oils are readily available.

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