Journal of Agricultural Technology 2012 Vol. 8(3): 881-902
Available online http://www.ijat-aatsea.com
ISSN 1686-9141

Management of Adzuki bean beetle (*Callosobruchus chinensis* L.) using some botanicals, inert materials and edible oils in stored chickpea

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Tabu D., T. Selvaraj, S.K. Singh and N. Mulugeta (2012) Management of Adzuki bean beetle (*Callosobruchus chinensis* L.) using some botanicals, inert materials and edible oils in stored chickpea. Journal of Agricultural Technology 8(3): 881-902.

The present study was carried out to evaluate the efficacy of some botanicals, inert materials and edible oils against Adzuki bean beetle, *Callosobruchus chinensis L.* in stored chickpea. Four botanicals viz., *Milletia ferruginea* (Hochst) Backer (seed powder), *Azadrachta indica* A. Juss. (seed powder), *Datura stramonium* L. (seed and leaf powder), *Chenopodium ambrosioides* L. (leaf powder) , three edible seed oils viz., *Brassica juncea* L. , *Linum usitatissimum* L., *Guizotia abyssinica* L. and two inert materials such as wood ash and sand were used for the control against Adzuki bean beetle on stored chickpea. Malathion 5% dust and an untreated control check were included for comparison. The botanicals, inert materials and edible seed oils were caused high adult mortality, reduced egg laid, reduced F1 progeny emergence, low seed damage and low seed weight loss without affecting seed germination in stored chickpea grains .Seed powder of *A .indica* at the rate of 20 g kg^{-1} and the leaf powder of *C. ambrosioides* at the rate of 40 g kg^{-1} caused high adult mortality next to Malathion 5 % dust at the rate of 0.5g kg^{-1}, while the other botanicals, inert materials and the oils showed better performance than the untreated check. *B. juncea*, L. *usitatissimum* and *G. abyssinica* seed oils applied at the rate of 5.0 ml k g^{-1} resulted in high reduction in progeny emergence. Likewise, sand and wood ash at all the levels tested, gave effective inhibition in F1 progeny production. The biology of *C. chinensis* was also studied on chickpea and the results showed that 6 days of oviposition period, 49.5 percent of average number of eggs laid, 91.5 percent of eggs hatched, 79.5 percent of average number of adult emergence, 25.3 days of developmental period, 9.6 and 7.5 days of adult longevity for male and female beetles respectively. These results indicated that botanicals, inert materials and edible seed oils can effectively control Adzuki bean beetle, *C. chinensis* in stored chickpea.

Key words: Adzuki bean beetle, Callsobruchus chinensis, Botanicals, Inert materials, Edible oils, Stored Chickpea, Management.

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Introduction

Pulse crops have been cultivated and consumed in large quantities in Ethiopia. The major varieties of pulses grown in Ethiopia are the horse beans, chickpeas, haricot beans, lentil, dry peas and mung bean. It is providing an economic advantage to small farm holdings as an alternative source of proteins, cash income, and food security (CSA, 2002). Chickpea, *Cicer areitinum L.* is the third most important legume in the world. Ethiopia is the largest producer of chickpea in Africa accounting for about 46% of the continent‘s production during 1994-2008. It is also the seventh largest producer worldwide and contributes about 2% to the total world chickpea production (Joshi *et al*. 2000).

Chickpea is the second most important legume produced after faba bean in Ethiopia. The total annual average chickpea production is estimated at about 173 thousand tones (Menale *et al.* 2009). It is grown under rain fed conditions in areas receiving 350-600 mm annual rainfall. It is an important source of protein in human diets and plays a significant role in farming system (Tibebu, 1983). In Ethiopia, the average annual growth rate in area and production of chickpea showed that cultivated area and production increased by 2.1% and 7.6%, respectively. However, the national average yield of this crop has remained very low, less than one ton per hectare. This is mainly due to biotic and abiotic factors (Demisie, 2000). Among the major biotic factors contributing to pre and post harvest losses are the insect pests, fungi, birds and mites. In Africa, storage pests are estimated to cause 10 to 15 % losses and 23 to 80 % damage during 2–4 months of storage (FAO, 1994). In Ethiopia, a loss of 19.6 percent is recorded due to insects and moulds on pulses (Boxall, 1998). Especially small scale farmers loose a sizeable proportion of their harvested pulses which estimated to be 10 to 20 % for 3 to 6 months of storage (Khare, 1994). Among the insect pests of stored grain legumes, *Callosobruchus chinensis*, *Callosobruchus maculatus, Acanthoscelides obtectus,* and *Zabrotes subfasciatus* are the most important (NRI, 2003). These insects are belonged to the order Coleoptera and family Bruchidae, which are rapid in their breeding and can quickly cause a serious reduction in weight and the value of stored seeds (NRI, 2003).

Although chemical insecticides like fumigants and dusts are effective for the control of Bruchids, but it is not applicable at farm level because farmer’s storage structures are not air tight. It is also not safe to mix insecticides with food grain for protection against insects (Bekele *et al.* 1995). Under such circumstances, alternative methods like, the use of inert dusts, edible oils and plant products that could be easily used by farmers need to be considered (Isman, 2008). In parts of Uganda and Tanzania, 39 and 28% of farmers, respectively, were reported to admixing fine sand, clay dust or wood ashes with their common stored beans (Giga *et al.* 1992). In Eritrea, mixing of small sized grain and fine sand was found to be effective in controlling insect pest's food grain storage (Adugna *et al.* 2003). But in Ethiopia wood ash was found to have the potential for use on stored sorghum (Adane and Abraham, 1996). Using vegetable oils, essential oils and mineral oils by rural farmers in sub- Saharan Africa for the control of durable stored-product pest is in ancient practice (Baier and Webster, 1992). In Ethiopia, several edible and non edible oils have been tested as stored grain protectants against different insect pests.

The use of locally available plant materials to manage insect damage in stored foodstuffs is also a common practice in developing countries (Schmutterer, 1990). Plant products are widely used by small-scale farmers in different parts of the world to control pests. Botanicals have long been known by many tropical farmers and used for many years traditionally to control stored insect pests (Araya and Emana, 2009). In Ethiopia, farmers used different botanicals to protect their maize grain from insect infestation (Abraham, 1997; Emana, 1998) while the type of botanicals used varied from locality to locality. In spite of the importance of stored product insect pest, not much attention has been given to research on this insect pest and their control using locally available botanicals, edible oils and inert materials in West Showa Zone, Ethiopia. Therefore, this study was carried out to evaluate the efficacy of locally available some botanical plant parts powder, edible oils and inert materials for the management of Adzuki bean beetle, *Callosobruchus chinensis* L. in stored chickpea and also to study the biology of *C. chinensis* under laboratory condition.

Materials and methods

Rearing of Adzuki bean beetle

The laboratory experiment was conducted at the Department of Plant Sciences laboratory, Ambo University, Ambo, Ethiopia. Laboratory culture of Adzuki bean beetle was established to supply the same age group of bruchids for the experiment. The insects and the local chickpea cultivar named "Abashee" were obtained from farm stored chickpea in Ambo. The seeds were used for a rearing media following the method of Beck and Blumer (2010). Chickpea seeds were placed in plastic bags and kept in a refrigerator for four days at – 5^0C to disinfested chickpea seeds to eliminate any *infestation*. Then the seeds were removed from the refrigerator and kept for six days to achieve hygroscopic equilibrium. The disinfested chickpea seeds were kept in three plastic jars each having 2.5 kg seeds. About 150 adults' unsexed bruchids were released in each jar. The jar openings were covered with muslin clothes and placed on the bench at the room condition at 22^0C to 25^0C and 50- 65 % relative humidity (Abebaw, 2008). To maintain the temperature, an adjustable (60 watt) light lamps were used over the carton for 24 hours for 39 days. The relative humidity was maintained by regularly keeping a piece of wet jute sucks and the moist soil in the room. The newly emerged adults were used for the experiment.

Collection and preparation of botanicals, inert materials and edible seed oils

Four botanicals, viz., Milletia ferruginea (Birbra), Datura stamonium (Thorn apple), Azadirachta indica (Neem), Chenopodium ambrosioides (Mexican tea),three edible seed oils viz., Brassica juncea (Mustard), Linum usitatissimum (linseed), Guizotia abyssinica (Noug) and two inert materials, such as wood ash and sand were used for the experiment. Details of the treatments and concentrations are given in Table 1. The seeds and the leaves of the plants were dried under shade and crushed into fine powder using an electric grinder. The plant powders and the inert materials were kept in plastic bags and the oils were kept in vials for few days until use.

Table 1. List of botanicals, inert materials, edible seed oils and their concentration levels evaluated against *C. chinensis* on stored chickpea

Treatments	Common Name	Scientific name and plant parts used	Concentration *
T1	Neem	*A. indica* (seed powder)	1,1.5, 2 % w/w
T2	Birbira	*M.ferruginea* (seed powder)	4, 5, 6 % w/w
T3	Thorn apple	*D. stramonium* (seed powder)	4, 6, 8 % w/w
T4	Thorn apple	*D. stramonium* (leaf powder)	4, 6, 8 % w/w
T5	Mexican tea	*C.ambrosioides* (seed powder)	2, 3, 4 % w/w
T6	Mustard	*B. juncea* (seed oil)	0.2, 0.3, 0.5 % v/w
T7	Linseed	L. usitatissimum (seed oil)	0.2, 0.3, 0.5 % v/w
T8	Noug	G. abyssinica (seed oil)	0.2, 0.3, 0.5 % v/w
T9	Wood ash	------	3, 6, 9 % w/w
T10	Sand	------	3, 6, 9 %w/w
T11	Malathion 5%	Dust	0.05 % w/w
T12	Untreated check		

*w/w - weight by weigh, v/w – volume by weight

Evaluation of botanicals for the control of C. chinensis

The treatments were thoroughly mixed with chickpea seeds by shaking and rolling the jars to ensure uniform coating of the seeds. Untreated check and treatments with synthetic insecticide (Malathion 5% dust) were included for comparison. Twenty newly emerged 1-2 days old (10 male and 10 female) adults of *C chinensis* were introduced into each jar containing treated chickpea. They were sexed using the serration of the antennae described by Hill (1990).The body size also used as a parameter to identify the sexes (Teshome, 1991).

The experiment was arranged in a Complete Randomized Design (CRD) with three replications and placed at the room condition where the rearing was conducted and the same procedures were followed to maintain the temperature and relative humidity conditions. The temperature and relative humidity of the room was recorded daily until the end of the experiment to see the daily fluctuation and to maintain the required level.

Data collection and analysis: Adult mortality and oviposition

Adult mortality counts in each treatment of the jars were recorded at 1, 2, 3 and 4 days after treatment application. At each counting, dead bruchids were removed. Four days after treatment application, number of eggs/ 100 (randomly selected seeds) were recorded. Ten days after treatment application, all dead and live bruchids were removed as natural mortality which was expected after this date (Hill, 2002). The seeds were kept under the same condition for the emergence of progeny.

Progeny emergence

The plastic jars containing treated seeds were inspected for the emergence of F1 progeny 24 days after treatment application, because of *C. chinensis* needs about 22-25 days to complete its life cycle (Hill, 2002). The emerged F1 progeny was counted and removed. The observations continued for 90 days.

Chickpea damage and weight losses

Ninety days after treatment application, 100 seeds were taken randomly from each jar and were separated .The seeds were separated into damaged and undamaged categories. The damaged and undamaged seeds were counted and weighed. Seed weight loss was estimated by using count and weigh method (Gwinner *et al*., 1996).

$$\text{Weight loss (\%)} = \frac{(\text{Wu} \times \text{Nd}) - (\text{Wd} \times \text{Nu})}{\text{Wu} \times (\text{Nd} + \text{Nu})} \times 100$$

Where, Wu = Weight of undamaged grain, Wd = Weight of damaged grain, Nu = Number of undamaged grain, Nd = Number of damaged grain

Protection percentage

Ninety days after treatment application, the total number of progeny in each treatment was counted. The effectiveness of the treatments against bruchids was calculated using the formula developed by Eighar *et al.* (1987).

$$\%\ \text{Protection} = \frac{(\text{Total F1 progeny in untreated control}) - (\text{Total F1 progeny in treatment})}{\text{Total F1 progeny in untreated control}} \times 100$$

Percentage of seed germination

Ninety days after treatment application, germination test was carried out. 100 seeds were randomly taken from each replication of the different treatments and washed with 5% sodium hydro chlorite to check fungal contamination. The selected seeds were placed on moist filter paper in Petri dishes and kept for seven days on laboratory bench at room temperature. The number of germinated seeds were recorded. Analysis of variance of the data in each parameter was performed using SAS 9 Soft ware Computer Programs. The means were separated by New Duncan's multiple range test (New DMRT).

Biology of C. chinensis

A pair of 1-2 day old *C. chinensis* (1 male and 1 female) was transferred from the rearing colony to a plastic jar containing 10 undamaged and disinfested chickpea seeds. The jar was closed with muslin cloth and then placed on a laboratory bench at room temperature of 22°C to 25°C and 50 to 65 % RH. The jars were replicated five times and the seeds in the jars were changed daily. These removed seeds were kept in separate jars for the eggs to develop.

Observations were made daily and every event, such as the number of eggs laid emergence of adults, incubation, larval period and their mortality were recorded. The eggs were allowed to develop and as soon as the adult emergence began, the jars were examined, and the newly emerged adults were sexed, counted, and removed. The number of days from the start of egg laying to adult emergence was recorded for each adult. The date on which the egg laying started and terminated and the adults died were taken for the determination of the duration of oviposition and adult's longevity. Two weeks after the begging of adult emergence, the experiment was discontinued to eliminate the possibility of including second generation adults as used by the method of Teshome (1991) and Fatemeh *et al.* (2009).

Results and discussions

Effect of botanicals, inert materials and edible oils on percent mortality

The mortality level of adult *C chinensis* exposed to various dosages of plant parts powders, inert materials and edible oils during 1-4 days are presented in Table 2. The results showed that the significant differences among the treatments in causing mortality. One day after treatment application, *A. indica* seed powder at the rate of 20 g^{-}kg^{-1} and *C. ambrosioides* leaf powder at the rate of 40 g^{-}kg^{-1} induced 80 and 65% adult mortality respectively. The lowest rates of mortality 11.67 and 13.34% were recorded in G. *abyssinica* oil and *B. juncea* oil each at the rate of 2ml kg^{-1}, respectively followed by sand 11.67% and wood ash 11.67 % each at the rate of 30g kg^{-1}. Malathion 5% dust at the rate of 0.5gkg^{-1} caused 95% mortality after one day treatment application. Three days after treatment application, *A. indica* seed powder at the rate of 20 g kg^{-1} and *C. ambrosioides* leaf powder at the rate of 40g kg^{-1} were superior to the other treatments and caused 92 and 90% mortality, respectively, while the mortality in the untreated check was only 15%. Four days after treatment application, A. *indica* seed powder at the rate of 20 g kg^{-1} and *C. ambrosioides* leaf powder at the rate of 40g kg^{-1} caused 93.67 and 91.67 % adult mortality respectively, while, the mortality in the other botanicals ranged from 45 to 83.34%.Sand and wood ash at the dosage of 90 g kg^{-1} caused 66.67 and 70% adult mortality respectively. G. *abyssinica* and *B. juncea* oil at the rate of 5ml kg^{-1} caused 76.67 and 80 % adult mortality respectively which was also significant when compared to the untreated check.

Table 2. Effect of botanicals, edible seed oils and inert materials on mortality of adult *C. chinensis*

Treatment	**Mean percent mortality (days)**				
	Dosage %	**day- 1**	**day-2**	**day-3**	**day-4**
A. indica (seed powder)	1.0	40^{de}	53.34^{efghi}	70^{bcde}	84.34^{abcd}
	1.5	51.67^{dc}	71.67^{cde}	85^{abc}	91.67^{ab}
	2 .0	80^{bcd}	91.67^{ab}	92^{ab}	93.67^{ab}
M. ferrugginea (seed powder)	3.0	15^{fghij}	33.34^{ijkml}	45^{ghijk}	56.67^{hijkl}
	4.0	31.66^{defgh}	51.57^{efghij}	58.34^{defg}	70^{cdefgh}
	5.0	40^{de}	60^{efg}	68.34^{bcde}	83.34^{abcd}
D. stramonium (seed powder)	4.0	$10.^{ij}$	25^{lm}	33.34^{kj}	45^{kl}
	6.0	13.34^{ghij}	31.67^{jklm}	$40^{.hijk}$	51.67^{ijkl}

	8.0	25^{efghi}	55^{efgh}	45 ^{ghijk}	61.67^{fghijk}
D. stramonium (leaf powder)	4.0	15 ^{fghij}	26.67 ^{lm}	33.3^{4kj}	45^{kl}
	6.0	31.67^{defgh}	40^{ghijklm}	48.34^{fghijk}	56.67^{hijkl}
	8.0	35def	43.34^{ghijkl}	55^{efghi}	63.34^{efghij}
C.ambrosioides (leaf powder)	2.0	33.34^{defg}	55^{efgh}	73.34^{bcd}	86.67^{abc}
	3.0	51.67^{dc}	80^{bcd}	85^{abc}	90^{b}
	4.0	65 ^{bc}	88.34^{abc}	90.^{ab}	91.67^{ab}
B. junceae (seed oil)	0.2	13.34^{ghij}	26.67^{lm}	38.34^{ijk}	56.67^{hijkl}
	0.3	25^{efghi}	40^{ghijklm}	50^{fghij}	70^{cdefgh}
	0.5	40^{ed}	68.34^{def}	76.67^{bc}	80 ^{bcde}
L. usitatissmum (seed oil)	0.2	18,34^{fghij}	30^{klm}	50^{fghij}	45^{kl}
	0.3	40^{ed}	55^{efgh}	61.67^{cdefg}	70 ^{cdefgh}
	0.5	41.67^{ed}	56.67^{efg}	63.34^{bcde}	75^{cdefg}
G. abyssinica (seed oil)	0.2	11.67^{hij}	30^{lmk}	50^{fghij}	63.34^{efghij}
	0.3	33.34^{defg}	50 ^{fghijk}	61.67^{cdefg}	71.67^{cdefgh}
	0.5	43.34^{ed}	56.67^{efg}	70 ^{bcde}	76.67^{cdef}
Wood ash	3.0	11.67^{hij}	21.67^{m}	31.67^{k}	45^{jkl}
	6.0	23.34^{efghi}	35^{hijklm}	48.34^{fghijk}	58.34^{ghijkl}
	9.0	35^{def}	48.34^{ghijklm}	56.67^{defgh}	70 ^{cdefgh}
Sand	3.0	11.67^{hij}	26.67^{lm}	33.34^{kj}	43.34 ^{l}
	6.0	28.34^{efghi}	33.34^{ijklm}	48.34^{fghijk}	55^{hijkl}
	9.0	35^{def}	48.34^{ghijklm}	58.34^{defg}	66.67^{defghi}
Standard check/Malathion dust	0.05	95^{a}	100^{a}	100^{a}	100^{a}
Untreated check	-	0^{j}	0 ^{n}	15 ^{l}	25 ^{m}
C.V. (%)		32	22.3	16	13

Means followed by the same letter with in a column are not significantly different from each other at P< 0.05% (DMRT)

Generally it was observed that adult mortality increased with the increased dose and with time after treatment. The cumulative mortality of beetles after four days treatment application showed that botanicals, inert materials and the edible oils appeared to be more effective when compared with the untreated control.

As far as botanicals are concerned many researchers have reported the insecticidal activities of these plant derivatives against different types of storage insect pests that may be used in the control of storage insect pests. Tebekew and Mekasha (2002) reported that *M. ferruginea* seed powder against *C. chinensis* provides complete protection of stored chickpea for six months in the laboratory. Similarly, Bekele (2002) reported that rotenone is one of the dominant compound in the seed and stem bark of *M. ferruginea* and also a well known botanical insecticide that caused higher mortality to *S. zeamais*.

A. indica kernel powder mixed at the rate of 5 gm/ 100 g faba bean seed provided the best protection in faba bean cultivars (Ram *et al*. 2000). Jilani and Saxena (1988) also reported that in a warehouse trial conducted in the

Philippines, Rice grain treated with 0.05 to 0.1% neem oil and stored for 8 months contained significantly less *T. castaneum* adults than in the untreated control. Tapondjou *et al*. (2002) observed the dry leaves of *C. ambrosioides* mixed with grains at different dosages ranging from 0.05– 0.80% (w/w) for *C. chinensis*, and *C. maculate* and the dosage of 0.4% killed more than 60% of all the bruchids 2 days after treatment. The present laboratory trial indicated that, the leaf and seed powders of the tested plant materials were found effective in controlling *C chinensis* when compared to the untreated check, but their efficacies were less when compared to the pervious reports. This difference could be due to the environmental conditions and other factors under which the experiment was conducted.

As it was indicated above, the tested sand and wood ash powders showed significantly highest mortality when compared to the untreated check. This results were in line with the previous works who suggested that powdered inert dusts (clay, sand and earth) have been traditionally used as a control measure by applying a thick layer of dust on the top surface of a grain bulk and mixed with the grain, they will fill the spaces between the grain kernels and thus prevent movement and dispersal of insects inside the stored grain (Inge, 2004). In an experiment of stored maize protection from the weevil *S. zamias* (Girma *et al.,* 2008), found that the application of wood ash at the rate of 2.5, 5 and 10 % w/w against the maize weevil showed 98.7 % adult mortality after 7 days of application and F1 progenies were significantly lowered than that of the control. Mesele (2003) tested saw dust, coffee husk and wood ash at 10, 15, 20 and 30 w/w against the maize weevil of grain moth and he found that wood ash and coffee husk treatments were superior to the untreated check. Adugna (2006), also found that wheat grain treated with ash, sand and insecticides significantly lower percentage of grain damage and weight loss by *Sitophilus, Sitotroga cerealella* and *Tribolium* spp. Muluembet (2003) also tested the role of wood ash and found that 30% w/w provide effective control of bruchids on cowpea at Gambella, Ethiopia.

The edible oil of *G abyssinica, B. juncea* and *L. usitatissimum* (at the highest concentration) showed significantly the highest mortality when compared to the untreated check. It was even effective at the lowest concentration although the efficacy is gradual in killing the adult bruchids. In general, these results suggested that it is possible to control *C. chinensis* effectively by using edible oils though there appeared variation of efficacy due to concentration and exposure period. According to Inge (2004), oil may also kill the insect eggs. When the egg is already present at the surface of the seed or inside the seed, the oil coating prevents gaseous exchanges. So the larvae inside the egg or the kernel will die due to lack of oxygen. Abraham (2003) compared oils of maize, sunflower, *G. abyssinica* and *A. indica* against the maize weevil at Bako, Ethiopia. He obtained effective control of the pest with all oils at the rates ranging from 5 to 10 ml kg^{-1}. Similarly, Talekar (1976) also examined that, coating seeds with 5-10 ml of vegetable oils per kg of seeds, protect stored seeds from bruchid infestation. Mixing of soya bean or ground nut oil at the rate of 2-3 ml/100 g seeds gave mung bean considerable in bruchid infestation for up to two months. Khalequzzaman *et al*. (2007) also tested *B. juncea* oil at the concentrations of 0.5, 1 and 2% on pigeon pea against pulse beetle (*C. chinensis* L.) and resulted in 100% mortality within six days.

Effect of botanicals, inert materials and edible oils on oviposition of C. chinensis

There were significant differences (P<0.05) between treatments in reducing oviposition due to the effect of botanicals, inert materials and edible oils. One day after treatment of application, the lowest eggs were recorded on chickpea grains treated with B. juncea oil treatment at 5 ml kg^1 and C. ambrasioides leaf powder at the rate of 20gkg-$^{-1}$ which were 4, 5 and 7 eggs per hundred seeds, respectively. *D. stramonium* leaf powder treatment at the lowest dosage 40 g kg^{-1}, and *M. ferruginea* at the rate of 30 g kg^{-1} showed the highest number of eggs laid which ranged from 24 to30.33 eggs (Fig. 1). This treatment even showed significantly better effect in reducing oviposition of the insect than that of untreated check with 57 eggs count per hundred seeds. All treated materials showed better effect (5 to 30 eggs/100 seeds) in reduction of egg counts when compared with egg counts from untreated seeds. Generally all the botanical plant part powders, inert materials and edible oil treatments induced significant reduction in oviposition by *C. chinensis* when compared to the untreated check(Figs.1-3). This study indicated that the plant materials added to the chickpea seeds vary among themselves interims of the extent to which they affected oviposition. *C. ambrosioides* and *B. juncea* oil at the highest dosage were found superior to other treatments in reducing oviposition (Fig.1-3).

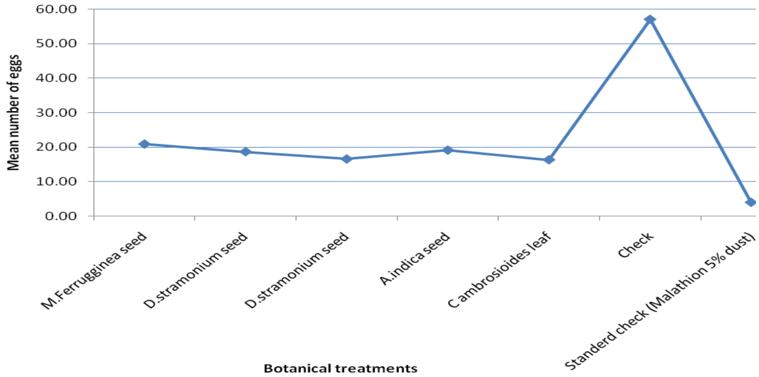

Fig. 1. Mean number of eggs/100 seeds of chickpea treated with different botanicals

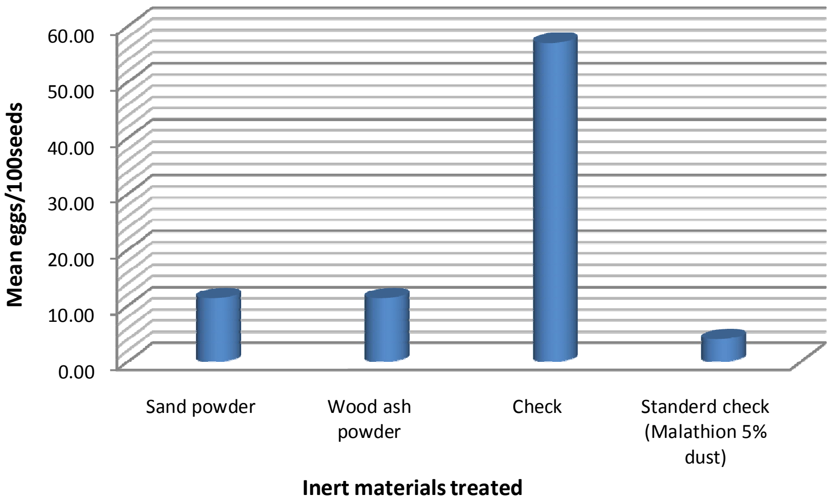

Fig. 2. Mean number of egg counts per 100 seeds of chickpea treated with inert materials

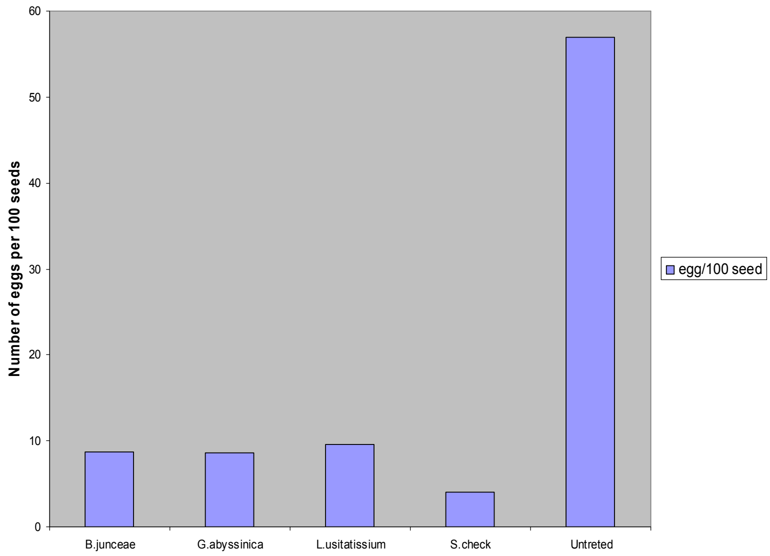

Fig. 3. Mean number of eggs per 100 seeds of chickpea treated with different edible seed oils

Various authors and researchers reported about the effectiveness of dry grounded leaf and seed powders of different plant materials elsewhere at different times. Kyamanyma (1999) tested two botanicals namely, *Chenopodium* spp. and *Tagetes* spp. against *A. obtectus* and found adverse effect on the oviposition and population density. The powdered leaves of aromatic mint completely suppressed oviposition of *Z. subfasciatus* at the rate of 2 % w/w. Muluemebet (2003) carried out the laboratory experiment to evaluate *C. ambrosioides* powder and other treatments including plant oils and inert dusts showed that *C. ambrosioides* seed and leaf powder at higher dose of 3 to 6% w/w significantly reduced oviposition, egg hatchability and adult emergence of *C. maculatus* on cow pea and the seed powder at the rate of 3% w/w as gave better protection especially when applied before infestation and the reports concluded that the reduction in oviposition in the treated grains could be resulted from increased adult mortality and ovicidal properties of the tested leaf and seed powders.

Ofuya (1991) also suggested that weakening of adults by botanical powders may make them lay fewer eggs than the normal ones. Moreover, edible oils of plant materials admixed to bean seeds exhibited ovicidal properties of adult *C chinensis*. Regarding the tested inert materials (wood ash and sand), as it was mentioned above they were significantly better than that of the untreated check in reducing oviposition. It has been suggested by Adane and Abraham (1996) free movements of the adults for oviposition is prevented by the ash filling in the inter-granular space as a result of this, egg lying and larval development of the beetles could be hampered and they are also forced to deposit their entire stock of eggs on relatively few grain kernels or beans. The authors have also concluded that wood ash was found to have the potential for use on stored sorghum. Adugna *et al.* (2003) also reported that the ash dust that reduces the relative humidity of the storage condition could also dry the grain surface as a result of this, egg lying and larval development of the beetles could be hampered. In the present study, the effectiveness of edible oils when applied to bean seeds clearly indicated the reduction of oviposition by *C. chinensis* . Khaire *et al*. (1992) suggested that vegetable oils affect egg laying as well as embryo and 5, 1 and 2% on pigeon pea against pulse beetle and resulted in 100% mortality within six days. Similarly, Inge (2004) reported that vegetable oils cause the eggs and larvae to die before they can bore into the seed properties. The present study findings regarding the use of edible oils in reducing oviposition by *C chinensis* is in line with the earlier findings.

Effect of botanicals, inert materials and edible oils on Progeny emergence and percent protection

Table 3 showed F1 progeny production and percent inhibition of *C. chinensis*. There were significant differences among all treatments in affecting progeny emergence and percent protection. Higher number of progeny (320 beetles) emerged from the untreated check. Low numbers of F1 progenies emerged from seeds treated with ash and sand. High number of F1 progenies were emerged from chickpea seeds treated with *A. indica, M. ferruginea* and, *D. stramonium* seed powders at the dose of 10, 30 and 40 g kg^{-1} respectively. Progeny production of the beetle was almost inhibited in chickpea seeds that when treated with malathion 5% dust. Treatments of ash and sand caused more than 90% reduction in F1 progeny production of *C chinensis.* Alternatively, more number of F1 progeny and less percent inhibition of reproduction of C.*chinensis* were recorded in grains treated with the lower dose of 20g kg^{-1} of *C. ambrosioides* leaf powder and 10 g kg^{-1} of *A. indica* seed powder treatments.

The other treatments also resulted in significantly higher protection when compared to the untreated check. In general, higher the doses of botanicals (plant parts), inert materials and edible oils, the lower the percentage progeny emergence and the higher the percent reduction in adult emergence. In addition to causing high adult mortality, the botanicals, inert dusts and edible oils reduced emergence of F1 progenies. The reduction in adult emergence could either be due to the larval mortality or reduction in the hatching of the eggs. It has been reported by Jilani *et al.* (1988) that the larvae which hatch from the eggs of *Callosobruchus* species must penetrate the seeds to survive. However, the larvae are unable to do so unless the eggs are firmly attached to the seed surface. The results of the present study is agreed with those of other works who have previously reported that plant powders reduces life span and oviposition of bruchids directly or indirectly and delayed also insecticidal effect. Regnault-roger and Hamrounil (1993) reported that the delayed effect operates indirectly by inhibiting reproduction and development oviposition, larval penetration into the seed and adult emergence. Similarly, Ahmed and Ahmad (1992) also indicated that *C. maculates* did not oviposition seeds that treated with 3% neem seed powder. Neem seed powder mixed with stored maize effectively reduced the progeny production of *Sitophilus oryzae* by disturbing larval development and adult fecundity. *M. ferruginea* leaf and seed powder at 5% w/w on Adzuki bean beetle gave complete protection for six months and deterred egg laying (Bekele, 2002). Giga *et al.* (1992), reported the efficacy of inert dusts in reducing adult emergence in parts of Uganda and Tanzania and confirmed that farmers who were admixing fine sand, clay dust or wood ashes with their common beans hindered the activities of newly hatched adults. Dratnasekera and Rhsrajapakse, (2009) also reported that *B .juncea* was effective against the pulse beetle, *C. maculatus*. In the Present study lower rate of oviposition and significant reductions of adult emergence was observed.

Similar with the reports that made by Ahmed *et al.* (1993) found that neem and sesame oils completely inhibited adult emergence and approved to be the most promising as a seed protectants. In general, the results of the present study showed that powders of plant materials, inert dusts and edible oils were found effective in reducing adult emergence of *C. chinensis* when compared to the untreated check.

Table 3. Effect of botanicals, inert materials and edible seed oils on progeny emergence, percent protection, % of seed damage, % seed weight loss and % 0f seed germination of stored chickpea

Treatments	Dosage %	No of Progeny emerged	Percent protection	% of seed damage	% of seed weight loss	% of Seed germination
A. indica (seed powder)	1.0	70.00 ab	78.00i	3.00ghi	2.00def	99.66a
	1.5	49.67 b	84.40k	1.80hij	0.46ghij	99.66a
	2.0	42.00 bdc	86.85kji	1.33kji	1.45 efg	100.00a
M. ferrugginea (seed powder)	3.0	47.00bc	85.30jk	9.33 b	3.33 b	100.00a
	4.0	38.33 bcd	87.96hijk	7.33 cd	2.33 cde	100.00a
	5.0	28.00 defgh	91.25abcdefgh	4.83 ef	1.43 efg	98.33a
D. stramonium (seed powder)	4.0	46.67 bc	85.40jk	9.00 b	3.00 cd	100.00a
	6.0	39.00 bcde	87.76hijk	6.83 cd	2.23 cde	100.00a
	8.0	31,00 defgh	90.30ghij	6.00 cd	1.10 fgh	98.66a
D. stramonium (leaf powder)	4.0	37.33 bcde	86.26hijk	8.33 bc	2.40cde	99.66a
	6.0	27.00defghij	91.55abcdefgh	6.33 de	2.33 cde	100.00a
	8.0	23.00efghijk	92.66abcdefgh	6,00 cd	1.43efg	96.66ab
C. ambrosioides(leaf	2.0	41,67 bcd	86.92ijk	3.00 ghi	2.66 bcd	100.00a

powder)	3.0	28.67 defgh	91.17abcdefghi	2.33 hij	1.26fgh	98.00a
	4.0	24.33 efghij	92.36abcdefgh	1.26fgh	0.46 ghij	98.33a
B. juncea (seed oil)	0.2	24.00efghij	92.48abcdefgh	3.03 ghi	0.73 ghij	99.00a
	0.3	19.33fghijk	93.94abcdefgh	2.43 hij	0,40 ghji	92.33b
	0.5	14.67 hijkl	95.41abcdef	1.50 kji	0.31hij	92.33b
L. usitatissimum (seed oil)	0.2	26.33 defgh	91.75abcdefghi	3.00 ghi	1.10 fghi	92.66b
	0.3	24.00efghij	92.49abcdefgh	2.06 hij	0.50 ghij	88.00c
	0.5	18.33ghijkl	94.26abcdefg	3.66 kji	0,26 hij	82.33d
G. abyssinica (seed oil)	0.2	35.33bcdef	88.95ghijk	4.33 ghi	0.73 ghij	92.66b
	0.3	29.67 defgh	90.71abcdefghi	3.33 fgh	0.66 efg	88.00c
	0.5	27.33 efghi	91.44abcdefgh	1,76 hij	0.50 hij	82..33d
Wood ash	3.0	13.00jklmn	96.15abcd	1.53 jki	0.25 hij	96.66a
	6.0	11.10 n	96.55ab	0.86 kj	0.22 ji	99.00a
	9.0	10.00lmn	96.87ab	0.66 kj	0.13 ji	98.66a
Sand	3.0	14.00ijklmn	95.63abcd	2.00 ij	0.16 ji	99.66a
	6.0	12.0klmn	95.23ab	1.19 kj	0.14 ji	100.00a
	9.0	10.00mn	96.85ab	1.06 kj	0.16 ji	98.66a
Standard check Malathion dust 5%	0.05%	8.00 n	97.50a	0.00 k	0.00 j	100.00a
Untreated check	-----	320.00a	000m	17.56 acd	6.00 a	100.00a
CV%	-----	29.65	2.96	27.10	18.16	9.78

Means followed by the same letter with in a column are not significantly different from each other at P<.0.05 (New DMRT)

Effect of botanicals, edible oils and inert materials on seed damage and seed weight loss

The amount of seed damage and grain weight losses that would be caused by *C. chinensis* was reduced in all of the treatments at all application rates when compared to the untreated check (Table 3). The minimum seed damage of 0.66 % was observed in wood ash, at 90 g kg-^{1}, and 1.06 % in *B. juncea oil at the rate of* 5 ml kg-^{1} whereas in the untreated check, the maximum seed damage recorded was 17.5%. However leaf powders of *D. stramonium* and seed powders of *M. ferruginea* at the lowest dose were found to be the least effective at 40 and 30 g kg-^{1} respectively. Generally powders of plant materials and inert dusts at the higher rates were significantly better in when compared to the lower ones. Hence the highest doses of botanical, inert dusts and edible oils were better in providing protection to seeds against the beetle. In similar trends, minimum seed weight losses 0.13, 0.16 and 0.31% were observed in these treatment percentage seed damage ranged from 0.00 to 9.33 % and was significantly different from untreated check (17.5 %). Similarly, the percent seed weight loss ranged from (0.1 to 3.3 %,) while it was 6 % in the untreated check. Abraham (2003), revealed that neem seed powder treatments differed significantly from the untreated check in the percentage of damaged grain and grain weight losses at different dates after infestations. Similarly, Muluembet (2003) tested the role of wood ash and found that 30% w/w provide effective control of bruchids on cowpea at Gambella, Ethiopia. Eventually the author reported neem leaf and mexican-tea powder forms reduced damage and weight loss due to *C. maculates* in treated cowpea seeds. Fikremariam (2005) also tested neem, datura and lantana plant seed powder at 5 % w/w against maize weevil on maize grains and reported that powdered plant materials were effective in reducing seed damage and weight loss. Regarding the effectiveness of inert materials were in reducing seed damage and weight losses by *C chinensis.* Adugna (2006) reported that, wheat grain treated with ash, sand and insecticides showed significantly lower percent of grain damage and weight loss. It was suggested that oils of mustard, sunflower, safflower castor and cotton acted as surface protectants against *C maculates* population growth by reducing the seed damage rate and the number of F1 adults that emerged. Baier and Webster (1992) also observed that different oils of neem, coconut and castor acted as surface protectants on green gram to check the pulse beetles.

Dawit *et al.* (2010) conducted laboratory experiment to test the efficacy of products of orange (*Citrus sinensis*) peels in the control of the stored products beetle *Zabrotes subfasciatus* in stored haricot beans and found that significantly reduced weight losses compared to the untreated check 45 days after introduction of *Z. subfasciatus* into treated and untreated beans. The present study is in line with the above works suggested by different authors.

Effect of botanical powders, edible oils and inert materials on germination of chickpea seeds

There were significant differences ($P<0.05$) among treatments in seed germination (Table 3). Seed germination ranged from 82.33 to 100 % Seeds treated with *G. abyssinica* and *L .usitatissimum* oils at the rate of 2 and 3ml kg^{-1}, respectively, were with reduced rate of germination as compared to the untreated check. Generally treatment of chickpea seeds with botanicals inert dusts and edible oils did not show any adverse effect on germination of seeds 90 days after treatment. Similarly, Gupta *et al. (*1989) and Abdul *et al*. (1989) reported that neem treatment does not impair the germination of seed treated with 2.5% neem seed kernel extract or with 2% neem cake, were rather vigorous and had higher root and shoot growth induce and dry weight than those from untreated seeds. Tigest (2004) investigated botanicals for the control of Z. *subfasciatus* and *C. chinensis* on haricot bean and chickpea seeds, respectively, and found that there was no adverse effect of botanicals.

Studies on the biology of C chinensis

Oviposition

The duration of egg deposition continued for about six days with a peak of oviposition on the 3 days after the beginning of oviposition. The number of eggs laid per female ranged from 47 to 52. The average egg laid was 49.4 (Table 4). The mean rate of oviposition was 8.25 eggs/day /female. The total of 83.4% of the eggs were laid during the first, second and the third days of oviposition period and after that the daily egg laying was gradually decreased and stopped on the fifth day for 3 of the females but two of the females stopped on the sixth day. The ovipostion period of the weevils took almost six days. The results of the experiment were almost coinciding with the ranges of oviposition period reported by various authors. Teshome (1991) reported that the oviposition period was 5 days which is almost closer to the present results. Fatemeh *et al.* (2009) also reported that 4-7 days and the females laid 95% their eggs in the first 5 days.

Egg hatchability and developmental period

The mean average percentage of eggs hatched were 91.6 % with a range of 91 to 93% (Table 4) which was in close agreement with the report of Teshome (1991), who reported that the average egg hatchability of *C chinensis* on chickpea was 89.6% with a range of 83 to 96.4%. The mean development period was recorded for 25.2 days, the range being between 24 and 26 days. Hill (1990) reported that the 22 to 23 days or longer period depending upon the environmental conditions. The author also reported different developmental periods depending upon the environmental conditions and found that the optimum conditions for the developmental period of 22-23 days at 32^0c and 90% RH and for the 36 days developmental period its requirement was observed at 25^0c and 70% RH.

Adult emergence, longevity and sex ratio

The mean average adult emergence was obtained (79.7%) with a range of 76 – 83% of the total eggs, with a mean of 42.4 % for males and 37.6 %for females (Table 4). Teshome (1991), reported that the percent adult emergence of 76.6- 88.4 % of the total oviposited eggs on chickpea. Talekar (1976) recorded that the developmental mortality from egg to the adult stage was 23% in *C. chinensis* and 9% in *C. maculates* and *C. analis*. Mekasha (2004) also reported that the 62% adult emergence from the total oviposited eggs of *C.*

maculates on chickpea. The average life span that recorded for the male and females were 9.6 and 8.0 days, respectively with the range of 7 to 9 days. Talekar (1976) recorded an average life span of C. chinensis for male and female 7.6 and 7.4 days on mungbean. Fatemeh *et al. (*2009) found that mean survival time was 8.29 for both male and female on green gram and 8.27 on chickpea for both sexes. Teshome (1991) also reported average life span of 8.3 with a range of 7 to 10 days and the mean average life span of 7.9 days for females of *C. chinensis* on chickpea. The present study showed a close agreement with the findings of the above works. The male to female ratio was recorded as 1.12 to 1.This is not much different from the reports of Teshome (1991) which was 1.06 to1 male to female for *C. chinensis* on chickpea. Talekar (1976) also recorded 6.5 to 7.6 males to females, respectively for *C.chinensis*, *C. maculates* and *C .analis* on mung bean. The variations that were observed in some cases may be related with fluctuations of environmental conditions in the experimental areas. The level of temperature and humidity of the laboratory sometimes observed to be influenced by external environmental situations in the course of experimental periods.

Table 4. Biology of C. *chinensis*

Parameters	Number/ Days/ Percentage
1. Oviposition	49.4±1.81
Percent egg hatchability	91.6±1.14
Developmental period	25.2±1.30
2. Adult emergence	
Male	42.4±1.81
Female	37.6±1.14
Total	79.7±2.73
3. Adult longevity	
Male	9.6±0.94
female	8±1.00

Conclusion

In this study, all the treatments showed insecticidal activities with varying degree and were found to be effective when compared with the untreated check in parent beetle mortality. *A. indica* at the rate of 20g kg^{-1} and C. *ambrosioides* at the rate of 40g kg^{-1} showed high adult mortality, next to malathion 5 % dust. All the treatments significantly reduced the number of eggs laid, inhibited F1 progeny emergence, reduced seed damage and seed weight loss by *C. chinensis* when compared with the untreated check. The minimum number of eggs was recorded in seeds treated with *B. juncea* and *G. abyssinica* oils at the dosage of

5ml kg^{-1}. Likewise, treatments of sand and wood ash at all tested levels gave more than 90% inhibition in F1 progeny production, minimum seed damage and seed weight loss by *C. chinensis*. All tested leaf and seed powders of the botanicals, the edible oils and the inert materials did not affect the viability of treated chickpea grains. These results indicated that botanicals, inert materials and edible seed oils can effectively control Adzuki bean beetle, *C. chinensis* at stored chickpea.

This experimental trials were laboratory based and of short duration and therefore do not necessarily reflect responses which would be observed under real farm conditions. Laboratory experiments cannot account for variables such as fluctuating ambient climatic conditions, the effects of store design and structure, a multitude of insect pest species and the family itself. Research priority should be designed on the farm trials to validate the efficacy of plant materials under real farm conditions. Especially the use of botanicals, inert materials and edible oils should be considered as an integrated management of *C. chinensis*.

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(Published in May 2012)