Univ. j. zool. Rajshahi Univ. Vol. 26, 2007. pp. 89-92
http://journals.sfu.ca/bd/index.php/UJZRU
ISSN 1023-6104

Efficacy of edible oils in the control of pulse beetle, *Callosobruchus chinensis* L. in stored pigeonpea

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Abstract: Seven vegetable oils viz., sunflower (*Heliunthus annus,* L.), mustard (*Brassica juncea* Cross), groundnut (*Arachis hypogaea*, L.), sesame (*Sesamum indicum* L.), soybean [*Glycine max* L. (Merril)], olive (*Olea europea*) and oil palm (*Elaeis guineensis* W. J. Jacquin), each were applied at the rates of 5, 7.5, and 10 ml.kg-1 of grain (0.5, 0.75 and 1% v/w concentrations) as grain protectants of pigeonpea against the pulse beetles (*Callosobruchus chinensis* L.). Effects on progeny emergence, loss in grain weight, and germination up to 66 days after treatment were measured. Adult emergence was completely prevented and the minimum grain loss was achieved by groundnut oil at 1% up to 66 days after treatment. Since treatments with groundnut and palm oils at 5 ml.kg-1 showed high acceptability by consumers, it can be recommended for *C. chinensis* control in stored pigeonpea for approximately two months.

Key Words: Vegetable oils, *Callosobruchus*, pigeonpea, progeny emergence, grain protectant

Introduction

Pigeonpea or red gram (*Cajanus cajan* L**.**) is an important pulse crop in Bangladesh and is the main source of protein for vegetarians. The pulse seeds suffer a great damage during storage due to insect attack (Sherma, 1989). Among the insect pests attacking stored products the pulse beetle *Callosobruchus chinensis* L. (Coleoptera: Bruchidae) is a serious one. This insect has been reported from the Philippines, Japan, Indonesia, Sri Lanka, Burma and India. It is a notorious pest of chickpea, mung, motor, peas, cowpeas, lentil and arhar (Aslam *et al*., 2002). Pulse beetle being an internal feeder cannot be controlled with insecticides. It is also not advisable to mix insecticides with food grains. Fumigation being the most effective method cannot be practiced in our villages because the storage structures are not airtight and these are are mostly built inside the residential areas. Plant materials which are being traditionally used by some farmers are quite safe and appear to be the most promising grain protectants (Al-Lawati *et al.*, 2002a,b).

Research on oils as protectants has been conducted on *Sitophilus* species and stored-product Lepidoptera (Koona & Njoya, 2004). Vegetable oils and plant products have been used for a long time for the protection of stored grains. But a very little work on the storage of pigeonpea seeds using vegetable oils has been carried out. Mummigatti & Raghunathan (1977), Singh *et al.*, (1978), Varma & Pandey (1978), and Ali *et al.*, (1983) tried different vegetable oils against pulse beetle on green gram (*Pluseolus aureus* Roxb.), black gram *(P. mungo* var. *radiutus* L.), and cowpea *(Vigna sinensis* Savi.). Khaire *et al*. (1993) reported the effectiveness of vegetable oils against *C. chinensis* on pigeonpea.

C. maculatus (F.) attacking *Vigna* species was also tested against several oils. Pandey *et al.* (1981), Santos *et al.* (1981), Messina & Renwick (1983) Pierrard (1986) and Ahmed *et al.* (1988) used oils of groundnut *(Arachis hypogaea* L.), castor *(Ricinus communis* L.), coconut, palm kernel, corn, cotton, babassu *(Orbignya* sp.*)*, mustard *(Brassica juncea* L.), olive (*Olea europea*), sesame *(Sesamum indicum* L.), sunflower *(Heliunthus annuus* L.), and rice (*Oryza sativa* L.) in their studies. There were differences in efficacy at the doses of oil tested under different experimental conditions, as noted by Pierrard (1986). Castor oil at 8 $mg.kg^{-1}$ provided complete protection against *C. maculutus* (Singh *et al.*, 1978).

For the protection of stored chick-peas, *Cicer arietinum* L., against C. *chinensis*, the application of mustard oil at 10 $ml.kg^{-1}$ was effective for 5 months of storage and did not affect seed germination. But this oil did not impart protection to seeds and caused complete inhibition of germination (Khalique *et al.*, 1988). Palm and coconut oils at 4 $ml.kg^{-1}$ were the most effective protectants of chick-pea seeds against *C. chinensis* for 3 months of storage, followed by groundnut, rapeseed and mustard oils. Sesame, sunflower and soybean oils were considered inferior to the others (Singh *et al.*, 1990). Neem seed oil showed 100% control of C. *chinensis* for 5 months when applied at 10 $ml.kg^{-1}$ (Das, 1987). In view of the encouraging results obtained by the above workers, the effectiveness of these and other vegetable oils were estimated against *C. chinensis* infesting pigeonpea seeds in respect of emergence of progeny adults, loss of grain weight, and seed germination.

Materials and Methods

Mass culture of *C. chinensis* was maintained using the procedure described by Strong *et al.* (1968). Edible oils of sunflower (*Heliunthus annus*, L.), mustard (*Brassica juncea* Coss), groundnut (*Arachis hypogaea*, L.), sesame (*Sesamum indicum* L.), soybean [*Glycine max* L. (Merril)], olive (*Olea europea*) and oil palm *(Elaeis guineensis* W. J. Jacquin) were applied at 5, 7.5, and 10 $ml.kg^{-1}$ of pigeonpea seed (0.5, 0.75, and 1% v/w concentrations). Samples of 600 g of healthy pigeonpea seeds were treated with known amounts of the oils. The requisite quantities of each oil were dissolved in 24 ml of petroleum ether and the treated sample was shaken slowly for 15 min on a mechanical shaker in a ground glass-stoppered conical flask. A stock of the pigeonpea seed treated with the oils was stored in perforated polythene bags.

Samples each of 10 g were drawn at intervals of 33 and 66 days and kept in small glass vials (7.5 × 2.5 cm). Three replications were used. Three pairs of 0-l day-old adults of *C. chinensis* were introduced into each vial, covered with muslin cloth and secured firmly with rubber bands. Dead beetles were removed 12 days after release when almost all parental beetles were found dead in all treatments. Emergence of adult progeny was recorded daily for a period of 20 days and the adults removed every 2-3 days to avoid the next generation. The percentage loss in grain weight was recorded at 33 and 66 days after release of beetles, *i.e.* after completion of emergence of the adult progeny. Seed germination was tested after 66 days treatment. The experiments were conducted at room temperatures ranging from 27° to 35° C with 50-80% relative humidity.

Results and Discussion

The average percentage of adults that had emerged at 33 days after treatment ranged from 1 to 49.33 in different treatments. Significantly lower numbers of progeny were observed in all treatments when compared with untreated control (77.00%). Fewer adults emerged from seeds treated with groundnut oil at all concentrations to show highest activity among the oils used in this investigation. At 66 days after treatment, the percentage of adult progeny ranged from 5.35 to 98.66 against 96.00 in control. In all treated oils the percentage of progeny emerged differed significantly between 33 and 66 days of storage (Table 1). Among different oil treatments percentage of progeny emerged also differ significantly at storage period of 33 days ($F_{6,12}$ = 34.54, LSD = 8.55, P<0.01) and 66 days ($F_{6,12}$ = 10.02, LSD = 24.23, P<0.01)

The average percentage of loss in grain weight after 33 days of treatment ranged from 0.6 to 6.9 in different treatments against 14.00% in control. Treatments with palm and groundnut oils at 1% appeared to be promising showing comparatively lower weight loss of grains. At 66 days after treatment, the average percentage loss in grain weight ranged from 0.9 to 16.9 in different treatments and in control it was 19.8%. Here t-values showed that statistical difference between storage periods occurred only sunflower (P<0.001) and sesame (P<0.05) oils. But the differences among treated oils are insignificant in both storage periods ($F_{6,12}$ = 2.71 for 33 days and $F_{6,12}$ = 1.70 for 66 days).

Considering the efficacy of different vegetable oils on the basis of various criteria, all the oils under study appeared to be promising as grain protectants. For *C. chinensis*, control in *V. unguiculata* (L.), purified oils of soybean and corn, and crude corn oil showed efficacy at 5,10 and 15 $g.kg^{-1}$ for 8 months (Cruz & Cardona, 1981). Castor oil on *V. radiata* (L.) seeds at 10 $ml.kg^{-1}$ provided complete control of C. *chinensis* for 18 months without affecting seed viability (Babu *et al.*, 1989). Mummigatti & Ranghunathan (1977) reported that oils of castor, groundnut, and mustard inhibited the multiplication of *C. chinensis.*

Khaire *et al.* (1992) studied efficacy of ten vegetable oils *viz.* sunflower, castor, mustard, safflower, palm, groundnut, sesame, neam, karanj and maize each applied at rates of 5, 7.5 and 10 $ml.kg^{-1}$ of grain (0.5, 0.75 and 1% v/w concentration) as grain protectants of pigeon pea against *C. chinensis*. Effects on progeny emergence, loss in grain weight and germination upto 100 days after treatment were measured. Adult emergence was completely prevented by karanj oil at 0.75 and 1% and neem oil at all levels up to 100 days. No emergence of adults occurred up to 66 days with castor oil at 0.75 and 1% levels. Minimum grain loss was noted with castor, mustard and groundnut oils at the 1% level up to 100 days after treatment. Ahmed *et al*. (2003) used neem and sesame oil and found both oils can control the larvae of *C. chinensis* inside the cotyledons of azuki beans . Swella & Mushobozy (2007) observed that coconut oil provided the best protection of the natural products against *C. maculatus*. In the present study only edible oils were used and groundnut oil provided the best protection followed by oil palm against *C. chinensis.*

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 & Ikan, 1978). Egg mortality has been attributed to toxic components and also to physical properties, which cause changes in surface tension and oxygen tension within the egg (Singh *et al.*, 1978). It is also thought that oils exert some lethal action on developing embryos or first-instar larvae, for example, by the reduction in rate of gaseous exchange due to a "barrier" effect and/or direct toxicity by penetrated oil fractions (Don Pedro, 1989). Since treatments with groundnut and palm oils at $ml.kg^{-1}$ preserved desirable characteristics, the dose can be recommended for suppressing *C. chinensis* in stored pigeonpea for approximately two months.

Table 1. Effect of edible oils on emergence of adult progeny of *C. chinensis* and loss in weight of pigeonpea

Oils	Dose of oil ($ml.kg^{-1}$)	Progeny emerged (%)		Grain loss (%)	
		33 days	66 days	33 days	66 days
Sunflower	0.50	44.00ef	66.33defg	1.9	10.1
	0.75	43.00def	74.66ef	3.6	10.8
	1.00	37.66de	68.66def	3.7	9.00
	t-values	8.94 ***		8.79***	
Mustard	0.50	7.66a	92.00hi	2.1	6.80
	0.75	10.00ab	88.00ghi	4.2	11.0
	1.00	10.00ab	78.93efghi	3.2	0.70
	t-values	19.94***		0.98ns	
Groundnut	0.50	8.33a	24.66ab	1.3	1.10
	0.75	8.00a	28.66ab	0.8	4.60
	1.00	1.00a	5.35a	1.5	0.80
	t-values	1.81ns		0.78ns	
Sesame	0.50	24.00c	49.00bcd	1.6	11.3
	0.75	11.33b	64.33defg	0.1	11.1
	1.00	16.66b	68.66defg	7.6	9.80
	t stat	6.19**		3.26*	
Soya bean	0.50	39.66de	98.66i	6.8	16.9
	0.75	35.00d	75.66efg	4.6	12.2
	1.00	49.33f	97.33i	6.6	1.00
	t-values	5.75**		0.84ns	
Olive	0.50	14.00b	73.66efg	1.4	6.80
	0.75	14.00b	48.00bcd	6.9	1.30
	1.00	10.33b	62.33cdef	5.4	6.00
	t-values	6.45**		0.06ns	
Oil Palm	0.50	12.66b	81.66fghi	1.0	0.90
	0.75	10.33b	55.66cde	0.6	3.00
	1.00	6.67b	37.33bc	0.6	10.0
	t-values	3.72*		1.42ns	
Untreated	-	77.00	96.00	14.0	19.8

Means followed by digits do not differ significantly;
*= $P<0.05$; **=$P<0.01$; ***=$P<0.001$; ns = not significant

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Manuscript received on 02.01.08, accepted on 24.01.08