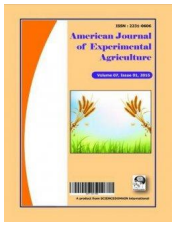

American Journal of Experimental Agriculture
8(3): 167-177, 2015, Article no.AJEA.2015.160
ISSN: 2231-0606

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Callosobruchus chinensis (L.) (Coleoptera: Bruchidae) Management on Stored Chickpea Using Botanicals in Amhara Region, Ethiopia

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Authors' contributions

This work carried out by cooperation between authors MA and EG. Author MA designed the study, wrote the protocol and wrote the first draft of the manuscript. Author EG reviewed the experimental design and all drafts of the manuscript. Authors MA and EG managed the analyses of the study. Both Authors performed the statistical analysis. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJEA/2015/17428
Editor(s):
(1) Masayuki Fujita, Dept. of Plant Sciences, Faculty of Agriculture, Kagawa University, Japan.
Reviewers:
(1) B. Vidya Vardhini, Dept. of Botany, Telangana University, India.
(2) Anonymous, Nigeria.
Complete Peer review History: http://www.sciencedomain.org/review-history.php?iid=1077&id=2&aid=9037

Original Research Article

Received 13th March 2015
Accepted 30th March 2015
Published 29th April 2015

ABSTRACT

Chickpea is an important legume crop in Amhara region. The harvested grain of the crop could be stored for more than six months to look for better price and/or as insurance for food security. In the store *Callosobruchus chinensis* (L.) cause considerable damage to the grain. Noug oil and lemon oil at 4 ml/kg, powder form of neem seed and leaves, pepper seed and leaves, hag enea leaves, endod seed, eucalyptus leaves and Persian lilac seed and leaves at 4% w/w were evaluated for their efficacy against *C. chinensis*. Primiphos-methyl at the rate of 0.5 gm/kg was used as a standard check. Noug oil was the most effective botanical and statistically at par with primiphos-methyl in inducing adult mortality, reducing initial number of eggs laid on grains, number of holed grains, adult progeny emergence and weight loss. Among other treatments, lemon oil, neem seed and pepper leaves were promising. Botanicals afforded the protection of 59.2% to 99.2% over the untreated check. Noug oil and eucalyptus significantly delayed the developmental period of *C.*

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chinensis from 4.67 to10.3 days. The germination of grains treated with botanical was significantly higher than grains from the untreated check. Thus, botanicals proved promising and effective for the control of *C. chinensis* and can be used as a component of IPM.

Keywords: Botanical control; formulation; efficacy; Callosobruchus chinensis; chickpea.

1. INTRODUCTION

Pulses are highly valuable crops and are grown in a great number of varieties in most parts of the world. The seeds, if properly stored, remain edible for several years and are rich in protein [1] [2]. Chickpea is one of the most important pulse crops in many parts of the world including Ethiopia [3]. Since Ethiopia is considered as secondary center of diversity for chickpea, there is a large reservoir of variability in the populations. The country is the third largest chickpea producer in the world next to India and Pakistan [4,5]. In tropical Africa, Ethiopia is the leading country with 312,080 tons of chickpea production annually with a total area of 233,400 ha^{-1} [6]. However, the national average yield is very low which is attributed both by abiotic and biotic factors. The pod borer, *Helicoverpa armigera* (Hb.), cut worm (*Agrotis segetum* Schiff.) in the field, and Bruchids in the store are serious insect pests of chickpea in the country in general and Amhara Region in particular. Adzuki bean beetle, *Callosobruchus chinensis* (L.) is known to be prolific and rapid in breeding and can quickly cause a serious quantitative reduction as well as diminish nutritive value of stored grains.

Storage losses caused by Bruchids in the store are irreversible [7] which makes stored product pests to be more important when compared with field pests. The eggs of *C. chinensis* are laid on chickpea seeds and the larvae and pupae complete their development inside the grain. To decrease such problem farmers are using conventional pesticides which are proved to be effective. However, the use of chemical pesticides not only involves potential health hazards, residues, pollution, and contamination, but also beyond the financial capability of the farmers [8]. Hence, pest control strategies need to look for safer and affordable alternatives to chemical control.

Many experts reported the effectiveness of botanical powders and vegetable oils to control storage pests. Insect attacks on stored grains can be minimized by mixing grains with botanical powders or coating with vegetable oils [9,10]. The increased interest in most of the use of plant products lies in their safety to non-target animals and the environment.

Currently, the Ethiopian government identified some commodities that can bring a difference in the agricultural led industrialization economy policy of the country. Chickpea is one of the commodities selected for this purpose. Hence, this study was conducted to evaluate the efficacy of some locally available botanicals for the management of *C. chinensis*.

2. MATERIALS AND METHODS

2.1 Description of the Study Area

The study was carried out in Amhara Region, Enemay District, situated in the North Western part of the country. It is located 260 km away from Addis Ababa with an average altitude of 2,400 meters above sea level (masl) and known for high production of chickpea. The area has an average minimum and maximum temperature of 15 and 25°C, respectively.

2.2 Evaluation of Some Botanicals against *C. chinensis*

2.2.1 Rearing of *C. chinensis*

Culture of *C. chinensis* was established to obtain the same age group and required numbers of Bruchids for the experiment. The insects to be reared were collected from local chickpea stores. Chickpea grains to rear the Bruchids were obtained from local market. The grains were kept in a refrigerator at 0-4°C for three weeks to disinfest from Bruchid eggs and to kill larva and pupa within the grains [11]. The disinfested grains were kept in three plastic jars. Each jar (5 litters capacity) was half filled with 3 Kg chickpea grains. About 200 unsexed adults were released to each jar. The jars were covered with muslin cloths held in place with rubber bands. The newly emerged F_1 progenies were used for the experiment.

2.2.2 Preparation of botanicals and chickpea grains

Eight different types of botanicals were evaluated for their efficacy against *C. chinensis*. These were seeds and leaves of *Schinnus molle*, *Melia azedarach*, *Azadiracta indica*, seeds of *Phytolacca dodecandra*, leaves of *Hagenia abyssinica* and leaves of *Eucalyptus globulus*. Oils of *Guizotia abyssinica* and *Citrus lemon* were also tested. The details on dosages of botanicals used are given in Table 1.

All botanicals were collected from localities around the experimental site except *A. indica* seeds and leaves that were collected from Tony Farm, Dire Dewa in the eastern lowland part of Ethiopia. Lemon oil and *G. abyssinica* oil were purchased from local producers. The botanicals in the form of seed and leaves were collected and air-dried for 21 to 80 days under shade and crushed using pestle and mortar to get fine powder. 200 gram disinfested chickpea grains were placed in one litter capacity of plastic jars and stored at the experimental room for one week, to equilibrate with experimental conditions.

2.2.3 Treatments application

Each jar containing 200 grams of chickpea grains received 4% W/W in the case of powders and 4ml/kg in the case of oil treatments. The treatments were applied and mixed uniformly by shaking and rolling the jars containing the disinfested grains. An insecticide, primiphos-methyl (Actellic 2%) dust at the rate of 0.5 gm/kg of seed was used as standard check and untreated check was also used for comparison purpose. Subsequently, 20 newly emerged unsexed adult Bruchids were introduced to each jars. The trials were arranged in a completely randomized design (CRD) in three replications.

2.2.4 Data collected

2.2.4.1 Parent adult Mortality and initial number of eggs laid

Parent adult Bruchids mortality were counted and removed as well as number of eggs laid were recorded on the grains 1, 2, 4, 6, and 8 days after treatment application by taking 50 grains from each jar. On the tenth day after introduction of insects, all dead and alive Bruchids were removed from the jars as natural death is very likely after this date.

2.2.4.2 Emergence, mortality and eggs laid by progeny adults

Progenies were inspected 22 days after treatment. Data were recorded and counted on total adults emerged from each treatment. Numbers of dead and alive progeny adults at weekly interval were recorded. Data on fifty grains from each treatment with eggs, holes and normal grains were taken for 3 months of storage period. The data collected were used to determine the efficacy of the various botanicals against Bruchids.

2.2.4.3 Developmental period

Median developmental period in days was estimated based on the biology of the insect from the middle of oviposition period to the emergence of 50% of the F_1 generation.

Table 1. Botanical plants evaluated for their efficacy against *C. chinensis* on chickpea grains

Common name	Scientific name	Plant parts/ preparation	Dosage
Noug	*Guizotia abyssinica*	Oil	4 ml/kg
Lemon	*Citrus lemon*	Oil	4 ml/kg
Pepper	*Schinus molle*	Leaves	4% (w/w)
		Seed	4% (w/w)
Neem	*Azadiracta indica*	Seed	4% (w/w)
		Leaves	4% (w/w)
Hagenea	*Hagenia abyssinica*	Leaves	4% (w/w)
Endod	*Phytolaca dodecandra*	Seed	4% (w/w)
Eucalyptus	*Eucalyptu globules*	Leaves	4% (w/w)
Persian lilac	*Melia azedarach*	Leaves	4% (w/w)
		Seed	4% (w/w)
Primiphos-methyl	Actellic	2% dust	0.5 gm/kg
Untreated check	-	-	-

2.2.4.4 Percentage protection

Protective efficiency of each treatment was calculated using the following formula [12]:

$$Protection\ (\%) =$$

$$\frac{Total\ F1\ progeny\ in\ untreated\ check - Total\ F1\ progeny\ in\ treatment}{Total\ F1\ progeny\ in\ untreated\ check}\ X\ 100$$

2.2.4.5 Grain weight loss

On the 90th day of treatment, 500 grains were randomly taken from each treatment and the grains were separated into damaged grains with exit holes and undamaged seeds. Grains with and without exit holes were counted and weighed separately, and the resulting data were used to calculate the percentage weight loss. Percent weight loss was determined by the count and weigh method [13].

$$Percent\ weight\ loss\ =$$

$$\frac{(W\mu\ \times\ Nd) - (Wd\ \times\ N\mu)}{W\mu\ \times\ (Nd\ +\ N\mu}\ X\ 100$$

Where Wμ = weight of undamaged grains
Nμ = number of undamaged grains
Wd = weight of damaged grains
Nd = number of damaged grains

2.2.4.6 Effect of botanicals on germination of chickpea seeds

Germinations of the treated seeds were tested after 3 months of the experiment. Fifty randomly selected seeds from each jar were placed on moist filter paper in petri dishes. Seeds from each treatment were treated separately with sodium hypoclorite (Chlorox) 10% for 1 minute to eliminate fungal contamination and wash with potable water to remove chlorox and to save external damage of chickpea grains. The experiment was arranged in a completely randomized design with three replications. The seeds that germinated were noted 7 days after incubating. The percentages of germinated seeds were calculated accordingly.

2.3 Statistical Analysis

Analysis of variance was performed [14]. Appropriate transformation was done to normalize the data. Transformation systems were selected based on the nature of data recorded from different treatments. Accordingly, an arc sin transformation was used for parent adult mortality percentage. Square root transformation was used for data recorded on eggs laid by parent adult Bruchids per 50 grains, grains with egg(s), holes per 50 grains, percentage weight loss and germination. Number of eggs laid by progeny adults and normal grains per 50 seeds, total number of emerged progeny adults and protection percentage were performed by logarithmic transformation. One star (*), two stars (**) and three stars (***) were used to indicate arc sin, square root and logarithmic transformation, respectively.

All statistical procedures were done using SAS program 9.2. Mean separation was done using Tukey's studentized range test (HSD). All means are presented in the table by their back transformed values.

3. RESULTS AND DISCUSSION

3.1 Parent Adult Mortality of *C. chinensis*

One day after treatment application, noug oil and lemon oil caused 86.6% and 33.3% adult mortality, respectively. Noug oil resulted in significantly higher mortality than all other treatments except primiphos-methyl, which caused 96.6% mortality and was the most effective of all the treatments tested. The other treatments were found to be not significantly different from the untreated check.

Observations on two days after treatment application indicated that 100% adult mortality was caused by treatments of noug oil and primiphos-methyl, whereas lemon oil caused 70% mortality to Bruchids. All the powder forms of the botanical treatments showed lower adult killing capacity compared to noug oil; the mortality in neem leaves powder and untreated check was only 18.33% and 13.33%, respectively. Eucalyptus leaf powder caused 41.67% mortality and its efficacy was next to lemon oil. Statistically, with the exception of neem leaves, endode seed and Persian lilac seed and leaves, all other treatments killed the Bruchids significantly better than the untreated check. After four days of treatment, mortality caused by lemon oil was 90%. The mortality recorded in all other treatments ranged from 35% to 65% compared to 23.3% in the untreated check (Table 2).

Adult mortality observed after six days in lemon oil treatments was 100% like already recorded values to that of primiphos-methyl and noug oil. Persian lilac seed and leaves resulted in

significantly lower mortality than noug and lemon oils, but significantly higher than the untreated check. Neem seed, leaves of pepper, hagenea and eucalyptus gave adult mortality ranging from 81.67% to 88.33% while the mortality in the untreated check was 50.3% (Table 2).

After eight days of treatment application, the mortality in the untreated check was 70%, whereas excluding neem leaves and endod seed the mortality in all other treatments ranged between 93.3% - 100% (Table 2). As *C. chinensis* biology has indicated, the adults were short lived (6-10 days) and the mortality at this time of treatment is most likely natural death.

The results revealed that the effectiveness of noug oil 4 ml/kg was at par with the insecticide at two days after treatment and of lemon oil at six days after treatment. The two oils caused significantly higher mortality of *C. chinensis* over the other treatments starting from day one after treatment application. Leaf or seed powders of different botanicals gave variable mortality levels and were superior to the untreated check (Table 2).

The current finding is in agreement with various scholars who reported on the effectiveness of vegetable oils that cause high mortality to Bruchids. Previous workers reported that coating seeds with vegetable oils can prevent insect's attack on stored grains [15]. Vegetable oils are penetrated the egg of Bruchids, decrease oviposition and increase adult mortality [16]. At different concentrations, noug oil gave comparable results with primiphos-methyl (2%) dust in reducing longevity of *C. maculates* [17].

3.2 Eggs Laid by Parent Adult Bruchids on Chickpea Grains

The number of eggs laid by parent Bruchids introduced to the seed admixed with different treatments and untreated check indicated that the oviposition started on the first day after adults were introduced and, therefore, number of eggs was counted on 1, 2, 4, 6, and 8 days after treatment application.

One day after treatment application, *C. chinensis* laid significantly fewer numbers of eggs on seeds treated with primiphos-methyl and noug oil, which was 4 eggs and 5.33 eggs per 50 seeds, respectively, as compared to 19.67 eggs on the untreated check and 20.33 eggs on seeds treated with neem leaves. The mean number of eggs laid on lemon oil treated seeds was 9.33, which was significantly higher than that of noug oil, but significantly lower than other treatments. As indicated in Table 3, treatments with fast lethal action against adult Bruchids had shown less number of eggs. The results indicated that the treatments like neem or pepper leaves, pesian lilac leaves or seed powder were not significantly different from the untreated check one day after treatment application.

Table 2. Effectiveness of botanical treatments against adult's *C. chinensis* in chickpea grains

Treatment	Plant parts	Dosage	Mortality after treatment application (%) **				
			1 dat	2 dat	4 dat	6 dat	8 dat
Noug	Oil	4 ml/kg	86.60^{b}	100.0^{a}	-	-	-
Lemon	Oil	4 ml/kg	33.33^{c}	70.00^{b}	90.00^{b}	100.0^{a}	-
Pepper	Leaves	4% (w/w)	13.33^{d}	30.60^{c}	56.67^{cd}	85.00^{bc}	100.0^{a}
	Seed	4% (w/w)	10.00^{d}	31.67^{c}	58.30^{cde}	81.67^{bc}	98.30^{abc}
Neem	Seed	4% (w/w)	11.67^{d}	33.33^{c}	65.00^{c}	88.33^{b}	100.0^{a}
	Leaves	4% (w/w)	6.67^{d}	18.33^{d}	35.00^{ef}	58.30^{e}	86.67^{cd}
Hagenea.	Leaves	4% (w/w)	15.00^{d}	33.33^{c}	60.00^{cd}	85.00^{bc}	98.30^{abc}
Endod	Seed	4% (w/w)	8.33^{d}	20.00^{d}	35.00^{ef}	58.3^{e}	93.30^{bcd}
Eucalyptus	Leaves	4% (w/w)	18.33^{d}	41.67^{c}	56.67^{cd}	81.67^{bc}	100.0^{a}
Persian lilac	Leaves	4% (w/w)	13.33^{d}	21.67^{d}	41.67^{def}	70.00^{d}	98.30^{ab}
	Seed	4% (w/w)	10.00^{d}	25.00^{d}	46.67^{def}	71.60^{d}	96.67^{abc}
Primiphos-methyl	2%	0.5 gm/kg	96.67^{a}	100.0^{a}	-	-	-
Untreated check	-	-	6.33^{d}	13.30^{d}	23.30^{f}	50.30^{e}	70.00^{d}

*Means followed by the same letter(s) within a column are not significantly different at 1% Tukey's studentized range test (HSD); dat=Day after treatment Application, **= Arc sign transformation; Means presented in the table are back transformed values*

Eggs counted two days after treatment indicated that noug oil and primiphos-methyl with 6 and 4 eggs respectively were at par whereas lemon oil, leaves of pepper and eucalyptus showed 14.33 to 20 eggs were next to primiphos-methyl and noug oil. Neem leaves, Persian lilac leaves and seed showed lower efficacy against *C. chinensis* which is not significantly different from untreated check. Eggs laid by *C. chinensis* four days after treatment application showed that some botanicals were not significantly different from the untreated check. However, treatments such as primiphos-methyl and noug oil were significantly superior over all other botanicals as well as the untreated check 6 and 8 days after treatment application (Table 3).

3.3 Effect of Botanicals on Number of Emergence Holes and Damaged Grains of Chickpea Caused by *C. Chinensis* Progenies

The number of damaged grains in primiphos-methyl and noug oil treated grains was significantly lower compared to the untreated check. Significantly lower numbers of eggs were oviposited on primiphos-methyl, lemon oil and neem seed powder treated grains. All the treatments showed numerically lower number of eggs compared to the untreated check (Table 4). Lemon oil was effective compared to powdered botanical treatments in terms of adult mortality, but its effect decreased with time. [18] tried to control *C. maculatus*, *Sitophilus* spp and *Dermestus* spp by using lemon oil, mandarin and grape fruit peel reported that reduced oviposition, and high adult mortality, but decreased residual activity on the egg or larva produced by survivors.

The activity of lemon oil against the insect was found to be dependent on the time interval between the application and its effects, on the other hand, neem seed powder was also effective in reducing the number of eggs oviposited by the progeny. The present study was in agreement with [19] who indicated that, the higher dosage of neem seed powder (2-3% w/w) treated grains resulted in lower number of eggs (Table 4).

Untreated check showed significantly higher number of holed grains than other treatments except neem leaves and seed powder of pepper and persian lilac. The lowest numbers of exit holes were recorded in primiphos-methyl, noug oil, and neem seed powder treated grains in that order. An association between number of exit holes and number of eggs counted indicated highly positive correlation with 0.96 r value (Fig. 1).

As the result indicated in (Table 4), grain assessment on 50 randomly selected seeds per replication for three months revealed that primiphos-methyl, noug oil and neem seed powder treated seeds had resulted in lower number of damaged grains and grains with exit holes. On the other hand, treatments like seed of pepper as well as leaves of neem and Persian lilac were not significantly different from the untreated check.

Table 3. Effect of botanical treatment on the number of eggs laid by parent *C. chinensis* on chickpea grains

Treatment	Plant parts	Dosage	Initial number of eggs laid/ 50grains **				
			1 dat	2 dat	4 dat	6 dat	8 dat
Noug	Oil	4 ml/kg	5.3^{e}	6.0^{e}	5.3^{e}	5.33^{e}	5.3^{c}
Lemon	Oil	4 ml/kg	9.3^{d}	14.3^{d}	24.3^{d}	28.3^{d}	31.6^{b}
Pepper	Leaves	4% (w/w)	18.0^{ab}	20.0^{d}	32.6^{cd}	26.6^{d}	42.3^{ab}
	Seed	4% (w/w)	17.0^{bc}	29.0^{cd}	46.6^{bcd}	57.3^{bc}	50.3^{ab}
Neem	Seed	4% (w/w)	13.3^{bc}	28.0^{cd}	47.0^{bc}	44.6^{cd}	52.0^{ab}
	Leaves	4% (w/w)	20.3^{a}	45.0^{ab}	56.0^{ab}	74.0^{ab}	63.0^{a}
Hagenea	Leaves	4% (w/w)	12.3^{bc}	26.3^{cd}	34.0^{bcd}	43.0^{cd}	48.6^{ab}
Endod	Seed	4% (w/w)	11.6^{cd}	30.3^{cd}	54.6^{ab}	50.0^{bcd}	60.3^{a}
Eucalyptus	Leaves	4% (w/w)	11.6^{cd}	17.6^{d}	35.0^{bcd}	33.6^{cd}	51.3^{ab}
Pesian lilac	Leaves	4% (w/w)	18.0^{ab}	43.6^{abc}	45.3^{abc}	43.0^{cd}	61.0^{a}
	Seed	4% (w/w)	18.6^{ab}	38.6^{abc}	54.0^{ab}	74.6^{ab}	59.6^{ab}
Primiphos-methyl	-	0.5 ml/gk	4.0^{e}	4.0^{e}	4.0^{e}	4.0^{e}	4.0^{c}
Untreated check	-	-	19.6^{a}	50.3^{a}	64.6^{a}	92.0^{a}	83.3^{a}

*Means followed by the same letter(s) within a column are not significantly different at 1% Tukey's studentized range test (HSD); dat =Day after treatment application, **=Square root transformation Means presented in the table are back transformed values*

Table 4. Effect of botanicals on damage and oviposition by *C. chinensis* progenies on chickpea grains

Treatment	Plant parts	Dosage	Number of grains /50 seeds			
			**With egg	***Eggs (no.)	**Holed	***Normal
Noug	Oil	4 ml/kg	2.8^{c}	4.1^{c}	0.12^{d}	47.0^{a}
Lemon	Oil	4 ml/kg	18.6^{b}	27.8^{b}	2.95^{bc}	26.6^{bc}
Pepper	Leaves	4% (w/w)	23.2^{ab}	59.1^{b}	2.98^{bc}	23.3^{bcd}
	Seed	4% (w/w)	29.4^{a}	73.8^{b}	5.14^{ab}	15.3^{de}
Neem	Seed	4% (w/w)	20.8^{b}	39.2^{b}	1.82^{c}	26.8^{b}
	Leaves	4% (w/w)	29.2^{a}	78.1^{b}	5.18^{ab}	16.1^{de}
Hagenea	Leaves	4%(w/w)	23.8^{ab}	47.3^{b}	2.77^{bc}	24.9^{bc}
Endod	Seed	4%(w/w)	25.3^{ab}	55.7^{b}	3.62^{bc}	20.8^{bcd}
Eucalyptus	Leaves	4% (w/w)	25.0^{ab}	75.2^{b}	4.95^{bc}	15.6^{de}
Persian lilac	Leaves	4% (w/w)	29.6^{a}	66.9^{b}	4.12^{b}	20.9^{cd}
	Seed	4% (w/w)	28.9^{a}	79.1^{b}	5.14^{ab}	16.6^{de}
Primiphos-methyl	-	0.5 gm/kg	1.4^{c}	1.6^{c}	$-^{d}$	48.4^{a}
Check	-	-	29.8^{a}	104.3^{a}	7.26^{a}	13.4^{e}

*Means followed by the same letter(s) within a column are not significantly different at 5% Tukey's studentized range test (HSD); **=Square root transformation, ***=Logarithism transformation Means presented in the table are back transformed values*

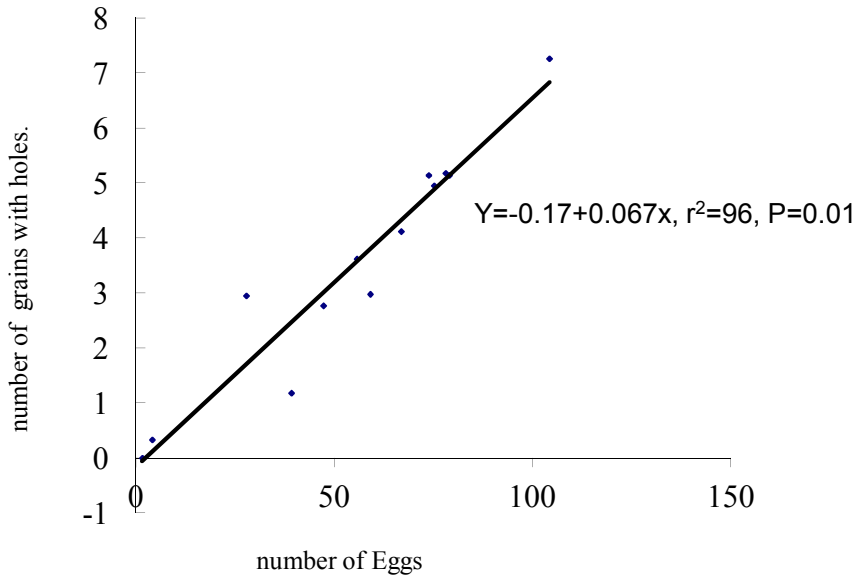

Fig. 1. Relationship between number of eggs laid by *C. chinensis* and holed chickpea grains

3.4 Effect of Botanicals on Progeny Adults Emergence and Developmental Period

The number of progeny adults emerged in the untreated check was significantly higher than all other treatments except neem leaves and pepper seed powder (Table 5). The numbers of emerged adults were lowest in the treatments of primiphos-methyl (3.33) and noug oil (5.33). Neem seed, lemon oil, leaves of pepper and hagenea were also effective in reducing adult progeny emergence that ranged from 114.67 to 178.3 compared to 426.33 in the untreated check (Table 5). Botanical treatments of leaves of eucalyptus and seed of endod and Persian lilac were also significantly superior to the untreated check. As the finding indicated that numbers of progenies and percentage weight loss was determined and a positive correlation with r value 85% was recorded (Fig. 2).

Table 5. The effect of botanicals on developmental period and *C. chinensis* emergence on chickpea grains

Treatment	Plant parts	Dosage	Number of emerged adults ***	Developmental period (days)
Noug	Oil	4 ml/kg	5.33^{d}	34.0^{a}
Lemon	Oil	4 ml/kg	114.6^{c}	27.6^{bc}
Pepper	Leaves	4% (w/w)	170.6^{bc}	26.33^{bc}
	Seed	4% (w/w)	311.3^{ab}	25.0^{bc}
Neem	Seed	4% (w/w0	133.6^{c}	26.3^{bc}
	Leaves	4%(w/w)	320.0^{ab}	27.67^{bc}
Hagenea	Leaves	4% (w/w)	178.3^{bc}	27.0^{bc}
Endod	Seed	4% (w/w)	210.3^{b}	25.3^{bc}
Eucalyptus	Leaves	4% (w/w)	243.3^{b}	28.3^{b}
Persian lilac	Leaves	4% (w/w)	235.6^{b}	26.0^{bc}
	Seed	4% (w/w)	303.0^{ab}	26.6^{bc}
Primiphos-methyl	-	0.5 gm/kg	3.3^{d}	33.3^{a}
Untreated Check	-	-	426.3^{a}	23.6^{c}

*Means followed by the same letter(s) within a column are not significantly different at 5% Tukey's studentized range test (HSD); ***=Logarithism transformation Means presented in the table are back transformed values*

Dales [20] tested 12 species of plant material as grain protectants of chickpea against *C. chinensis* and their report indicated that adult emergence to be the lowest from the seeds treated with oils.

Mean developmental period of *C. chinensis* varied from 23.67 days in the untreated grains to 34 days in noug oil treated grains (Table 5). All the botanicals except noug oil and eucalyptus failed to affect the developmental period as compared to the untreated check. Eucalyptus dust, primiphos-methyl and noug oil treatments caused significant prolongation of developmental period from 4.67 to 10.33 days than all the other treatments.The current findings are in agreement with [21,22] who reported that botanicals gave control of *C. chinensis* by reducing oviposition and delaying developmental period from 6 to 14 days may be by affecting the overall physiology of the insect.

3.5 Percentage Weight Loss and Germination

Percentage weight loss caused by *C. chinensis* on chickpea grains treated with different botanicals resulted in significantly lowest weight loss in the grains treated with primiphos-methyl followed by noug oil (Table 6). Weight loss in other treatments ranged between 0.7 to 4.7% compared to 6.23% in the untreated grain.

In the current studies percentage protection in chickpea grains treated with botanicals ranged from 56.2% (neem leaves) to 99.2% (primiphos-methyl). All the treatments tested were statistically superior and provided a better protection against *C. chinensis* compared to the untreated check. However, the results revealed that powdered form of neem leaves and Persian lilac seed were least effective against the Bruchids (Table 6).

The above findings are in agreement with [23] who tested six plant species to control *Accanthoscelides. obtectus* (Say.) on bean seeds and reported that all powdered plant materials showed better protection of Bruchids than the untreated check. [24] also reported the effect of botanical powders found lower number of progeny emergence of *Z. subfasciatus* in treated seeds.

Germination of chickpea seeds treated with botanicals was tested after 90 days of the experiment. All the botanical treated seeds showed significantly higher germination that ranged from 80.39% to 100% compared to the untreated check (66.67%). Noug oil and primiphos-methyl treated grains gave 100% germination followed by Lemon oil (98%) and neem seed (96.08%). Thus, the result indicated that chickpea seeds treated with botanicals after 90 days of application germinated well (Table 6).

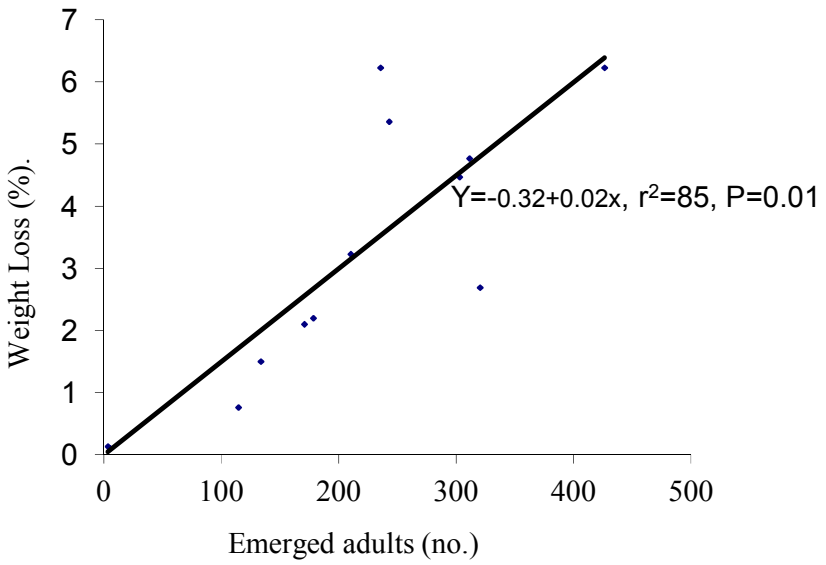

Fig. 2. Relationship between adult emergence and weight loss of chickpea grains infested by *C. chinensis*

Table 6. Effects of botanicals on weight loss, percent protection and viability of chickpea grains against *C. chinensis*

Treatment	Plant parts	Dosage	Weight loss (%)**	Protection (%)***	Germination (%)**
Noug	Oil	4 ml/kg	0.1^{e}	98.2^{a}	100.0^{a}
Lemon	Oil	4 ml/kg	0.7^{de}	86.7^{bc}	98.0^{a}
Pepper	Leaves	4% (w/w)	2.1^{cd}	89.7^{bc}	100.0^{a}
	Seed	4% (w/w)	4.7^{b}	83.0^{bc}	88.3^{bcd}
Neem	Seed	4% (w/w)	1.5^{d}	84.3^{b}	96.1^{ab}
	Leaves	4% (w/w)	5.3^{ab}	56.2^{f}	82.3^{cd}
Hagenea	Leaves	4% (w/w)	2.2^{c}	80.4b^{cd}	92.1^{ab}
Endod	Seed	4% (w/w)	3.2^{bc}	78.2^{cde}	86.2^{bcd}
Eucalyptus	Leaves	4% (w/w)	2.7^{bc}	69.1^{cde}	88.2^{bcd}
Persian lilac	Leaves	4% (w/w)	6.2^{a}	66.4^{ef}	80.3^{d}
	Seed	4% (w/w)	4.4^{b}	58.6^{f}	86.2^{bcd}
Primiphos-methyl	-	0.5 gm/kg	0.1^{e}	99.2^{a}	100.0^{a}
Untreated Check	-	-	6.2^{a}	-g	66.6^{e}

*Means followed by the same letter(s) within a column are not significantly different at 5% Tukey's studentized range test (HSD); **=Square root transformation, ***=Logarithism transformation Means presented in the table are the back transformed values*

According to [25] report, plant extracts offered protection against insect pests of stored rice and maintained seeds germinability. [26] observed that oil treatments of grains did not affect the germination or water absorption by maize and sorghum. The structure and composition of chickpea seed greatly differs from cowpea and haricot bean. Therefore, differential effect on germination to some extent may be attributed to the variation in the two types of commodities used in the studies.

4. CONCLUSION

Botanical dusts from *Azadiracta indica* seed and *Schinus molle* leaf and lemon oil were found to be the most effective treatments following primiphos-methyl and noug oil in reducing bruchid eggs and exit holes on chickpea grains. Moreover, primiphos-methyl and noug oil delayed developmental period. All the treatments except *Azadiracta indica* and *Melia azedarach* leaf were effective in preventing weight loss of

chickpea grains. No adverse effects on the viability of the grains were observed as the germination percentages were found to be significantly higher than the untreated check. Most of the botanicals are relatively, inexpensive, simple to apply, safe to the environment, animals and plants. They are easily avail to the farmers, adopted readily and integrated with other pest management practices. However, further research is needed on non-target effect and effective rate and frequency determination among others.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history.php?iid=1077&id=2&aid=9037