Journal of Science and Technology 17 (June 2019): 20-31

ANTI-OVIPOSITIONAL, OVICIDAL AND LARVICIDAL EFFECTS OF PLANT OILS AGAINST *Callosobruchuschinensis*L. (BRUCHIDAE: COLEOPTERA)

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ABSTRACT

Pulse beetle, *Callosobruchuschinensis*L.,(Bruchidae: Coleoptera) is globally distributed notorious insect of stored chickpea and major threats of stored pulses. The efficacy of six plant oils was assessed in the laboratory for their grain protectant efficacy against the attack of *C. chinensis.* All the tested oils were effectively reduced oviposition, adult emergence, seed infestations and weight loss as compared to control. Black cumin and mustard oils showed best reduction of adult emergence, seed infestation and seed weight loss when applied those at the rate of 10% concentration. Black cumin (95.86%) and mustard (91.05%) oils provided the highest inhibition rate of adult emergence when egg bearing seeds were treated at 10% concentration. Additionally, black cumin (94.47%) and mustard (88.33%) oils also markedly reduced the adult emergence while larva bearing seeds were treated the same concentration. Therefore, black cumin and mustard oils could be used for the protection of chickpea seeds from the infestation of *C. chinensis*.

Keywords: Plant oils, pulse beetle, management, legumes

INTRODUCTION

Farmers of Bangladesh usually store pulses in traditional and improvised storage containers that are penetrable to insect pests. One of the major limiting factors of an increasing pulses production is the damage of pulse grains from insect infestation in storage. Among the stored pest the bruchids, pulse beetle (*C. chinensis*) is globally distributed and as major threats of stored pulses (Atwal and Dhaliwal2005). The larvae destroy seeds by feeding inside partially or completely. It attacks all kinds of pulses (Ahmed *et al.* 2003). Pulse seeds can be damaged up to 100% due to pulse beetle infestation at 3 months of storage (Yamane 2013).

Control of this insect mostly relied on synthetic insecticides and fumigants (Atwal and Dhaliwal 2005). But chemical protection measures suffer serious drawbacks

(Hossain*etal.*2014). Their non-judicious use causes ecological imbalance, pest resistance and resurgence, outbreak of secondary pests, creates phytotoxicity, residues on foods, killing beneficial organisms etc. (Mahmud *et al*. 2002,Nas 2004). Researchers are globally trying to adopt alternative methods to protect grains from insect infestation. Various plant products have been showed a good degree of success as grain protectants against pulse beetle to reduce infestation in storage (Epidi*et al*. 2008, Mahadi and Rahman 2008). Among the various alternatives, use of plant based materials, i.e. botanicals stand top most position to protect storage insect pests. In Bangladesh, limited work has been done in recognizing the insecticidal potency of edible oils against pulse beetle (Khalequzzaman*et al*. 2007; Sarker *et al.* 2015). Therefore, necessary to identify the locally available indigenous botanicals as natural insecticide for grain protection.So, the present research work was planned and designed toexplore the appropriate indigenous edible oils and doses for the management of pulse beetle in stored chickpea seed.

MATERIALS AND METHODS

The experiment was conducted from May to November 2017 at the laboratory of the Department of Entomology, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur, Bangladesh. Details methodologies of the experiment are described below.

Source and collection of oils: Tested plant oils of mustard, palm, soybean, groundnut, linseed and black cumin were collected from (Table 1) the market of Maldaho Patty of Dinajpur town in separate glass bottles (150 mL). Collected oils were preserved in the refrigerator (4°C) for experimental use.

Table 1. List of indigenous plant oils tested

Serial no.	Common name	Scientific name	Family
1	Mustard	*Brassica campestris*	Cruciferae
2	Black cumin	*Nigella sativa*	Ranunculaceae
3	Palm	*Elaeisguinensis*	Palmae
4	Soybean	*Glycine max*	Fabaceae
5	Linseed	*Linumusitatissimum*	Linaceae
6	Ground nut	*Arachishypogaea*	Fabaceae

Data recording procedure: Fifty gram of healthy chickpea seeds were taken in a plastic container (300 ml) and mixed with 5, 7.5 and 10% concentrations of each tested oils (v/v) and then air dried for 30 minutes. Five pairs of newly emerged one day old adult beetles were released in each plastic container and the mouth was closed with its lid. Each treatment was replicated thrice including control. All treated containers were kept at ambient room temperature (28 ± 5°C) in the laboratory for oviposition. After 7 days, dead and alive beetles were removed from each container and seeds along with eggs were kept in the laboratory for further development of the insect. The efficacy of plant materials as protectant of chickpea seeds against *C. chinensis*was assessed considering oviposition, adult's emergence, seed infestation and seed weight loss done. For the determination of oviposition of the beetle seeds were collected from each plastic container of each treatment and examined under 10x magnifying glasses and the number of seeds along with eggs (egg bearing seeds) and the number of eggs deposited were counted. After each observation, the grains were returned to the respective containers for the furtherdevelopment of the beetle. The adults were removed daily from each plastic container and the data were recorded. Percent seed infestation and weight loss were determined at the completion of adult emergence. The sample of each replicate were examined carefully and damaged and healthy seeds were separated, cleaned, counted and weighed. Percent seed infestation and weight loss were calculated by using the following formulae:

Infestation (%) = $\frac{N_b}{T_n} \times 100$ (Enbakhare and Law-Ogbomo 2002)

Where N_b=Number of bored seed and T_n=Total number of seeds

Weight loss (%) = $\frac{IW - FW}{IW} \times 100$ (Keita *et al*. 2001)

Where, IW = Initial weight of seed, FW = Final weight of seed.

Ovicidal and larvicidal efficacies of oils: This test was conducted to investigate whether black cumin, mustard, linseed, soybean, groundnut, and palm oils have ovicidal and larvicidal efficacy. For this, 100 chickpea seeds along with one-day old egg (forovicidal experiment) and 1-2 days old larvae (forlarvicidal experiment) containing one egg or larvae per seed were separately placed in each container and mixed properly with those oils at 5, 7.5, 10% concentrations including control treatment. Each treatment was replicated thrice. Until adult emergence the mouth of the container was closed with its cap and left undisturbed in the laboratory after proper mixing. The number of adults were counted and recorded daily from the first to last emergence and removed from the containers. After completion of adult emergence, the inhibition was computed by using the following formula as stated by Shukla *et al.*(2007).

$$\text{Inhibition (\%)} = \frac{\text{Control mean - Treatment mean}}{\text{Control mean}} \times 100$$

Statistical analyses: The collected data were statistically analyzed in accordance with Completely Randomized Design (CRD) along with analysis of variance ANOVA) through MSTAT program. Mean values were separated with DMRT at 5% level of probability.

RESULTS AND DISCUSSION

Effect of plant oils on oviposition: The effects of different plant oils, doses and their interactions differed significantly (P < 0.05) among the treatments on oviposition of *C. chinensis*(Table 2). Among the treatments, the lowest number of eggs was recorded in black cumin oil (9.0) treated seeds while the highest in the control (181.0). Doses were significantly (P< 0.05, F = 115.12, df = 2) the highest (49.05) and the lowest (38.24) at 5% and 10% concentrations (Table 2). The effects of oils and doses were significantly (P< 0.05, F = 6.67, df = 12) the lowest (5.0) in black cumin oil at 10% concentration (Table 2). Conversely, the highest number of eggs was recorded in the untreated control (181.0). Among the oils, the highest number of egg bearing seeds was recorded in the control (146.7) but the lowest in black cumin (7.67) oil treated seeds (Table 2). The highest (42.38) and the lowest (31.52) number of egg bearing seeds was found at 5% and 10% concentrations (Table 2). Owing to interaction effects of oils and doses, significantly (P< 0.05, F = 5.13, df = 12) the highest (40.67) and the lowest (3.33) number of eggs was found in palm and black cumin oils at 5% and 10% concentration, respectively (Table 2).

From the above finding it is observed that all the tested oils showed promising results against the invasion of *C. chinensis*on chickpea seeds. Activity of these oils inhibits oviposition, adult emergence, seed infestation and weight loss from *C. chinensis*. Among the tested oils, black cumin and mustard oil markedly reduced the oviposition and significantly inhibited the adult emergence against the*C. chinensis* on chickpea seeds (Table 2). Black cumin and mustard oils at 10% concentration distinctly reduced the insect oviposition, number of egg bearing seeds, and adult emergence (Table 2). The present findings on the rate of oviposition and number of egg bearing seeds are comparable with the results of Upadhyay *et al.*(2007) and Hossain *et al.* (2014). They used various plant oils including black cumin, mustard, linseed,soybean, groundnut and palm with various doses against the bruchids hosted on pulse seeds. Singh (2003) reported that botanical oils treated grain impaired oviposition of pulse beetle. Biswas and Biswas (2005) cited that edible oils comprising mustard, black cumin and sesame at 8.0 ml/kg seeds gave best protection of pea seeds against pulse beetle.

Adult emergence: Plant oils, doses and their interactions differed significantly ($P < 0.05$) among the treatments on number of adult emergence of *C. chinensis*(Table 2). Among the oils the highest number of adult emergence was recorded in the control (165.7). On the other hand, the lowest number of adult emergence was recorded in black cumin (6.22) oil treated seeds. The highest (43.29) and the lowest (24.52) number of adult emergence was found at 5% and 10% concentrations (Table 2). Due to the interaction effects of oils and doses, significantly ($P < 0.05$, $F = 12.32$, $df = 12$) the highest (165.7) number of adults were experienced in the control but the lowest (1.0) from the black cumin oil at 10% and statistically similar with other oils at same concentration (Table 2).

It was experienced from the results that all the tested oils, black cumin and mustard at 10% concentration inhibited the adult emergence successfully by reducing oviposition. Our results are in agreement with the results opined by Chander *et al.* (2007), Haghtalab *et al.* (2009) and Hossain *et al.* (2014). They reported that oils of neem, castor, karanja, sesame and mustard markedly reduced adult emergence of pulse beetle when admixed with various pulse seeds. Again, Rahman and Rahman (2004) experienced that oils of black cumin, mustard, linseed, soybean, groundnut and palm at 10.0 ml/kg seeds reduced emergence of adult of pulse beetle on chickpea seeds at certain potential level although could not completely inhibited.

Seed infestation: Due to the oils, the highest seed infestation was recorded in the control (42.35%) while the lowest in black cumin (2.09%), and mustard (3.11%) oils treated seeds. Among the doses of oilsthe highest (13.11%) and the lowest (6.42%) number of seed infestation was found at 5% and 10% concentrations which statistically significant. Effects of oils and doses were also significantly ($P< 0.05$, $F = 31.03$, $df = 12$) differed in different treatments (Table 2). This result is comparable with those of Abulude *et al.* (2007), Bamaiyai *et al.* (2007) and Sarker *et al.* (2015). They cited that oils of sesame, mustard, groundnut, palm and many other oils were also found effective against the pulse beetle in reducing the intensity of infestation on chickpea seeds at 10.0 and 5.0 ml/kg against the infestation of *C. chinensis.*

Seed weight loss: Among the oils, the control treatment showed the highest (7.20%) seed weight loss while the lowest (0.45%) inblack cumin oil (Table 2). The highest (2.14%) and the lowest (1.09%) seed weight loss was found at 5 and 10% concentrations among all the doses applied. The effects of oils and doses significantly ($P< 0.05$, $F= 13.62$, $df= 12$) found the lowest (0.05%) seed weight loss in black cumin at 10%concentration. The findings of present study are also parallel with those of Khalequzzaman *et al.* (2007) andSrinivasan (2008). They experienced that stored grains treated with neem, castor, sesame, karanja and mustard oils provided lowest weight loss over the control.

Ovicidal efficacy of oils: Among the treatments of oils, the lowest (12.89) adult was recorded in black cumin oil treated seeds but the highest (97.0)inthe control. Similarly, among the oils, the highest (86.59%) and lowest (65.15%) inhibition was recorded in black cumin and palm oil treated seeds. The highest (45.67) and the lowest (24.24) number of adult emergence was found at 5 and 10% concentrations, respectively (Table 3). Likewise, among the dosesthe highest (87.50%) and the lowest (61.67%) inhibition were calculated at 10% and 5% concentrations, respectively (Table 3). The interaction effects of oils and doses significantly ($P< 0.05$, $F = 14.10$, $df =2$) the lowest (4.0) and highest (50.0) number of adult emergence was recorded in black cumin oil and palm oil at 10% and 5% concentrations, respectively (Table 3). Statistically ($P< 0.05$, $F = 5.23$, $df =10$) the highest (95.86%) and the lowest (48.43%) inhibition over control was found in black cumin and palm oils at 10% and 5% concentrations.The results obtained from the present study are in agreement with the observations of Bhatnagar *et al.* (2001). They opined that mustard, and black cumin oils showed ovicidalproperties that suppressed the emergence of pulse beetle, *C. chinensis.*

Table 2. Plant oils, doses and their interaction effects on oviposition, adult emergence, seed infestation, and weight loss done by *C. chinensis*

	Treatments / doses (%)	Number of eggs	Number of egg bearing seeds	Number of adult emergence	Seed infestation (%)	Seed weight loss (%)
Plant effects	Black cumin	9.0 f	7.67 f	6.22 e	2.09 f	0.45 e
	Mustard	15.67 e	13.56 e	9.11 de	3.11 e	0.70 d
	Linseed	16.56 e	14.33 e	9.67 d	3.31 e	0.72 d
	Soybean	22.11 d	20.00 d	15.0 c	5.29 d	0.86 c
	Groundnut	27.44 c	24.89 c	16.11 c	6.42 c	0.95 bc
	Palm	31.56 b	29.44 b	21.44 b	7.85 b	1.08 b
	Control	181.0 a	146.7 a	165.7 a	42.35 a	7.20 a
	LSD	2.21	2.52	3.02	0.71	0.13
	P-value	0.00	0.00	0.00	0.00	0.00
Dose effects	Dose 1(5.0)	49.05 a	42.38 a	43.29 a	13.11 a	2.14 a
	Dose 2(7.5)	42.71 b	36.05 b	36.43 b	10.65 b	1.90 b
	Dose 3(10.0)	38.24 c	31.52 c	24.52 c	6.42 c	1.09 c
	LSD	1.45	1.65	1.98	0.47	0.08
	P-value	0.00	0.00	0.00	0.00	0.00
Interaction effects of plants and doses	Black cumin-dose 1	12.0 gh	11.0 h	10.0 ef	3.41gh	0.78 f
	Black cumin-dose 2	10.0 h	8.67 h	7.67 f	2.44 h	0.51 g
	Black cumin-dose 3	5.0 i	3.33 i	1.0 g	0.42 i	0.05 h
	Mustard-dose 1	19.33 f	17.33 fg	15.33 de	5.11 f	1.09 de
	Mustard-dose 2	15.33 g	13.0 gh	11.0 ef	3.80 g	0.95 ef
	Mustard-dose 3	12.33 gh	10.33 h	1.0 g	0.42 i	0.06 h
	Linseed-dose 1	23.0 ef	20.33 ef	17.33 d	5.89 f	1.13 cde
	Linseed-dose 2	15.0 g	13.0 gh	10.67 ef	3.63 gh	0.98 ef
	Linseed-dose 3	11.67 gh	9.67 h	1.0 g	0.43 i	0.07 h
	Soybean-dose 1	30.0 d	28.0 d	26.33 c	9.46 d	1.38 c
	Soybean- dose 2	21.33 f	19.33 ef	17.67 d	5.97 f	1.13 cde
	Soybean- dose 3	15.0 g	12.67 gh	1.0 g	0.44 i	0.09 h
	Groundnut-dose 1	35.67 c	32.67 c	30.67 c	11.43 c	1.61 b
	Groundnut-dose 2	26.0 e	24.0 de	16.67 d	7.41 e	1.18 cde
	Groundnut-dose 3	20.67 f	18.0 f	1.0 g	0.42 i	0.05 h
	Palm- dose 1	42.33 b	40.67 b	37.67 b	14.17 b	1.79 b
	Palm- dose 2	30.33 d	27.67 d	25.67 c	8.95 d	1.33 cd
	Palm- dose 3	22.0 ef	20.0 ef	1.0 g	0.45 i	0.11 h
	Control	181.0 a	146.7 a	165.7 a	42.35 a	7.20 a

Table 2 Contd.

LSD	3.82	4.37	5.23	1.24	0.23
P-value	0.00	0.00	0.00	0.00	0.00

Values within column followed by different letter(s) are significantly different by DMRT at 5 % level of probability.

Larvicidal activity of oils: Among the oils, the highest number of adult emergence was recorded in the control (96.0) treatment. Contrary, the lowest was recorded in black cumin (17.78) oil treated seeds. The highest (81.48%) and the lowest (58.59%) inhibition was observed in black cumin and palm oil treated seeds. Among the doses, the highest (52.67) adult emergencewas found at 5% while the lowest (30.48)wasat 10% concentration (Table 3).Statistically (*P*< 0.05, *F* = 336.14, *df* = 2) the highest (79.67%) and lowest (52.67%) inhibition was found at 10% and 5% concentrations, respectively. The effects of oils and doses, significantly (*P*< 0.05, *F* = 10.36, *df* = 12) the lowest (5.33) and the highest (54.67) number of adult emergence was found in black cumin and palm oil at 10% and 5% concentrations, respectively (Table 3). Similarly, the highest (94.47%) and the lowest (43.08%) inhibition were computed from black cumin and palm oils at 10% and 5% concentrations as compared to control..

Table 3. Effect of plant oils, doses and their interactions on number of adults of *C. chinensis*emerged from egg and larvae bearing chickpea seeds.

	Treatments / doses (%)	Egg bearing seed		Larva bearing seed	
		Number of adult emerged	Inhibition (%)	Number of adult emerged	Inhibition (%)
Plant effects	Black cumin	12.89 f	86.59 a	17.78 e	81.48 a
	Mustard	20.44 e	78.92 b	27.56 d	71.35 b
	Linseed	26.22 d	72.97 c	33.33 c	65.30 c
	Soybean	29.33 c	69.74 d	42.00 b	56.23 d
	Groundnut	31.33 bc	67.68 de	31.33 c	67.36 c
	Palm	33.78 b	65.15 e	39.78 b	58.59 d
	Control	97.00 a	-	96.00 a	-
	LSD	2.65	3.00	2.93	2.99
	P-value	0.00	0.00	0.00	0.00
Dose effects	Dose 1(5.0)	45.67 a	61.67 c	52.67 a	52.67 c
	Dose 2(7.5)	37.67 b	71.35 b	40.19 b	67.82 b
	Dose 3(10.0)	24.24 c	87.50 a	30.48 c	79.67 a

Table 3 Contd.

	LSD	1.73	2.12	1.92	2.18
	P-value	0.00	0.00	0.00	0.00
Interaction effects of plants and doses	Black cumin-dose 1	20.67 g	78.33 de	26.67 g	72.21 d
	Black cumin-dose 2	14.00 hi	85.57 bc	21.33 h	77.77 c
	Black cumin-dose 3	4.000 k	95.86 a	5.333 j	94.47 a
	Mustard-dose 1	26.67 f	72.50 f	42.67 c	55.58 h
	Mustard-dose 2	26.00 f	73.20 ef	28.67 fg	70.14 de
	Mustard-dose 3	8.667 j	91.05 ab	11.33 i	88.33 b
	Linseed-dose 1	37.33 cd	61.53 hi	46.00 c	52.12 h
	Linseed-dose 2	30.67 ef	68.40 fg	33.33 def	65.28 efg
	Linseed-dose 3	10.67 ij	88.98 b	20.67 h	78.49 c
	Soybean-dose 1	41.33 c	57.40 i	58.00 b	39.57 i
	Soybean- dose 2	33.33 de	65.61 gh	37.33 d	61.10 g
	Soybean- dose 3	13.33 hij	86.23 bc	30.67 efg	68.03 def
	Groundnut- dose 1	46.67 b	51.87 j	44.67 c	53.44 h
	Groundnut- dose 2	29.33 ef	69.74 fg	29.33 fg	69.43 de
	Groundnut- dose 3	18.00 gh	81.43 cd	20.00 h	79.21 c
	Palm- dose 1	50.00 b	48.43 j	54.67 b	43.08 i
	Palm- dose 2	33.33 de	65.61 gh	35.33 de	63.21 fg
	Palm- dose 3	18.00 gh	81.42 cd	29.33 fg	69.48 de
	Control	97.00 a	-	96.00 a	-
	LSD	4.59	5.20	5.08	5.18
	P-value	0.00	0.00	0.00	0.00

Values within column followed by different letter(s) are significantly different by DMRT at 5 % level of probability.

CONCLUSION

The results of the present findings stated that black cumin and mustard oils prevented oviposition, egg from hatching of *C. chinensis*thus reduced the seed infestation and weight loss. This study indicated black cumin and mustard oils may be used for sustainable management of chickpea seeds from the invasion of *C. chinensis*in storage.

ACKNOWLEDGEMENT

This study was carried out with the financial support of Ministry of Science and Technology, Government of the People's Republic of Bangladesh.

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