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STUDY THE EFFECTIVENESS OF PLANT MATERIALS IN CONTROLLING PULSE BEETLE, *CALLOSOBRUCHUS CHINENSIS* ON LENTIL SEEDS

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ABSTRACT

Taleb MA (2021) Study the effectiveness of plant materials in controlling pulse beetle, *Callosobruchus chinensis* on lentil seeds. *Int. J. Sustain. Crop Prod.* 16(3), 16-26.

The leaf extract and powder of *Polygonum hydropiper* (biskatali), *Vitex negundo* (nishinda), *Calotropis gigantea* (akanda), *Azadirachta indica* (neem), *Aphanamixis polystachya* (pithraj) and seed oil of neem and pithraj were tested in the laboratory for their effectiveness against the attack of *Callosobruchus chinensis* on lentil seeds. The seeds treated with plant materials were also tested for their viability after six months storing. The oviposition and adult emergence of *C. chinensis* were significantly different among the various treatments. Biskatali leaf extract at 6% dose was most effective reducing 48.69% oviposition and 54.63% adult emergence compared to control. The treatment of neem leaf extract caused slightly less oviposition rate and adult emergence. The pulse beetle built up large populations in six months storage period causing 97.34% seed damage in untreated condition. Biskatali leaf extract being potent plant material reduced 2.01 times less quantitative loss of lentil seeds. The other plant materials showed less reduction of seed damage than in biskatali leaf extract. The mortality of adult pulse beetle increased with dose and exposure time and the mortality was dose-dependant. It was found that all the twelve plant materials were toxic to *C. chinensis* and their effectivenesses were in the following descending order: biskatali leaf extract, neem leaf extract, biskatali leaf powder, neem oil, nisainda leaf extract, neem leaf powder, nishinda leaf powder, akanda leaf extracts, pithraj oil, akanda leaf powder, pithraj leaf extract, pithraj leaf powder. The germination rate of lentil seeds was found higher treated with different plant materials than control. The germination rate was found 1.65 times higher in the treatment of leaf extract and powder of biskatali and neem than the control treatment.

Key words: *effectiveness, plant materials, Callosobruchus chinensis, lentil seeds*

INTRODUCTION

There are 0.715 million hectares of land in Bangladesh brought under cultivation of pulses with an annual production of 0.53 million tons in 2016 (Anonymous 2017). About a dozen of pulse crops are grown in winter and summer seasons. Summer crops contribute about 83% of the total pulses. Among different pulses lentil, chickpea, black gram and green gram recorded greater cropping area and higher production than other pulses in our country. The first three crops are widely grown in winter and the last two crops in summer. Majority of the pulses are harvested in the spring, but all pulses are consumed throughout the year. The production of pulses is not adequate for consumption of the people of Bangladesh and these commodities are imported to meet the domestic needs. Among different factors causing low productivity, insect pests and diseases are considered to be important. The farmers also play little attention in respect of better seed use. Pulses being a rich source of protein (20-30%), offer the most practical means of solving malnutrition in our country. As these are generally harvested in the spring and consumed throughout the year, their seeds must be stored and protected against storage pests for rest of the year. Pulse seeds stored in farmer's houses and godowns furnish a suitable habitat for many insects (Akhtari *et al.* 1993). Pulse seeds are more difficult to store than cereals as these suffer a great damage due to insect pests and micro-organisms. Pulse beetle. *Callosobruchus chinensis* L. is known to inflict quantitative and qualitative losses to various stored pulses. Pulse beetle is considered to be a very serious pest in Bangladesh causing enormous damage to almost all kinds of stored pulses. If the infestation goes announced, complete damage of seeds may occur. The infestation caused by this insect reduces the germination ability of the seeds and results in some chemical changes that alter flavor and nutritive value. This bruchid insect is also an important pest in the field infesting pod seeds of pulse crops and that possess the source of infestation in the storage.

Callosobruchus chinensis is one of the most destructive storage pests. It mainly attacks stored grains of cowpea, mung bean and pigeon pea. Sharma (1984) reported grain damage by pulse beetle in pigeon pea, grass pea, cowpea, black gram, bengal gram, field bean, peas, lentil and cluster bean respectively, but the highest damage was found in lentil and pigeon pea. The adult pulse beetle does not feed on seeds but they mate and oviposit on them. The larva is uniquely responsible for damaging the pulse seeds by feeding inside partially or completely in the stored condition resulting in damage of whole seeds which become unfit for human consumption and sowing in the field. *Callosobruchus chinensis* breeds throughout the year in stored pulse seeds. But it is generally found that intensity of infestation is higher in summer than winter mainly due to high temperature and humidity. Pulse beetle infestation causes significant weight losses of legume seeds like 55-60 per cent losses in seed weight and 45.5-66.3 per cent losses in protein content. The degree of damage caused by the pulse beetle depends on the exposure time and storage facilities. The longer exposure time, the higher is the infestation and damage (Gujar and Yadav, 1987) and the extent of damage up to 100 per cent occurs during storage periods. *Callosobruchus chinensis* L. caused great losses of black gram as 56.26 per cent, mung bean 46.70 per cent, chickpea 44.08 per cent and pea 5.0-9.00 per cent in storage (Rustanmani *et al*. 1985). In contrast, *C. maculatus* caused 55 per cent losses of blackgram in storage (Sharma 1984). He reported that *C. chinensis* is a serious pest of pulses in storage. Anonymous (1984) reported that 98.04 per cent, 73.20 per cent, 53.00 per cent, 54.37 per cent and 64.33 per cent grain of mung bean, black gram, grass pea, lentil and chickpea respectively were to be infested by pulse beetle in Bangladesh under farmers storage condition. Information is not sufficient on the damage estimate of lentil seeds.

There are several methods of controlling pulse beetle namely mechanical, cultural, physical, biological, chemical and to some extent use of botanicals etc. (Katiyar and Khaire, 1989). Pulse beetles are the most damaging stored product pests and more difficult to control because of their small size, feeding behavior and ability of attacking grains before harvest. Chemical control of pulse beetle in storage had been practiced for a long time, but it has serious drawbacks. Chemical insecticides are the major tools for pulse protection in developed countries. Generally, our farmers use chemical insecticides on lentil seeds against the attack of pulse beetle, *Callosobruchus chinensis* in storage for quick result. But the application of chemical insecticides to protect pulses from pulse beetle in storage may cause serious health hazards (Bhaduri *et al.* 1989). The residues of some of the insecticide remain in stored grain and also in environment which may cause miserable consequences after consumption of grain. Sometimes persistent insecticides accumulate in the higher food chain of both wild life and human being and concentrate by biomagnification (Fishwick 1988). The biological activity of botanicals can be credited to its alkaloid contents having deterrent action to insect and can play a vital role as alternate method for the control of pulse beetle in storage (Quasem and Barua, 1985; Prakash and Rao, 1996). In many countries, efforts are being made to minimize the use of indigenous plant products, implementation of integrated pest management approaches, the use of biodegradable product, gamma radiation, insect growth regulators in protecting stored grains (Khattack and Hameed, 1986).

Locally available plant materials are found worldwide which are used to protect stored products against damage caused by insect infestation. Many workers at home and abroad studied the insecticidal action of plant materials, various edible and non-edible oils as a protectant of pulses against pulse beetle (Doharey *et al.* 1988; Choudhury 1990). Botanical insecticides tend to have broad-spectrum activity and are relatively specific in their mode of action and easy to use. Ahmed *et al.* (1984) also reported that there are about 2000 plants species to possess pest control properties. Indigenous plant materials are cheaper and hazard free in comparison to chemical insecticides (Saxena *et al.* 1992). These are also easily available in everywhere of our country. There are many reports published on the use of plant products against pulse beetle tested on lentil, cowpea, chickpea, green gram, black gram, but the information of the use of plant products in lentil is not sufficient. There is no work conducted on the simultaneous use of leaf extracts, powder and seed oil of indigenous plants as protectant of lentil seeds against *Callosobruchus chinensis* in Bangladesh. The leaves of biskatali, nishinda, akanda, neem, pithraj and seeds of neem and pithraj are available everywhere of our rural areas and it is easy to prepare leaf extracts and powder. The main advantage of these botanicals is that they can be easily used by farmers and less expensive. The present research was carried out under the following objectives: i) to determine the effectiveness of using plant materials as protectant of lentil seeds against pulse beetle, *Callosobruchus chinensis*, ii) to find out the effects of treatments on the viability (germinating capacity) of lentil seeds.

MATERIALS AND METHODS

The study on the effectiveness of different plant materials as leaf extracts and powder of biskatali (marsh pepper), nishinda (horseshoe vitex), akanda (kapok tree), neem (margosa), pithraj (rohituka tree) and seed oils of neem and pithraj as protectant of lentil seeds against *Callosobruchus chinensis* and also the treated lentil seed viability tests were carried out in the laboratory of Bangladesh Open University, Gazipur during April 2019 to March 2020.

Collection of Test Materials

The seeds of lentil (*Lens culinaris*) used in this study were collected from the local market of Jashore. The seeds were mature and completely free from insects and microorganisms. There were no other crop seeds and foreign materials in the seed lot. No insecticide was used on the seeds in the storage. The indigenous plant materials i.e. branch of biskatali, nishinda, akanda, neem and pithraj were collected from the rural part of the country and brought to laboratory. Neem and pithraj oil were collected from the local market of Tongi, Gazipur. For the preparation of crude mixture, freshly collected leaves of the plants were separately washed in water in a plastic bowl and dried in shade for 30 minutes to remove the surface water. Six grams of individual plant leaves without midrib were taken in a grinder and the grinding material was transferred to a 500 ml beaker separately by cleaning the grinder with little distilled water. Then the mixture was passed through a piece of fine nylon net before to collect in a 100 ml measuring glass separately. The volume of this extract was made up to 100 ml with distilled water and stored in 5 bottles. This solution contained 6% active plant material. The 4% stock solution each of 200 ml taking 8 g leaves was prepared following the above technique. The half of the 4% stock solution was taken and 100 ml water was added to this. This solution contained 2% of the test material. Collected green leaves of these plants were kept in the laboratory for 15 days for the purpose of air drying followed by one day sun drying before making powder. After the leaves had dried, they were made into powder by blender in the laboratory. The leaf powder was stored in separate plastic jars for use in the experiments. These powders were used as weight by weight basis i.e. 4 g, 3 g and 2 g powder mixing with 100 g seeds means 4%, 3% and 2% powder used respectively. For the preparation of 1.00% oil solution, 1.00 ml of oil was taken in 100 ml distilled water separately kept in a beaker. The oil concentration of 0.75% and 0.50% were also prepared following the above method. One drop of 0.01% Tween 20 solution was added to oil for proper mixing with water (Ram and Gopal, 2000/2001).

Collection of Source and Culture of Beetles

Several adult beetles of *Callosobruchus chinensis* were collected from the culture of this insect infesting black gram at the pulse division of Bangladesh Agricultural Research Institute (BARI) to maintain a laboratory culture. They were reared in the plastic containers (26 cm long×10 cm dia) with lentil seeds in the laboratory, School of Agriculture and Rural Development, BOU, Gazipur. Adult beetles were separated from infested seeds and then transferred to another plastic container and supplied with fresh lentil seeds and then transferred to another plastic container and supplied with fresh lentil seeds for multiplication. The newly emerged pulse beetles from this stock culture were utilized in the experiments. The stock culture was maintained at temperature in the laboratory.

Identification of Adult Male and Female of *C. chinensis*

The male and female beetles of *C. chinensis* were identified before using in the experiments following some of the identifying characters of this insect (Bandara and Saxena, 1995). The color of the adults of *C. chinensis* were pale brown with small median dark marks and larger posterior dark patches which may merge to make the entire posterior part of the elytra dark in colour. The side margins of the abdomen have distinct patches of coarse white setae. *C. chinensis* has a pair of distinct ridges (inner and outer) on the ventral side of each hind femur and each ridge has a tooth near the apical end. The inner tooth is slender, rather parallel sided and equal to (or slightly longer than) the outer tooth. The male beetle was smaller in size than the female beetle. Males have comparatively shorter abdomens and the dorsal side of the terminal segment is sharply curved downwards and inward. In contrast, the females have comparatively longer abdomens and the dorsal side of terminal segment is only slightly bent downward. The male beetle had pectinate antennae curved towards each other with elongate and oblong apical segment and the female beetle possessed serrate antennae with somewhat bluntly round or ovate apical segment. Variations in morphological parameters may be induced by different host densities, whether development occurs in pods or in loose seeds (Nahdy *et al*. 1998) or by population source (George and Verma, 1997).

Test of Efficacy of Plant Materials against Pulse Beetle

The previously prepared leaf crude mixture and powder of biskatali, nishinda, akanda, neem and pithraj and oil of neem and pithraj were taken separately in 36 plastic containers. Then leaf crude mixtures and oils were sprayed and leaf powders were mixed with fresh and healthy 50 g lentil seeds. The dose of leaf extract, leaf powder and oil were 6 per cent, 4 per cent and 1 per cent respectively. The moisture content in the lentil seeds was 13 percent. Five pairs of newly emerged male and female beetles of *C. chinensis* obtained from the stock culture were released in each plastic container. The ratio of male and female insects was always maintained as 1:1 following the identifying characters. The mouth of the plastic container was closed with its cap. Control plastic containers where no plant material was used included in this experiment. Each treatment was replicated thrice. The containers were kept in laboratory without any disturbance. This treatment was made for 6 months storage period. After the above storage period the efficacy of plant materials as protectant of lentil seeds against *C. chinensis* was evaluated considering oviposition of the beetle, emergent adults, number of egg bearing and damaged/holed seeds from the treated and untreated seeds. The methods employed to record data on the above-mentioned parameters are described separately. Fresh adult pulse beetles were collected from the culture. One hundred nine petri dishes were washed properly with detergent powder. Five pairs of adult pulse beetles were placed in each of the petri dishes containing 50 g lentil seeds for every dose. The prepared crude leaf extracts (2, 4, 6%) and oils (0.50, 0.75, 1.00%) were sprayed on lentil seeds uniformly by a hand sprayer and leaf powder (2, 3, 4%) were mixed with lentil seeds properly. The spraying was done in such a way that there was no excess extract/oil left in the dish. After spraying and mixing, the Petri dishes were covered. Each dose had three replicates. The control was sprayed with distilled water.

Oviposition Record

Data on the rate of oviposition was recorded after 6 months of the release of beetles. Ten lentil seeds were selected randomly from each plastic container. The selected seed were carefully examined using magnifying glass and counted the number of eggs glued on the surface of lentil seeds in each treatment.

Observation on Adult Emergence

The pulse beetle started emerging 17 days after release in the plastic container, it was observed from the outside the disk. The development of all stage from egg deposition until emergence of adults took place in the seed.

After hatching the eggs, the larvae of the beetle entered the seeds and fed on the cotyledons where they pupated and came out as adults by making hole(s) on the seeds. The mummer of emergent adults counted after six months storage condition in each treatment. The adults were removed from each plastic container after the counting and data recorded.

Number of Egg Bearing Lentil Seeds

After the six months storage period the observation on the number of eggs bearing lentil seeds was made. The seeds having eggs of *C. chinensis* were called egg bearing seeds. These seeds from each plastic container of each replicate were recorded and removed.

Intensity of Infestation

Seeds with hole(s) were considered as infested seeds or damaged seeds. To determine the percentage of infested lentil seeds, number of holed seeds were counted per plastic container per replicate and percentage of infested seeds were calculated.

Mortality of Pulse Beetle at 24, 48 and 72 HAT

Observations on the mortality of pulse beetles were made at 24, 48 and 72 hours after treatment. The mortality percentages were corrected by using Abbot's formula (Abbot 1987).

Seed Viability Test

Lentil seeds were stored for three months spraying with 6% leaf extracts, 1.00% seed oils and mixed with 4% leaf powder. After three months storing, seeds of lentil were placed for germination in covered petri dishes between filter paper moistened. Three layers of Whatman No. 2 filter paper disks were used in each dish, two below the seeds and one on top. Six ml of distilled water were added to petri dishes, each containing 10 seeds. Petri dishes were then placed in dark places at room temperature. Germination counts that were taken every 24 h for 21 days. Seeds with a radical extension equal to greater than 2 mm were considered as germinated, counted and then discarded. Seeds that developed fungal growth were removed from the dishes and considered as dead. Percentage germination was calculated based on the total number of germinated seeds per treatment. The seeds treating without plant materials were used for the control of germination test. Each dose has three replicates.

Data Analysis

The mortality data and the percentage germination were analyzed through Completely Randomized Design (CRD) and the means were compared by Duncan's multiple range test (DMRT).

Meteorological Data

During the period of the study in laboratory, temperature and relative humidity were recorded daily at 12:00 noon of the day using the thermometer and hygrometer respectively.

RESULTS AND DISCUSSION

Leaf extracts, powders and seed oils of five indigenous plants as protectant of lentil seeds against attack of pulse beetle, *Callosobruchus chinensis* were studied in the laboratory at temperature ranged from 26.4^0C to 35^0C with mean 31.60 ± 1.7^0C and relative humidity 67 to 82 per cent with mean 77 ± 0.27 per cent determined by thermometer and hygrometer respectively.

Effect of Plant Materials on Oviposition

The female adults of *C. chinensis* laid eggs on the surface of lentil seeds. The eggs looked like white dots clearly visible on the seeds. The number of eggs differed significantly ($P<0.0001$) among the treatments and control (Table 1). The highest number of 11.83 eggs per seed were found in control where no plant material was used. The second highest number of 11.47 eggs were found in the lentil seeds treated with pithraj leaf powder which was also significantly different from other treatments. The lowest number of 6.07 eggs per seed recorded in biskatali leaf extract treatment. In akanda leaf powder and pithraj leaf extract treatments the number of eggs was close to each other but lower than that of pithraj leaf powder and higher than that of other plant material treatments.

Table 1. Mean number of eggs laid by *C. chinensis* on lentil seeds treated with different plant materials stored in six months

Plant Materials	Dose (% ai)	Mean egg (no.) per seed per replicate			Mean egg per seed (no)
		1	2	3	
Biskatali leaf extracts	6	6.0	6.2	6.0	6.07 J
Nishinda leaf extracts	6	9.7	10.0	9.6	9.77 G
Akanda leaf extracts	6	10.6	10.4	10.0	10.33 E
Neem leaf extracts	6	7.2	7.1	7.0	7.10 I
Pithraj leaf extracts	6	11.4	11.0	11.1	11.17 C
Biskatali leaf powder	4	9.2	9.0	8.7	8.97 H
Nishinda leaf powder	4	10.0	9.8	10.3	10.03 FG
Akanda leaf powder	4	10.9	11.0	10.5	10.8 CD
Neem leaf powder	4	9.8	10.3	9.2	9.77 G
Pithraj leaf powder	4	11.9	11.5	11.0	11.47 AB
Neem oil	1	9.6	9.8	9.5	9.63 G
Pithraj oil	1	10.5	10.4	10.6	10.5 DE
Control	0	12.1	11.8	11.6	11.83 A

Means having different letter differed significantly (P<0.0001)
10 seeds were randomly selected per replicate

The results of the experiments with different treatments of biskatali, nishinda, akanda, neem and pithraj leaf extracts and powders and seed oils of neem and pithraj on lentil seeds exhibited different effects on *Callosobruchus chinensis* in six months storage period. Different products of these plants significantly inhibited oviposition of *C. chinensis* on the lentil seeds as compared to untreated seeds. These plant materials reduced 1.03-1.95 times oviposition than untreated one. Biskatali leaf extract caused the highest reduction of oviposition of *C. chinensis*. This result indicated that biskatali leaf extract was the best on the inhibition of oviposition by decreasing almost half the oviposition of *C. chinensis*. Neem leaf extract, biskatali leaf powder, neem oil, nishinda leaf extract and neem leaf powder, nishinda leaf powder, akanda leaf extracts. pithraj oil, akanda leaf powder, pithraj leaf extracts, pithraj leaf powder affected inhibition of oviposition next to bishatali leaf extract and caused 1.67, 1.32, 1.23, 1.21, 1.18, 1.15, 1.13, 1.10, 1.06, 1.03 times reduction of oviposition in comparison with untreated seeds. The present results on the rate of the oviposition were consistent on the results reported by Singal and Chauhan (1997), Misra (2000) who used neem leaf and seed powder and nishinda leaf powder with varied dosages against the pulse beetle hosted on blackgram, pigeonpea, lentil, chickpea, cowpea and mungbean. Leaf powder of various plants, for example wood apple, tobacco, mentha, *Piper quineans*, *Lantana camara* etc. were also found to be effective on the inhibition of oviposition of pulse beetle on chickpea, mungbean and cowpea (Saxena *et al.* 1992). In contrast, Mathur *et al*. (1985) reported that the turmeric powder enhanced oviposition of pulse beetle, *C. chinensis* on blackgram. Neem and nishinda oil performed better as protectant of pulses against the oviposition of pulse beetle than leaf powder (Khaire *et al*. 1993). Coverage of seeds by the oil than leaf powder hindered oviposition in a better way (Ahmed *et al*. 1993; Bhargava and Meena, 2002).

Treatments on Number of Egg Bearing Seeds

The females of *C. chinensis* deposited eggs on lentil seeds. The seeds having eggs and no damage symptom as absence of hole(s) are referred to egg bearing seeds. Such type of seeds was considered to be normal seeds like non-egg bearing seeds counted is the treated and untreated containers. Data on the number of eggs bearing seeds observed from different treatment after six months storage. The mean number of eggs bearing seeds differed

Table 2. Number of eggs bearing seeds due to oviposition of *C. chinensis* in different plant material treatments on lentil seeds stored in six months

Plant Materials	Dose (% ai)	Egg bearing seeds (no.) per replicate			Mean egg bearing seeds (no)
		1	2	3	
Biskatali leaf extracts	6	8	7	9	8.00 I
Nishinda leaf extracts	6	12	11	12	11.67 FG
Akanda leaf extracts	6	14	15	16	15.00 D
Neem leaf extracts	6	9	9	10	9.33 H
Pithraj leaf extracts	6	17	18	18	17.67 B
Biskatali leaf powder	4	10	9	9	9.33 H
Nishinda leaf powder	4	13	14	14	13.67 E
Akanda leaf powder	4	16	17	16	16.33 C
Neem leaf powder	4	12	13	12	12.33 F
Pithraj leaf powder	4	17	19	18	18.00 AB
Neem oil	1	11	10	11	10.67 G
Pithraj oil	1	15	16	15	15.33 CD
Control	0	18	19	20	19.00 A

Means having different letters differed significantly (P<0.0001) significantly (P<0.0001) among the treatments. The highest mean of 19.00 egg bearing seeds were found in untreated container followed by the treatment with pithraj leaf powder (Table 2). The mean number of eggs bearing seeds treated with akanda leaf powder and pithraj oil were very close to each other and same type of results were also found in the treatment of nishinda leaf extracts and neem oil. The lowest mean of 8.00 egg bearing seeds were found in biskatali leaf extracts treatment. Neem leaf extracts and biskatali leaf powder showed statistically similar egg bearing seeds and greater than that of biskatali leaf extracts treatment.

The plant materials possess toxic, repellent and antifeedant effects on various stored grain and grain product insects (Hussain *et al.* 1995). It was possible that tested plant materials might cause any of these effects on *C. chinensis*. The highest number of eggs bearing lentil seeds were found in untreated seeds whereas less egg bearing seeds in treated seeds. Significantly least egg bearing lentil seeds were recorded in biskatali leaf extract treatment. Egg bearing seeds were statistically identical in number in neem leaf extract and biskatali leaf powder treatment and less than in other treatment except biskatali leaf extract treatment. David *et al*. 1988 observed that leaf powder of nishinda showed the repellent activity against several species of stored products pests including pulse beetle. Misra (2000) reported that several indigenous plant materials have traditionally been used as stored grain protectant against insect pests in various parts of the world. The plant such as neem, turmeric and sweet flag have been found to possess insect repellent properties. Many research works in controlling pulse beetle, *C chinensis* through plant products have been done (Parsai *et al*. 1990; Begum and Quinones, 1991).

Adult Population

The adults of *C. chinensis* emerged from the lentil seeds through hole(s) and remained in the plastic containers. Data on emergent beetles were recorded after the completion of the six months storage period. The number of adult beetles emerged from the lentil seeds with different treatments infested by this insect showed a similar trend as observed in the oviposition rate. The number of adults emerged from different treatments of plant materials ranged from 370-718 per 50 g seeds per replicate and 811-855 adults in control and these differed significantly (P<0.0001) (Table 3). The highest number of adults emerged from untreated lentil seeds (control) having mean of 828.67 which was significantly greater than the means of all other treatments. The second highest number of adults emerged from pithraj leaf extracts treated seeds which was statistically identical to akanda and pithraj leaf powder followed by akanda leaf extracts and pithraj oil. The lowest number of beetles (376.00) recorded in the treatment of biskatali leaf extracts which was statistically differed from all other treatments.

Table 3. Number of emergent adults of *C. chinensis* on lentil seeds treated with different plant materials stored in six months (50g seeds per replicate)

Plant Materials	Dose (% ai)	Adult emerged (no.) per replicate			Mean adult (no)
		1	2	3	
Biskatali leaf extracts	6	373	370	385	376.00 H
Nishinda leaf extracts	6	621	633	614	622.67 D
Akanda leaf extracts	6	676	699	718	697.67 BC
Neem leaf extracts	6	433	421	399	417.67 G
Pithraj leaf extracts	6	710	706	715	710.33 B
Biskatali leaf powder	4	527	555	536	539.33 F
Nishinda leaf powder	4	671	690	689	683.33 C
Akanda leaf powder	4	700	711	706	705.67 B
Neem leaf powder	4	625	631	629	628.33 D
Pithraj leaf powder	4	711	705	718	711.33 B
Neem oil	1	611	587	593	597.00 E
Pithraj oil	1	696	700	699	698.33 BC
Control	0	820	811	855	828.67 A

Means having different letters differed significantly (P<0.0001)

Ten Adults were released per plastic container

The adult emergence commenced 17 days after releasing of pulse beetles in the treatments and this might be the normal phenomenon of pulse beetle in the six months storage period. Indigenous plant materials had significant effect on the decrease of adult populations. The highest number of adults emerged from untreated lentil seeds. It was evident that the plant materials used in the experiment effectively controlled adult emergence by inhibition of oviposition and adverse effect on the growth and development of life stages of *C. chinensis*. They're supposed to be positive relation between the eggs laid and the number of adult emergence although no analysis of coefficient correlation was done in this respect. Plant materials reduced 1.19-2.20 times adult emergence in comparison with untreated control. Biskatali leaf extract provided the highest inhibition on adult emergence of *C chinensis*. This indicated that biskatali leaf extract had effect on inhibition of adult emergence by 54.63 per cent over control next to neem leaf extract and it was statistically differed from all other treatments. The statistically identical adult emergence was found in pithraj leaf extract and powder and also in akanda leaf powder treatment followed by akanda leaf extract and pithraj oil treatment. These results agreed with Singal and

Chauhan (1997) who reported that leaf powder of neem, nishinda and datura and neem seed powder reduced adult emergence of pulse beetle admixed with cowpea, pea, chickpea, mungbean, blackgram and lentil. Conversely, Olifa and Erhum (1988) found that leaf powder of neem, datura and *Piper nigrum* did not affect adult emergence of pulse beetle on cowpea seeds. The F_1 adult emergence of pulse beetle, *C. chinensis* from mungbean, corn and sorghum treated with neem and nishinda oil and powder was markedly reduced (Khalequzzaman *et al.* 2007; Pandey and Singh, 1997) which was similar to that of the present study of research.

Intensity of Seed Damage

The seeds of lentil showing hole(s) due to feeding of *C. chinensis* larva were regarded as damaged seeds. Such seeds could not be used for any purposes, Data on seed damage estimation were recorded after completion of the six months storage period. The number of holed seeds, egg bearing seeds and seeds without eggs were counted and recorded in each treatment for the determination of the percentage of the damaged lentil seeds. Finally, the percentage of damaged seeds were calculated per container. It was observed that the percentages of damaged seeds were significantly different among the treatments (P<0.0001). The seed damage ranged from 47.27 to 96.23 per cent in treated condition and 96.91 to 97.92 per cent in the control treatment (Table 4).

Table 4. Percentage of damaged lentil seeds by *C. chinensis* in different plant material treated seeds in six months storage

Plant Materials	Dose (% ai)	Damaged seeds (no) per replicate			Mean damaged seed (no)
		1	2	3	
Biskatali leaf extracts	6	49.39	48.55	47.27	48.40 K
Nishinda leaf extracts	6	80.10	79.21	75.31	78.21 G
Akanda leaf extracts	6	90.34	89.27	89.55	89.72 DE
Neem leaf extracts	6	60.10	59.43	58.58	59.37 J
Pithraj leaf extracts	6	94.10	93.23	93.25	93.53 BC
Biskatali leaf powder	4	65.03	60.11	62.22	62.45 I
Nishinda leaf powder	4	87.29	88.10	87.39	87.59 EF
Akanda leaf powder	4	92.11	92.57	93.10	92.59 C
Neem leaf powder	4	85.19	86.00	85.12	85.44 F
Pithraj leaf powder	4	95.20	94.30	96.23	95.24 AB
Neem oil	1	70.01	69.22	66.05	68.43 H
Pithraj oil	1	90.50	90.12	89.22	89.95 D
Control	0	97.20	96.91	97.92	97.34 A

Means having different letters differed significantly (P<0.0001)

Significantly highest damage occurred in control followed by the treatment of pithraj leaf powder. The pithraj oil treatment showed 89.95 per cent seed of akand leaf extracts which was very close to the nishinda leaf powder treatment. The lowest mean seed damage of 48.40 per cent recorded in biskatali leaf extract treatment and all other treatments caused higher seed damage than that of biskatali leaf extracts treatment in six months storage period.

The quantitative losses resulted in lentil seeds due to the damage of *C. chinensis*. The untreated lentil seeds suffered from 97.34 per cent damage which is significantly higher than that of all other treatments. The seed damage in treatments ranged from 48.40 to 95.24 per cent which was the high rate of damage perhaps because the efficacy of the plant materials decreased in long six months period of storage. The longer exposure time, the higher is the infestation and damage (Gujar and Yadav, 1987). The treated lentil seeds with maximum damage occurred in pithraj leaf powder followed by pithraj leaf extracts. The intermediate infestation occurred in neem and nishinda leaf powder and the least damage was with biskatali leaf extract. This intensity of damage was reduced to 2.01 times as compared to control against *C. chinensis* in six months storage period. Rouf *et al.* (1996) found that *C. chinensis* caused 100 per cent damage to lentil seeds in untreated condition, but the percentage of damage was found significantly less when the seeds were treated with neem, nishinda, biskatali leaf powder in 75 days of storage. Sharma (1984) reported 49 per cent pigeon pea seeds damaged by *C. chinensis* and 84 per cent bengal gram seeds damaged by *C. maculatus* after six months of storage. Singh and Sharma (2002, 2003) also reported that plant materials such as *Annona* sp. (custard apple) seed powder, mentha powder, rhizome powder, powder of *Acorus Calamus*, leaf powder of sadabahar etc. were also found effective against the pulse beetle in reducing the intensity of infestation on chickpea cowpea and mungbean seed.

Laboratory Test of Plant Materials Against Pulse Beetle

Different plant products as leaf extracts, powders and oils were tested against pulse beetle *C. chinensis* in the laboratory on lentil seeds. The efficacies of these plant materials were evaluated on the basis of per cent reduction of pulse beetle. At 24 HAT, 6-23 adult pulse beetles killed with 2-6% leaf extracts and 6-22 adult pulse beetles killed with 2-4% leaf powders of biskatali, nishinda, akanda, neem and pithraj respectively and 6-23 beetles killed at 0.50-1.00 neem and pithraj oil (Table 5). The mortality percentages ranged from 6.67 to

76.67 among the different treatments and differed significantly. The highest mortality of 76.67 per cent was found at 6% biskatali leaf extract identical to 1% neem oil treatment followed by the treatment of 4% biskatali leaf extracts, 6% neem leaf extracts and 4% biskatali leaf powder. The lowest mortality of 20.00 per cent was obtained with o.50% pithraj oil treatment identical to 2% pithraj leaf extract and powder followed by the treatment of 2% nishinda leaf extracts and powders. The mortality of adult pulse beetle increased at all doses of plant materials at 48 and 72 HAT and reached to 93.33 per cent at 6% biskatali leaf extract application (Table 5). The 4% dose of this plant killed 90.00 per cent beetles identical to 6% neem leaf extracts, 4% biskatali leaf powder and 1.00% neem oil. The highest concentration of 6% of biskatali and neem leaf extracts, biskatali leaf powder killed beetles at the similar rate of 86.67-93.33 per cent identical to 1.00% neem oil treatment. The lowest mortality of 36.67 per cent was recorded at 2% pithraj leaf extract and powder identical to 2% neem leaf powder treatment. Both neem and pithraj oil provided statistically different mortality at different doses ranged from 30.00 to 86.67 per cent.

Table 5. Mortality of adult pulse beetle, *C. chinensis* in laboratory at different hours treated with different plant materials on lentil seeds

Plant Materials	**Dose (% ai)**	**Total adult pulse beetle tested (no)**	**24 hours**		**48 hours**		**72 hours**	
			Pulse beetle dead (no)	**Mortality (%)**	**Pulse beetle dead (no)**	**Mortality (%)**	**Pulse beetle dead (no)**	**Mortality (%)**
Biskatali leaf extracts	6	30	23	76.67 A	25	83.33 A	28	93.33 A
	4	30	22	73.33 AB	25	83.33 A	27	90.00 AB
	2	30	11	36.67 IJ	13	43.33 IJ	15	50.00 HI
Nishinda leaf extracts	6	30	20	66.67 BC	22	73.33 BCD	23	76.67 CD
	4	30	17	56.67 DEF	20	66.67 DEF	20	66.67 EF
	2	30	8	26.67 KLM	11	36.67 JKL	14	46.67 IJ
Akanda leaf extracts	6	30	19	63.33 CD	22	73.33 BCD	23	76.67 CD
	4	30	13	43.33 HI	16	53.33 GH	19	63.33 FG
	2	30	10	33.33 JK	12	40.00 JK	14	46.67 IJ
Neem leaf extracts	6	30	22	73.33 AB	23	76.67 ABC	26	86.67 AB
	4	30	16	53.33 EFG	19	63.33 EF	21	70.00 DEF
	2	30	10	33.33 JK	11	36.67 JKL	12	40.00 JK
Pithraj leaf extracts	6	30	16	53.33 EFG	19	63.33 EF	21	70.00 DEF
	4	30	13	43.33 HI	16	53.33 GH	17	56.67 GH
	2	30	6	20.00 M	8	53.33 GH	11	36.67 K
Biskatali leaf powder	4	30	22	73.33 AB	24	80.00 AB	26	86.67 AB
	3	30	20	66.67 BC	23	76.67 ABC	25	83.33 BC
	2	30	10	33.33 JK	13	43.33 IJ	14	46.67 IJ
Nishinda leaf powder	4	30	19	63.33 CD	21	70.00 CDE	22	73.33 DE
	3	30	16	53.33 EFG	19	63.33 EF	20	66.67 EF
	2	30	7	23.33 LM	10	33.33 KLM	13	43.33 IJK
Akanda leaf powder	4	30	18	60.00 CDE	21	70.00 CDE	22	73.33 DE
	3	30	14	46.67 GH	15	50.00 HI	17	56.67 GH
	2	30	9	30.00 JKL	11	36.67 JKL	12	40.00 JK
Neem leaf powder	4	30	20	66.67 BC	22	73.33 BCD	25	83.33 BC
	3	30	15	50.00 FGH	18	60.00 FG	20	66.67 EF
	2	30	9	30.00 JKL	10	33.33 KLM	11	36.67 K
Pithraj leaf powder	4	30	15	50.00 FGH	18	60.00 FG	20	66.67 EF
	3	30	13	43.33 HI	16	53.33 GH	17	56.67 GH
	2	30	6	20.00 M	8	26.67 M	11	36.67 K
Neem oil	1.00	30	23	76.67 A	24	80.00 AB	26	86.67 AB
	0.75	30	18	66.67 CDE	20	66.67 DEF	22	73.33 DE
	0.50	30	11	36.67 IJ	13	43.33 IJ	14	46.67 IJ
Pithraj oil	1.00	30	16	53.33 EFG	19	63.33 EF	23	76.67 CD
	0.75	30	14	46.67 GH	18	60.00 FG	20	66.67 EF
	0.50	30	6	20.00 M	9	30.00 LM	13	43.33 IJK
Control	0	30	2	6.67 N	3	10.00 N	5	16.67 L

Means having same letter(s) in a column did not differ significantly (P<0.0001)

The results of the experiment with different treatments of plant materials on adult pulse beetle, *C. chinensis* revealed that the mortality of pulse beetle was lower in 24 hours after treatments with increased mortality after 72 hours of treatment. The toxicity increased with the increase of the dose. It showed that the highest mortality occurred in 6% leaf extract of biskatali and the lowest in 2% pithraj leaf extract identical to neem leaf powder. No research reports are available to compare this result. However, Bhuiyah and Quinones (1990) reported the toxicity of crude leaf extracts of neem, nishinda and biskatali against insects which might support the present findings. Between tested two oils, neem oil was found more toxic than prthraj oil to adult pulse beetle. The botanical based pesticides caused death of *C. chinensis* and mortality was dose-dependant. Parsai *et al*. (1990) reported that commercial formulation of botanical oils efficiently controls the adult pulse beetle.

Germination Rate of Treated lentil Seeds

The lentil seeds were treated with different plant materials and stored for six months. After six months, the seeds were placed for germination test in the petri dishes and normal seedlings were counted per replicate to determine the germination rate of treated lentil seeds. The germination rate was statistically differed (P<0.0001) among the different treatments (Table 6). The highest percentage of 93.33 was found in biskatali leaf extract treatment identical to neem leaf extracts, biskatali leaf powder and neem leaf powder treatment. The identical germination rate of 73.33 per cent were recorded is akanda leaf extract, nishinda and pithraj leaf powder and also in neem oil. Akanda leaf powder and pithraj oil treatment showed 70.00 per cent germination rate. The lowest rate (56.67) was recorded in the control treatment.

Table 6. Germination rate of lentil seeds after six months storing treated with different plant materials (10 seeds/replicate; 3 replicates/treatment)

Plant Materials	Dose (% ai)	Total lentil seeds tested (no)	Total germinated lentil seeds (no)	% germinated lentil seeds
Biskatali leaf extracts	6	30	28	93.33 A
Nishinda leaf extracts	6	30	24	80.00 B
Akanda leaf extracts	6	30	22	73.33 BC
Neem leaf extracts	6	30	28	93.33 A
Pithraj leaf extracts	6	30	23	76.67 BC
Biskatali leaf powder	4	30	28	93.33 A
Nishinda leaf powder	4	30	22	73.33 BC
Akanda leaf powder	4	30	21	70.00 C
Neem leaf powder	4	30	28	93.33 A
Pithraj leaf powder	4	30	22	73.33 BC
Neem oil	1	30	22	73.33 BC
Pithraj oil	1	30	21	70.00 C
Control	0	30	17	56.67 D

Means having same letters in a column did not differ significantly (P<0.0001)

The lentil seeds treated with different plant materials were stored for six months in different plastic containers. The seeds were tested for the viability through germination test. The highest germination rate was found in the leaf extracts and powders of biskatali and neem which was 1.65 times higher than that of control treatment. The germination rate of lentil seeds was significantly different with various treatments which was supported by the findings of Ali *et al.* (2017); Raghvani and Kapadia (2003).

CONCLUSION

The indigenous plant materials such as leaf extract and powder of biskatali, nishinda, akanda, neem and pithraj and oil of neem and pithraj seed mixed with water acted differently on the pulse beetle. Varied effectiveness of different plant materials revealed that the pest suppressing properties are not uniformly distributed among the tested plant materials. The leaf extract of biskatali and neem and neem oil applied on lentil seeds had comparatively better performance in the reduction of oviposition, adult emergence, intensity of infestation, mortality of beetles and seed viability. The experiment presented evidence that all the twelve plant materials were toxic to *C. chinensis* and their toxicity levels were different. Obtaining lower infestation of seeds treated with different plant materials over untreated control clearly indicated that these materials might have some mechanisms of toxic, repellents or other effects to protect lentil seeds from the attack of *C. chinensis*. However, with the finding of the present study, it may be opined that the leaf extract of biskatali and neem and neem oil may be considered at farmer's level for eco-friendly management of *C. chinensis* as they are cheaper, easily available, processable and usable. Further research might be conducted to obtain more information on the effectiveness of different plant materials in controlling pulse beetle on lentil seeds.

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