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Insecticidal potentials of plant oils against *Callosobruchus chinensis* (Coleoptera: Bruchidae) in stored chickpea

Md. Alamgir Hossain[1&*], Md. Abdul Alim[1], K. Shahanara Ahmed[2] and Md. Azizul Haque[2]
1. Department of Entomology, Hajee Mohammad Danesh Science and Technology University, Dinajpur-5200, Bangladesh, 2. Department of Entomology, Bangladesh Agricultural University, Mymensingh, Bangladesh.
*Corresponding author, E-mail: alamgirhstu@gmail.com

Abstract

Pulse beetle, *Callosobruchus chinensis* L., is an important pest of stored chickpea and widely distributed in the world. Chemical insecticides and fumigants are common control tactics against pulse beetle, even though they have caused serious drawbacks. As an alternative control method, botanical compounds and their constituents have been successfully used against this pest. We tested the protective efficacy of 18 edible and non-edible oils in storage in ambient room condition. The efficacy was evaluated considering oviposition, adult emergence, seed infestation and seed weight loss caused by pulse beetle. All the tested oils effectively checked the oviposition, adult emergence, seed infestation and weight loss compared to control. However, the oils of neem, castor, karanja, and sesame at 4.0 to 8.0 ml/kg seed showed significant reduction of oviposition, and completely inhibited adult emergence, seed infestation and weight loss of chickpea seeds. The mustard oil could reduce the oviposition, adult emergence, seed infestation and seed weight loss at 8.0 ml/kg. Tested oils did not show any adverse effects on seed germination up to three months of storage. Therefore, neem, castor, karanja, and sesame oils can be used as environmentally safe management tactic for *C. chinensis* in protecting pulse seeds in store.
Key words: plant oil, pest management, chickpea, *Callosobruchus chinensis*

چکیده

توان حشره‌کشی روغن‌های گیاهی علیه *Callosobruchus chinensis* (Col.: Bruchidae) روی نخود در انبار

محمد علمگیر حسین، محمد عبدل علیم، کازی شهنارا احمد و محمد عزیزل حق

سوسک چینی حبوبات، *Callosobruchus chinensis* L.، آفت مهم نخود است و انتشار جهانی دارد. حشره‌کش‌های شیمیایی و سموم تدخینی، اگرچه تبعات شدیدی را سبب می‌شوند، از روش‌های رایج کنترل این آفت هستند. ترکیبات گیاهی و مواد سازنده آن‌ها، به‌عنوان روش کنترلی دیگری به‌طور موفقیت‌آمیز علیه این آفت به‌کار رفته‌اند. در این تحقیق، اثر محافظتی ۱۸ روغن خوراکی و غیرخوراکی در انبار را در یک اتاق بسته آزمایش کردیم. این اثر محافظتی، با درنظر گرفتن میزان تخم‌ریزی، ظهور حشرات کامل، آلودگی دانه و کاهش وزن دانه در اثر این حشره، ارزیابی شد. در مقایسه با شاهد، تمامی روغن‌های آزمایش‌شده به‌طور مؤثری مانع تخم‌ریزی، ظهور حشرات کامل، آلودگی دانه و کاهش وزن آن شدند. باوجوداین، روغن‌های چریش، کرچک، کارانجا (باقلای هندی) و کنجد، به میزان ۴ تا ۸ میلی‌لیتر بر کیلوگرم بذر کاهش معنی‌داری روی تخم‌ریزی داشتند و به‌طور کامل مانع ظهور حشرات کامل، آلودگی دانه نخود و کاهش وزن آن شدند. روغن خردل به میزان ۸ میلی‌لیتر بر کیلوگرم، میزان تخم‌ریزی، ظهور حشرات کامل، آلودگی دانه و کم‌شدن وزن آن را کاهش داد. روغن‌های آزمایش‌شده، پس از سه ماه نگه‌داری بذور در انبار، هیچ‌گونه تأثیر سوئی روی جوانه‌زنی آن‌ها نداشتند. بنابراین، روغن‌های چریش، کرچک، کارانجا و کنجد می‌توانند به‌عنوان یک روش مدیریتی سازگار با محیط زیست برای حفاظت از حبوبات در مقابل سوسک *C. chinensis* در انبار استفاده شوند.

واژگان کلیدی: روغن گیاهی، مدیریت آفت، نخود، *Callosobruchus chinensis*

Introduction

Pulse (Leguminosae: Fabales) is the fifth leading legume crop in the world (Aslam *et al*., 2002). It plays a pivotal role in the diet of common people of developing countries, including Bangladesh. Farmers usually store pulses in traditional and improvised storage containers that are penetrable to insect pests. One of the major limiting factors of on increasing pulses production is the loss of seed viability and damage of pulse grains from insect infestation in storages. Pulse beetle, *Callosobruchus chinensis* L., is widely distributed and known as a major destructive insect of stored chickpea (Park *et al*., 2003; Aslam, 2004). The larvae destroy seeds by feeding inside and make them completely unfit for human consumption (Atwal & Dhaliwal, 2005). Pulse seeds were completely destroyed due to pulse beetle infestation after 3 months of storage (Jat *et al*., 2013).

At present, the control methods of this insect are mostly based on using synthetic insecticides and fumigants (Environmental Protection Agency, 2001). But chemical control measures have suffer serious deficiencies (Luckman & Metcalf, 1978; Wink, 1993; Lee *et al*., 2001; Mahmud *et al*., 2002; Ashamo, 2004;

Nas, 2004). Continuous uses of insecticides are hazardous on beneficial organisms in both fields and storages and cause environmental pollution (Nagarare & More, 1998; Hossain, 2001). Current research illustrated that botanical oils and their constituents may have potentials as alternative to fumigants (Tunc *et al.*, 2000; Lee *et al.*, 2001; Yamane, 2013) as they are non-toxic to mammals and beneficial organisms, less prone to insect resistance, readily biodegradable and less expensive (Saxena, 1992). Various plant oils that have been tried by researchers showed satisfactory degree of success against pulse beetle in storages (Yadav *et al*., 2004; Ghosal *et al*., 2005; Upadhyay *et al*., 2007), although, research on plant oils against pulse beetle in Bangladesh remains scanty (Rahman & Rahman, 2004; Khalequzzaman *et al*., 2007). Therefore the present study was conducted to investigate the insecticidal potentials of some botanical oils against *C. chinensis* on chickpea seeds in storage.

Materials and methods

Sources and collection of oils

The experimental plant oils (table 1) were purchased from the local market of Choto bazar, Mymensingh town and Shaheb bazar of Rajshahi city in Bangladesh. The oils were stored separately at room temperature in air tight glass bottle.

Collection of chickpea seeds

Chickpea, *Cicer arietinum* L., seeds were purchased from the local market of Mymensingh town and thoroughly cleaned, sun dried, cooled and stored with 10 ± 2 % moisture content. The seeds were kept in air tight plastic containers (25 cm height x 15 cm dia.) and preserved at room temperature for study.

Insect culture

The insects were reared according to Mollah & Islam (2005) with a slight modification. For this, approximately 200 adults of pulse beetle were released in each jar (47 cm H × 4 cm D, 30 ± 3 ^{o}C) containing 500 grams of chickpea seeds in the laboratory with ambient room conditions. The jars were tightly closed with fine nylon cloths. The beetles were left to mate and oviposit for 7 days. Then the beetles were separated from the seeds by sieving and seeds while the eggs were left in the container for the emergence of adult beetles. The newly emerged adults were transferred to different containers supplied with fresh seeds to maintain a series of stock culture.

Screening procedure of oils

Screening of plant oils as grain protectants against *C. chinensis* was carried out following two steps: primary and secondary screening.

Table 1. List of plants oils assayed**.**

Common name	Scientific name	Family
Black cumin	*Nizella sativa*	Umbelliferae
Ground nut	*Arachis hypogea*	Leguminosae
Joytun	*Gyrocarpus americana*	Gyrocarpaceae
Karamcha	*Apo sinensis*	Apoaceae
Mustard	*Brassica campestris*	Cruciferae
Palm	*Elaeis guinensis*	Palmae
Olive	*Olea europea*	Oleaceae
Soybean	*Glycine max*	Leguminosae
Til	*Sesamum indicum*	Pedaliaceae
Sunflower	*Helianthus annuus*	Compositae
Coconut	*Cocos nucifera*	Palmae
Neem	*Azadirachta indica*	Meliaceae
Pithraj	*Aphanamixis polystachya*	Meliaceae
Castor	*Ricinus communis*	Euphorbiaceae
Spanish jasmin	*Jasminum sambac*	Oleaceae
Tishi	*Linium usitatissimum*	Linaceae
Karanja	*Pongamia pinnata*	Fabaceae
Mehogani	*Switenia mehogani*	Meliaceae

Protocol of primary screening

Fifty grams of undamaged chickpea seeds were placed into a plastic container (8.5 H × 7.5 D cm). Using a micropipette, we added oils at 8.0 ml/kg seeds and mixed it properly by hand. Five pairs of one-day old adult *C. chinensis* were released in each plastic container including the control and the containers were closed with perforated lids. Plant oils were not used in control treatment. All treated containers were replicated thrice and kept at ambient room conditions in the laboratory for oviposition and development of *C. chinensis*. Dead and alive beetles were removed after 7 days from containers. The effect of plant materials as protectant against *C. chinensis* was assessed. For determining the oviposition rate, 100 seeds were collected randomly from each plastic container in each treatment and examined under magnifying glass (10 x). The number of seeds along with their eggs (i.e. egg bearing seeds) and the number of deposited eggs were counted. After each observation, the grains were put back in the containers for further development of the beetles. After emergence, adults were removed daily and recorded. Infested and healthy seeds were separated, cleaned, counted and finally weighed after adult emergence. Seed infestation and seed weight loss were computed by using the following formulae:

1. Infestation (%) = $(N_b / T_n) \times 100$

where, N_b = number of bored seeds, T_n = total number of seeds (Enobakhare & Law-Ogbomo, 2002).

2. Weight loss (%) = $(UNd – DNu / U(Nd + Nu)) \times 100$

where, U = weight of undamaged seeds, D = weight of damaged seeds, Nu = number of undamaged seeds, Nd = number of damaged seeds (Lal, 1988).

Protocol of secondary screening

From primary screening, it was found that neem, castor, karanja, sesame and mustard oils completely inhibited the emergence of F_1 progeny of *C. chinensis*. Therefore, those oils were further tested at the lower doses at 4.0, 2.0, 1.0 and 0.5 ml/kg seeds. Each dose was replicated five times along with control treatment. The screening protocol and observations maintained was same as the primary screening.

Ovicidal and larvicidal effect

Another experiment was conducted to discover whether oils selected from primary screening possesses ovicidal and larvicidal efficacies. For this, 100 chickpea seeds containing one day old eggs (ovicidal experiment) and up to 2-day-old larvae (larvicidal experiment) containing one egg or larva per seed were placed separately in Petri dishes (120 D × 20 H mm). Then different tested oils at 8.0, 4.0, 2.0, 1.0 and 0.50 ml/kg seeds with the help of micro pipette were added and mixed. The container was lidded and left undisturbed in the laboratory until adult emergence. Each treatment was replicated five times. The number of adult beetles were counted daily and removed from the containers. After completion of adult emergence, the inhibition was computed using the following formula by Shukla *et al*. (2007).

Inhibition (%) = (Control mean – Treatment mean / Control mean) × 100

Seed germination test

Seed germination test was carried out according to Enobakhare & Law-Ogbomo (2002) with a slight modification. To study the effects of neem, castor, karanja, sesame and mustard oils on seed viability and germination, chickpea seeds were treated at different doses for a period of 3 months. A total of 100 seeds were placed in Petri dishes (120 D × 20 H mm) containing water soaked blotting paper (Whatman no. 1, UK) at the bottom. The Petri dishes were placed in the laboratory under ambient room conditions. Germinated seeds were counted after incubation and rated for seed germination.

Statistical analyses

The data were analyzed based on Completely Randomized Design (CRD) and analysis of variance (ANOVA). Data were transformed by log, arcsine and square root transformation before analysis. The treatment mean values were compared by Duncan's New Multiple Range Test (DMRT) (Gomez & Gomez, 1984). All statistical analyses were done through a Mathematical and Statistical (MSTAT) program.

Results

Primary screening

The number of eggs ($F = 43.93$, $df = 18$, $p < 0.05$), eggs bearing seeds ($F = 66.41$, $df = 18$, $p < 0.05$), adult emergence ($F = 232.08$, $df = 18$, $p < 0.05$), seed infestation ($F = 418.97$, $df = 18$, $p < 0.05$) and seed weight loss ($F = 144.45$, $df = 18$, $p < 0.05$) were done by *C. chinensis* on chickpea seeds differed significantly among the treatments at 8.0 ml/kg seed (table 2). Among the treatments, the highest number of eggs (95.67) and egg bearing seeds (79.67) were found in the control. The lowest number of eggs and egg bearing seeds were found when seeds treated with neem (9.33 and 9.0), castor (13.0 and 13.0), karanja (16.67 and 16.33), sesame (17.0 and 16.33) and mustard (15.0 and 14.33) oils at 8.0 ml/kg seeds. Similarly, the highest number of adult emergence (194.0), seed infestation (61.26%) and weight loss (4.01%) were found in the control treatment. Adults did not emerge when seeds had been treated with neem, castor, sesame, karanja and mustard oils at 8.0 ml/kg seeds (table 2). Therefore, no seed infestation and weight loss was observed at that dose.

Secondary screening

From the primary screening, it was found that neem, castor, sesame, karanja and mustard oils were satisfactory among all the tested botanical oils. Therefore, they were further tested at lower doses for ovicidal and larvicidal efficacies against *C. chinensis*.

Effect on oviposition

The number of eggs ($F = 1.78$, $df = 16$, $p < 0.05$) and egg bearing seeds ($F = 1.76$, $df = 16$, $p < 0.05$) treated with oils were significantly different (table 3). The highest number of eggs (95.20) was found in the control treatment. The lowest number of eggs was counted in neem oil (19.0) at 4.0 ml/kg seeds. But no adult was emerged when seeds were treated by neem, castor, karanja and sesame oils at 4.0 ml/kg seeds. Similarly, the highest number of egg bearing seeds (76.60) was found in the control treatment. Conversely, the lowest egg bearing seeds were counted in neem oil (18.80) at 4.0 ml/kg seeds (table 3).

Adult emergence

The number of adult emergence differed significantly ($F = 39.47$, $df = 16$, $p < 0.05$) (table 3). The highest number of adults was recorded in the control (190.0) treatment. On the contrary, no adult was found to emerge when seeds were treated by neem, castor, karanja and sesame oils at 4.0 ml/kg seed.

Seed infestation and seed weight loss

Results indicated that the percentage seed infestation ($F = 17.97$, $df = 16$, $p < 0.05$) and seed weight loss ($F = 21.91$, $df = 16$, $p < 0.05$) due to treatments by oils were significantly different (table 3). The highest seed infestation (64.34%) and weight loss (4.17%) were found in the control treatment. Nevertheless, no seed infestation and weight loss was found when seeds were treated with neem, castor, karanja and sesame oil at 4.0 ml/kg seeds.

Seed germination

The germination percentages of chickpea seeds treated with various oils including control were not significantly different (table 3). The germination in different treatments including control ranged from 88.80 to 90.80%.

Ovicidal and larvicidal efficacy

The effects of oils and different doses on egg ($F = 222.27$, $df = 20$, $p < 0.05$) and larva ($F = 9.68$, $df = 20$, $p < 0.05$) bearing chickpea seeds were significantly different (table 4). The highest number of adults was found to emerge (90.2) from egg bearing seeds in control treatment. Conversely, no adult emerged when egg bearing seeds were treated with neem, castor,

Table 2. Effect of different oils (8.0 ml/kg) on oviposition, adult emergence, seed infestation and seed weight loss of *Callosobruchus chinensis* on treated chickpea seeds.

Treatments	Egg/100 seeds (no.)	Egg bearing seeds/100 seeds (no.)	Adult emergence (no.)	Seed infestation (%)	Seed weight loss (%)
Black cumin	24.00 fg	22.33 e	11.67 ef	4.55 ef	0.36 ef
Ground nut	41.67 cd	39.33 cd	6.33 h	2.88 g	0.16 h
Joytun	52.00 bc	43.33 cd	18.67 cd	6.59 cd	0.39 de
Karamcha	64.67 b	59.33 b	30.00 b	9.86 b	0.60 b
Mustard	15.00 hi	14.33 fg	0.00 i	0.00 h	0.00 i
Palm	36.00 de	33.00 d	7.00 h	2.68 g	0.16 h
Olive	50.67 bc	46.00c	20.00 c	6.33 cd	0.36 ef
Soybean	26.33 f	23.33 e	9.67 fg	3.67 fg	0.24 g
Sesame	17.00 hi	16.33 f	0.00 i	0.00 h	0.00 i
Sunflower	29.33 ef	26.67 e	14.67 de	5.19 de	0.32 efg
Coconut	25.00 f	24.00 e	11.67 ef	4.46 ef	0.26 fg
Neem	9.33 j	9.00 h	0.00 i	0.00 h	0.00 i
Pithraj	18.33 gh	17.67 f	7.67 gh	2.95 g	0.17 h
Castor	13.00 i	13.00 g	0.00 i	0.00 h	0.00 i
Spanish jasmin	46.33 cd	42.00 c	21.00 c	7.43 c	0.45 cd
Tishi	35.67 de	34.00 d	29.33 b	9.59 b	0.58 bc
Karanja	16.67 hj	16.33 f	0.00 i	0.00 h	0.00 i
Mehogani	36.33 de	34.00 d	14.33 de	5.42 e	0.32 efg
Control	95.67 a	79.67 a	194.00 a	61.26 a	4.01 a
CV (%)	4.65	3.63	8.07	8.30	7.27

Values in each column followed by different letter are significantly different ($P < 0.05$).

Table 3. Effects of different oils on oviposition, adult emergence, seed infestation and seed weight loss in *Callosobruchus chinensis* and germination of treated chickpea seeds.

Treatments (oils)	Dose ml/kg seeds	Eggs/100 seeds (no.)	Egg bearing seeds/100 seeds (no.)	Adult emergence (no.)	Seed infestation (%)	Seed weight loss (%)	Seed germination (%)
Neem	4.0	19.00 m	18.80 j	0.00 k	0.00 k	0.00 j	89.00
	2.0	28.80 jk	27.60 fg	16.60 i	5.88 j	0.23 k	90.20
	1.0	45.00 fg	40.40 d	38.60 fg	13.08 h	0.87 h	90.40
	0.5	73.20 bc	61.80 b	112.20 c	27.07 e	1.65 e	90.60
Castor	4.0	22.40 lm	20.20 ij	0.00 k	0.00 k	0.00 j	88.80
	2.0	35.20 hi	31.00 ef	27.40 h	9.6 2i	0.58 ij	89.40
	1.0	51.00 ef	41.40 d	61.00 e	19.89 g	1.21 g	89.60
	0.5	77.80 abc	63.60 b	136.80 b	40.30 d	2.44 d	90.00
Karanja	4.0	27.00 kl	22.40 hi	0.00 k	0.00 k	0.00 j	89.20
	2.0	33.20 ij	30.60 ef	32.40 gh	10.69 i	0.69 i	89.60
	1.0	56.40 de	48.80 c	70.40 e	23.17 f	1.42 f	90.20
	0.5	80.00 abc	67.80 ab	147.40 b	44.72 c	2.76 c	90.20
Sesame	4.0	25.80 kl	23.60 h	0.00 k	0.00 k	0.00 j	89.00
	2.0	36.40 hi	32.40 e	35.80 g	13.43 h	0.94 h	89.80
	1.0	56.00 de	51.40 c	84.80 d	26.52 e	1.66 e	90.00
	0.5	83.80 ab	66.40 ab	159.40 ab	44.31 c	2.77 c	90.00
Mustard	4.0	29.80 ijk	24.00 gh	10.60 j	4.84 j	0.20 k	89.20
	2.0	41.20 gh	35.20 e	45.80 f	14.66 h	0.89 h	89.20
	1.0	66.60 cd	54.00 c	95.60 cd	28.14 e	1.73 e	90.00
	0.5	84.40 ab	69.20 ab	164.80 ab	52.38 b	3.15 b	90.20
Control	-	95.20 a	76.60 a	190.00 a	64.34 a	4.17 a	90.80
CV (%)		3.55	2.78	4.16	5.43	4.82	NS

Mean numbers in each column that is followed by same or no letter(s) are not significantly different ($P < 0.05$).

karanja and sesame oils at 4.0 and 8.0 ml/kg as well as mustard oil only at 8.0 ml/kg seeds. Those oils provided 100% inhibition over control at 4.0 and 8.0 ml/kg seeds while mustard oil only at 8.0 ml/kg seeds. Similarly, the highest number of adults was found to emerge from larva (90.8) bearing seeds in control treatment (table 4). Conversely, the lowest number of adults (14.4) emerged when larva bearing seeds were treated by neem oil at 8.0 ml/kg seeds. Neem oil showed maximum (84.14%) inhibitions at 8.0 ml/kg seed over the control while the minimum (2.64%) from mustard oil at 0.5 ml/kg seeds.

Discussion

All the tested oils were significantly effective against the pulse beetle, *C. chinensis* of chickpea seeds. Among the tested oils, neem, castor, karanja, sesame and mustard significantly reduced the oviposition and completely inhibited the adult emergence, seed infestation and weight loss (table 2). Mustard oils remarkably reduced the oviposition, inhibited adult emergence, seed infestation and weight loss at 4.0 ml/kg seeds (table 3). Higher oil doses protected the grains properly where no infestation occurred. None of the other tested oils (table 1) at those doses checked oviposition but failed to provide absolute protection of chickpea seeds from the attack of *C. chinensis*. Significant level of success in the management of bruchids has been reported by various authors using plant oils. A number of oils including neem, castor, sesame, karanja and mustard at various doses used against pulse beetle on pulse seeds to reduce the infestation (Singh & Sharma, 2003; Bamaiyai *et al*., 2007; Chander *et al*., 2007; Srinivasan, 2008; Haghtalab *et al*., 2009). Our results are consistent with the aforesaid researchers.

Tested oils also showed egg and larval mortality and inhibited emergence of F_1 progeny in both stages (table 4). The suppression could be due to egg mortality by the direct oil coating. This may hampered suitable micro environment surrounding immature stages of the insects. The suppression of emergence might have been also caused physically by oil coating, critically blocked respiration, and inhibited further development of *C. chinensis*. The findings of the present investigation are in accordance with other researchers (Ahmed *et al*., 2003; Yadav & Bhargava, 2005). They have previously reported that the plant oils showed ovicidal and larvicidal properties that suppressed the F_1 progeny of bruchids. Copping & Menn (2000) mentioned that the application of oils occluded seed funnels leading to the death of the developing stages due to asphyxia.

Besides, oils treated grains had no adverse effects on viability (table 3). Thus, such plant oils could reduce the bruchid infestations of storage grain without any negative impact on grain quality. These results are comparable with those of Raja & Ignacimuthu (2001), Bhargava & Meena (2002), Haque *et al*. (2002), Raghvani & Kapadia (2003). They opined that seeds of green gram, mungbean, cowpea, pigeon pea and black gram treated with neem, castor, karanja, sesame and mustard oil at 5.0 and 10.0 ml/kg didn’t damage their germination and nutritional properties (Dhulia *et al*., 1999).

The biological activities of tested oils can be ascribed to several alkaloid contents as an insecticidal potency (Ghosal *et al*., 2005; Alice *et al*., 2007). The alkaloids, terpinoids, steroids, glycosides as morgason-O, nimbin, nimbidine, meliacins present in neem oil (Rejesus *et al*., 1990). The other alkaloids like ricinin, sesamin, karanjin and erucic acid are present in castor, sesame, karanja and mustard oils, respectively (Prakash & Rao, 1996). These chemical compounds might associate with deterrent, repellent and anti-feeding actions against pulse beetle. The biological activity of oils interferes with normal respiration of insects resulting suffocation (Schoonhoven, 1978). Some oils have broad spectrum insecticidal activity against pulse beetle, affecting insect nervous and defence systems (Hold *et al*., 2000; Isman, 2000; Ketoh, 2004). Therefore, the tested oils prevented oviposition, eggs hatching, larval and pupal development consequently

Table 4. Effects of different oils on the adult emergence of *Callosobruchus chinensis* from egg and larva bearing chickpea seeds.

Treatments (oils)	Dose (ml/kg)	Egg bearing chickpea seeds		Larvae bearing chickpea seeds	
		Adult emerged (no.)	Inhibition (%)	Adult emerged (no.)	Inhibition (%)
	8.0	0.0 k	100	14.4 l	84.14
	4.0	0.0 k	100	26.8 j	70.48
Neem	2.0	31.2 hi	65.41	46.4 f	48.90
	1.0	38.8 f	56.98	75.0 c	17.40
	0.5	80.6 b	10.64	82.6 a-c	9.09
	8.0	0.0 k	100	20.4 k	77.53
	4.0	0.0 k	100.0	34.6 hi	61.89
Castor	2.0	36.0 fg	60.08	56.2 e	38.11
	1.0	43.4 e	51.88	81.8 abc	9.11
	0.5	81.4 ab	9.76	85.2 a-c	6.17
	8.0	0.0 k	100.0	33.2 i	63.44
	4.0	0.0 k	100.0	40.6 fg	55.29
Karanja	2.0	30.0 i	66.52	76.4 bc	15.86
	1.0	46.2 de	48.78	85.6 a-c	5.73
	0.5	81.8 ab	9.31	87.4 a-c	3.74
	8.0	0.0 k	100.0	18.6 k	79.95
	4.0	0.0 k	100.0	41.0 fg	54.85
Sesame	2.0	32.8 gh	63.64	60.6 de	33.25
	1.0	46.0 de	49.0	81.6 a-c	10.13
	0.5	82.0 ab	9.09	87.7 a-c	3.30
	8.0	0.0 k	100.0	26.0 j	71.37
	4.0	22.8 j	74.72	38.0 gh	58.14
Mustard	2.0	48.8 d	45.90	65.8 d	27.53
	1.0	71.0 c	21.29	84.6 a-c	6.83
	0.5	85.8 ab	4.88	88.4 ab	2.64
Control	-	90.2 a	-	90.8 a	-
CV (%)		2.90	-	2.35	-

Means in a column having different letter(s) was significantly differ among the treatments by 5% level of probability.

leading to reduction in seed infestation and weight loss in post harvest storage.

Conclusively this study has showed that seeds treated with neem, castor, sesame, karanja and mustard oils may be readily used as eco-friendly and non-toxic chemicals in management of *C. chinensis* in chickpea stores.

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