ECO-FRIENDLY MANAGEMENT OF PULSE BEETLE

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ABSTRACT

An experiment on eco-friendly approach of managing pulse beetle (Callosobruchus chinensis L.) in chickpea (Cicer arietinum L) was carried out at the Institute of Agriculture and Animal Science (IAAS), Rampur, Chitwan, Nepal from April to July, 2007. The experiment consisted of fourteen treatments laid out in two factors Completely Randomized Design (CRD) with three replications. Among them, storage structure (aluminium sheet bin and jute bag with plastic lining) was considered as one factor and pesticidal materials (Xanthoxylum armatum DC fruit dust@ 30gm kg-1; Acorus calamus L. rhizome dust@ 30 gm kg-1; Cinnamom camphora balls@ 1.5 gm kg-1; Sesamum indicum L. oil@ 5 ml kg-1; Azadirachta indica A. Juss. leaf dust@30gm kg-1; malathion dust@ 1gm kg-1 and control) was as another factor. Among six pesticidal materials tested, mortality of adult bruchids was obtained significantly higher in chickpea treated by C. camphora balls (25.17) followed by A. calamus rizome dust (24.83) and Sesamum oil (24.50). Grain damage and weight loss was nil in chickpea treated by these three materials. Among botanicals used, X. armatum fruit dust and A. indica leaf dust were found ineffective to cause adult mortality (20.33 and 19.67) and adult emergence (1549 and 2292) in chickpea. Malathion, initially was found somewhat effective in adult mortality (21.67) and adult emergence (30.33). However, it was less effective from F2 generation resulting maximum adult emergence (2127). While comparing two storage structures, jute bag with plastic lining was better in terms of maintaining lower moisture (14.64%), higher germination (65.14%) and lesser grain damage (39.95%). Thus, the jute bag with plastic lining was found as a better storage structure and botanical materials such as A. calamus rhizome dust, Sesamum oil and C. camphora balls have been found as effective safe alternatives for the management of C. chinensis L. in the storage of chickpea.

Key words: *Callosobruchus chinensis*, eco-friendly, botanical materials

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is an ancient crop that has been grown in Pakistan, India, the Middle East and parts of Africa for many years. It provides high quality protein and considered to be best food for vegetarian population in South Asia, West Asia and Southern European countries (FAO, 2005). Chickpea is used in a range of different preparations in our cuisine and has a good source of energy i.e. 416 calories/100 gm chickpea (Shrestha, 2001) along with protein (18-22%), carbohydrate (52-70%), fat (4-10%), minerals (calcium, phosphorus, iron) and vitamins (Ali and Prasad, 2002). It is another one major winter food legumes in Nepal, which covers 11770 ha land and with total production of 10439 mt (ABPSD, 2005). It stands in the sixth place in order of both area and production out of total legumes in Nepal (NGLRP, 2005). National average productive viz. 887 kg/ ha (ABPSD, 2005) is higher than the average of the South Asia (844 kg/ha) and the world (826 kg/ha) as reported by FAOSTAT (2005). Besides production constraints, post harvest loss of chickpea is very high in farmers' storage conditions. The major factor of the heavy loss of the grain legumes in the storage is pulse beetle (*C. chinensis* L.) (Southgate, 1978; Talekar, 1988). Until recently, control of bruchid is heavily relied on the use of detrimental chemical pesticides. The plant products with insecticidal properties are becoming an attractive alternative to the synthetic, dangerous and more expensive insecticide used in developing

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countries (Rajapkse et al., 1998). The study in the efficacy of various botanical materials has been carried out by different international workers (Grainge and Ahmed, 1988; Karim, 1994; Rajapkse et al., 1998; Kumari and Singh, 1998; Juneja and Patel, 1994; Shivanna et.al, 1994; Singh and Pandey, 1996; Chiranjeevi and Sudhakar, 1996; Credland, 1992; Bullerman et al., 1977; Sujatha and Punnaiah, 1985; Doharey , et al. 1988; Choudhary, 1990; Ali, et al. 1983; Budavari, 1996; Obeng et al.1998; Ho et al. 1997; Huang & Ho, 1998) but very little work has been done in Nepal. Thus, the research work was carried out to explore the efficacy of botanicals having pesticidal value for management of *C. chinensis* L. in the pulse crop. Not much works are found so far done on the effective management of pulse beetle in Nepal. The major objectives of the study is to devise a suitable and eco-friendly control measures of pulse beetle in the major production pockets of Nepal.

MATERIALS AND METHODS

The experiments were carried out at the Department of Entomology, Institute of Agriculture and Animal Science, Rampur, Chitwan, Nepal. A popular chickpea variety viz. Koseli, obtained from the National Grain Legume Improvement Program (NGLIP), Rampur, Chitwan, Nepal, was selected for the study.

MAINTENANCE AND MASS REARING OF HOST INSECTS

Live insect specimens of *C. chinensis* were collected from insect infested stores. The species was confirmed on the basis of insect morphology as described by (Khare, 1994 and Hill, 1990). Clean and non-damaged chickpea variety "Dhanush" was used for insect rearing which was obtained from the National Grain Legume Improvement Program (NGLIP), Rampur, Chitwan, Nepal. Maintenance and mass rearing of insect was performed at room temperature in Entomology Laboratory, IAAS. The culture was produced as pure culture for the inoculation into each experiment.

PREPARATION OF SEED

Variety Koseli was used in the experiment. The variety is susceptible to *C. chinensis* (L.). The bulk of chickpea seeds were fumigated with celphos give the dose or amount of tablets and volum for 72 hours. The seed lot was washed thoroughly and sun dried. Initial moisture content of the seed was recorded with the help of Multigrain Tester. Similarly, initial germination percent was evaluated using blotting paper method. At the time of experimentation, the moisture content of chickpea was 12.3% and the germination percent was 96%.

PREPARATION OF TREATMENT MATERIALS

Among the different botanicals used in the research, *A. indica* leaves and *A. calamus* were obtained from nearby village and, *X. armatum*, *C. camphora* balls as well as *Sesamum* oil were purchased from nearby market. All the botanicals (*A.indica* leaves, *A. calamus* rhizome and *X. armatum* fruits) were dried under shade, to avoid loss of active ingredients, for about 20 days until the moisture content was completely removed from those materials. Well-dried botanical materials were made powder using grinder machine as well as using mortar and pestel.

The storage structures which were used for the research work viz. aluminum sheet bin and jute bag with plastic lining were ordered in the market to be made in the mini size i.e. 2 kg capacity of aluminum sheet bin and 5 kg capacity of jute bag (9"×16") and similar sized plastic bags were purchased from local market.

EXPERIMENT ON THE MANAGEMETN OF *C. chinensis* L.

The experiment consisted of fourteen treatments laid out in two factors Completely Randomized Design (CRD) with three replications. The first factor included in the research was storage structure and second factor was pesticidal materials. Aluminium sheet bin and jute bag with plastic lining were selected as storage structures. Pesticidal materials used in the research were Timur (*Xanthoxylum armatum* D.C) fruit dust, Bojho (*Acorus calamus* L.) rhizome dust and Neem leaf (*Azadirachta indica* A Juss.) dust, all three, applied @ 30 gm kg-1; Camphor (*Cinnamomum camphora*) balls @ 1.5 gm kg-1, *Sesamum* (*Sesamum indicum* L.) oil @ 5 ml kg-1, Malthion dust @ 1g kg-1 and the last one was control treatment (without any pesticidal materials).

According to the design 21 structures of aluminium sheet bins and 21 structures of jute bags with plastic lining were used. Each structure contained half kg of chickpea. Jute bags were closed tightly with jute rope and aluminum sheet bins were capped with tight tin cap after treating with pesticidal materials and inoculating 15 pairs of newly emerged adult bruchids (in the assumption of 1:1 male female ratio).

OBSERVATION AND RECORDING OF DATA

Count of total dead adults in each experimental unit at 15 days after treatment (DAT) of adult bruchids was taken. Adult emerged (both dead and alive), in each structure at 1st and 2nd generation i.e. at 45 and 75 DAT, were counted. Counted adults were thrown out at each time. Germination percent of the seeds was taken prior to the experimental set up and also at the last of the experiment (75 DAT) using blotting paper method. For the assessment of moisture percent, multigrain tester was used and moisture content of chickpea grains was measured prior to experimental setup and 75 DAT. For the assessment of percent weight loss, 100-grain sample was taken randomly at final recording followed by counting damaged and undamaged grains. Weight of damaged and undamaged grains was recorded with the help of electronic balance.

ANALYSIS OF GERMINATION PERCENT

In order to determine the viability of seeds, a random sample of fifty grains of each treatment and replication was taken. The seeds were cleaned properly and homogeneously distributed in plastic petridish (8.8 cm dm) coated with soaked blotting paper. All the plates were placed in germination chamber under normal room temperature of 27°C. Finally, the germination percent was calculated using the following equation:

$$\text{Germination \%} = \frac{\text{No of germinated seeds}}{\text{Total no of seeds}} \times 100$$

LOSS ASSESSMENT

The activity was done simply using the count and weight method as adopted by Joost et al. (1996). For this, the number and weight of damaged and undamaged grains of composite sample of 100 grains were taken from each experimental unit at final observation. The percent weight loss was calculated using following equation:

$$\text{Percent loss in weight} = \frac{(Wu \times Nd) - (Wd \times Nu)}{Wu \times (Nd + Nu)} \times 100$$

Where, Wu = weight of undamaged grains
Nu = number of undamaged grains
Wd = weight of damaged grains
Nd = number of damaged grains

DATA MAANGEMENT AND ANALYSIS

Recorded biological parameters were arranged in EXCEL Microsoft program and statistically analyzed using MSTATC statistical package. Data with higher CV were square root transferred.

RESULTS

Effect of different treatments on death and emergence of the *C. chinensis* L.

Table 1: Effect of botanical materials in adult mortality in chickpea

Treatments	Adult mortality at 15 DAT
Storage structures (Factor 1)	
Aluminium sheet bin	21.76[a] ± 0.84
Jute bag with plastic lining	20.29[a] ± 0.84
Pesticidal materials (Factor 2)	
X. armatum fruit dust (30 gm kg^{-1})	20.33[ab] ± 1.57
A. calamus rhizome dust (30 gm kg^{-1})	24.83[a] ± 1.57
C. camphora balls (1.5 gm kg^{-1})	25.17[a] ± 1.57
Sesamum oil (5 ml kg^{-1})	24.50[ab] ± 1.57
A. indica leaf dust (30 gm kg^{-1})	19.67[b] ± 1.57
Malathion dust (1 gm kg^{-1})	21.67[ab] ± 1.57
Control	11.00[c] ± 1.57

(±) indicate standard error.

Storage structures did not show any significant effect on adult mortality but the botanical materials showed highly significant difference ($p< 0.05$) in the number of dead adults. The highest number of dead adults was observed in the structures treated with *C. camphora* balls (25.17) followed by treated with *A. calamus* (24.83) and *Sesamum* oil (24.50) and the lowest dead adults were observed in control treatment (11). Malathion had intermediate effect in causing death of adult (21.67).

Table 2: Interaction effect of storage structures and botanical materials in adult mortality in chickpea

Pesticidal materials	Aluminium sheet bin Adult mortality at 15DAT	Jute bag with plastic lining Adult mortality at 15DAT
X. armatum fruit dust (30 gm kg-1)	21.33abc ±2.22	19.33bc ±2.22
A. calamus rhizome dust (30gmkg-1)	23.33abc ±2.22	26.33ab ±2.22
C. camphora balls (1.5 gm kg-1)	24.00abc ±2.22	26.33ab ±2.22
Sesamum oil (5 ml kg-1)	27.67a ±2.22	21.33abc ±2.22
A. indica leaf dust (30 gm kg-1)	22.00abc ±2.22	17.33cd ±2.22
Malathion dust (1 gm kg-1)	23.00abc ±2.22	20.33abc ±2.22
Control	11.00d ±2.22	11.00d ±2.22

(±) indicate standard error

The significant differences were not observed on the number of dead adults in different combination of storage structures and pesticidal materials especially with *A. calamus* rhizome dust (23.33; 26.33), *Sesamum* oil (27.67; 21.33) and *C. camphora* balls (24.00; 26.33) and also with other pesticides too.

Table 3: Effect of botanical materials in adult emergence in chickpea

Treatments	Adult emergence at 75 DAT
Storage structures (Factor 1)	
Aluminium sheet bin	1534[a] ± 109.40
Jute bag with plastic lining	1519[a] ± 109.40
Pesticidal materials (Factor 2)	
X. armatum fruit dust (30 gm kg^{-1})	1549[c] ± 204.60
A. calamus rhizome dust (30 gm kg^{-1})	4.00[d] ± 204.60
C. camphora balls (1.5 gm kg^{-1})	2.67[d] ± 204.60
Sesamum oil (5 ml kg^{-1})	0.00[d] ± 204.60
A. indica leaf dust (30 gm kg^{-1})	2292[b] ± 204.60
Malathion dust (1 gm kg^{-1})	2127[bc] ± 204.60
Control	4713[a] ± 204.60

(±) indicate standard error

No any significant effect was shown by the storage structures in adult emergence too. In case of pesticidal materials, till 2nd generation (75 DAT), number of adult emerged was lowest in chickpea treated with *Sesamum* oil (0.00) followed by *C. camphora* balls (2.66) and *A. calamus* rhizome dust (4.00). Highest number of adults were emerged in control treatment condition (4713) followed by with *A. indica* leaf dust (2292) and malathion dust (2127). Initially, though malathion was somehow effective in causing death of adult (21.67), it could not control the adult emergence later.

Storage structures i.e. aluminium sheet bin and jute bag with plastic lining did not show any significant difference in adult emergence, too, when combined with *A. calamus* rhizome dust (7.33; 0.67), *Sesamum* oil (0.00; 0.00) and *C. camphora* balls (5.33; 0.00) till second generation of the insect (75 DAT). But, significant difference ($p < 0.05$) was seen with the combination of less effective pesticidal materials. Higher number of adult emergence were recorded in the treatment combination of *A. indica* leaf dust (3510) and *X. armatum* fruit dust (2545) with aluminium sheet bin over botanical materials (1074; 552.70) in the jute bag with plastic lining. Similar significant result was obtained from storage structures when combined with Malathion too.

In case of percent weight loss too, significant difference was not observed in the combination of storage structures and pesticidal materials. Only the significant difference in weight loss was assessed in the combination of *X. armatum* fruit dust and aluminium sheet bin (15.93) and jute bag with plastic lining (2.72).

Table 4: Interaction effect of storage structures and botanical materials in percent weight loss in chickpea at 75 DAT

Pesticidal materials	Aluminium sheet bin	Jute bag with plastic lining
	% weight loss	% weight loss
X. armatum fruit dust (30 gm kg^{-1})	15.93^{abc} ±9.43 (3.68^{ab})	2.72^{bc} ±9.43 (1.56^{b})
A. calamus rhizome dust (30 gm kg^{-1})	0.00^{c} ±9.43 (0.71^{b})	0.00^{c} ±9.43 (0.71^{b})
C. camphora balls (1.5 gm kg^{-1})	0.00^{c} ±9.43 (0.71^{b})	0.00^{c} ±9.43 (0.71^{b})
Sesamum oil (5 ml kg^{-1})	0.00^{c} ±9.43 (0.71^{b})	0.00^{c} ±9.43 (0.71^{b})
A. indica leaf dust (30 gm kg^{-1})	30.53^{ab} ±9.43 (4.98^{a})	32.50^{ab} ±9.43 (5.01^{a})
Malathion dust (1 gm kg^{-1})	27.10^{abc} ±9.43 (4.87^{a})	45.27^{a} ±9.43 (6.76^{a})
Control	38.44^{a} ±9.43 (6.06^{a})	46.04^{a} ±9.43 (6.58^{a})

(±) indicate standard error

Table 5: Interaction effect of storage structures and botanical materials in moisture percent of chickpea at 75 DAT

Pesticidal materials	Aluminium sheet bin	Jute bag with plastic lining
	Moisture percent	Moisture percent
X. armatum fruit dust (30 gm kg^{-1})	17.93^{b} ±0.70	15.27^{cd} ±0.70
A. calamus rhizome dust (30 gm kg^{-1})	13.73^{cdef} ±0.70	12.57^{ef} ±0.70
C. camphora balls (1.5 gm kg^{-1})	13.80^{cdef} ±0.70	13.33^{def} ±0.70
Sesamum oil (5 ml kg^{-1})	13.80^{cdef} ±0.70	12.40^{f} ±0.70
A. indica leaf dust (30 gm kg^{-1})	20.30^{a} ±0.70	15.77^{c} ±0.70
Malathion dust (1 gm kg^{-1})	19.40^{ab} ±0.70	14.77^{cde} ±0.70
Control	19.53^{ab} ±0.70	18.40^{ab} ±0.70

(±) indicate standard error

In the case of moisture percent, jute bag maintained significantly lower moisture (14.64) of chickpea seeds than aluminium sheet bin (16.93). Pesticidal materials, too, showed highly significant difference in maintenance of moisture percent of chickpea till 75 DAT. As initial moisture percent of chickpea was 12.30, *Sesamum* oil (13.10), *A. calamus* (13.15) and *C. camphora* (13.57) were found excellent to maintain the moisture percent of chickpea seeds till the end of the experimental period. *X. armatum* (16.60) showed better performance in maintaining moisture percent as compared to *A. indica* leaf dust (18.03).

On working out with interaction effect, the significant difference was resulted due to the interaction effect of storage structure and botanical plant materials at 75 DAT except with *A. calamus*, *C. camphora* and *S. indicum*. In case of treatment with malathion dust, *A. indica* and *X. armatum*, moisture percent was significantly lower in chickpea stored in jute bag with inner plastic lining (14.77; 15.77 and 15.27 respectively) than that stored in aluminium sheet bin (19.40; 20.30 and 17.93 respectively).

DISCUSSIONS

EFFICACY OF BOTANICALS AGAINST *Callosobruchus chinensis* L.

Botanical materials resulted significant difference over other treatments in terms of adult mortality, adult emergence, percent grain damage, percent weight loss, moisture content and germination percent. Among them, *Sesamu*m oil, *C. camphora* balls and *A. calamus* rhizome dust were found to have excellent efficacy in terms of different seeds qualities. Out of 30 adults inoculated in each experimental units, maximum number of dead adults was found with *C. camphora* balls (25.17), *A. calamus* rhizome dust (24.83) and *Sesamum* oil (24.50) followed by malathion (21.67) at 15 DAT. *X. armatum* fruit dust showed intermediate effect in adult mortality (20.33) whereas *A. indica* leaf dust did not give satisfactory result (19.67). Adult emergence was also very low in the seed treated with *Sesamum* oil (0.00) followed by *C. camphora* balls (2.67) and *A. calamus* rhizome dust (4.00) at 75 DAT. *X. armatum* fruit (1549) dust and *A. indica* leaf dust (2292) were not much effective in controlling adult emergence. Similar finding was reported by Malla (2006) that *A. indica*, *Melia azadarach*, *Eucalyptus* and *X. armatum* were not effective in reducing weevil population, moisture content, grain damage, weight loss and germination.

Singh et al. (1979) reported that the vegetable oil is active against eggs and larva and cause unable to oviposit or cause mortality of the adult bruchids. Only small amount of oil is needed to preserve the grains for months (1-5 ml oil kg-1 of grains). Credland (1992) examined the structure of bruchid eggs and suggested that the funnel structure at the posterior pole of bruchid eggs may be the major route for gaseous exchange. It was proposed that application of oil to bruchid eggs might occlude the funnel, and thus lead to the death of the developing insect by asphyxiation. Doharey, et al. (1988) reported that *Sesamum* oil 0.5 % (w/w) applied to green gram reduced the number of eggs laid by C. maculates F. and prevented F1 emergence. Ali, et al. (1983) reported that *Sesamum* oil @1 ml/100 g applied to gram caused 100 % mortality in adult *C. chinensis* L. within three days and completely prevented egg laying and the emergence of F1 adults.

Budavari (1996) reported that camphor is a natural compound derived from the camphor tree (*C. camphora*). It has a familiar and penetrating odour, and a slightly bitter and cooling taste. Obeng et al. (1998) reported that it is very good repellent to four species of stored-products beetles (*Sitophilus granaries* (Motsch.), *S. zeamais*, *Trilobium castaneum* (Herbst), *Prostephanus truncatus*). Oliveira & Vendramim (1999) reported that cinnamon oil, when applied at 0.5% concentration, reduced numbers of the beetle *Zabrotes subfasciatus* feeding on bean seeds by 96%. Ho et al. (1997) and Huang & Ho (1998) found that the extracts of cinnamon were also highly repellent to the stored-products beetles *T. castaneum* and *S. zeamais*.

Malathion, initially was effective in causing death of adults (21.67) and controlling adult emergence, but in long run (from F2 generation), malathion failed to minimize adult emergence (2127). Most probably, this may be due to resistance developed by the bruchid against malathion. DARP (2003) reported that malathion resistance in stored product insect-pests was found from all over the world and currently, there are 122 insect-pest species, which are found as resistant to this insecticide.

Baral (2002) reported more number of populations and more weight loss (21.7 %) even more than control (16.55 %) in *A. indica* leaf powder treated grains, where as in *A. calamus*, it was nil. *A. calamus* was found even more effective than malathion in controlling *S. oryzae* in wheat seed storage (Panthee, 1997a). *A. calamus* is an herb, which does not have any negative effect on human health and environment and available easily, which is likely to be accepted by the farmers (Panthee, 1997b). A compound ß- asarone with an insecticidal activity was found in *A. calamus* rhizome thought to be responsible for the mortality of weevils (Paneru et al., 1997). Chiranjeevi and Sudhakar (1996) reported that *A. calamus* powder prevented egg laying at 1.0 part per 100 parts of seed (w/w) and reduced the development at higher concentrations in other treatments [1.5 and 2.0 parts per 100 parts (w/w)]. The egg laying capacity of the pest and total number of adults emerging decreased with increase in concentrations of the powder.

Percent grain damage and percent weight loss were very much low, almost no damage and no loss in chickpea treated with *C. camphora* balls, *A. calamus* rhizome dust and *Sesamum* oil. Shivanna et.al, (1994) trialed *A. calamus* at 0.5, 1.5 and 2.5 g-50g of seeds as pre-storage treatments against *C. chinensis* on red gram (*Cajanus cajan*). He measured fecundity; adult emergence and percent grain weight loss and found that the *A. calamus* powder applied at all 3 rates gave maximum protection against all 3 generations of the pest.

Choudhary (1990) reported that 1 % *Sesamum* oil (w/w) applied to chickpea and stored for six months significantly reduced egg laying by *C. chinensis* L. and prevented seed damage. Timur showed the intermediate effect whereas *A. indica* leaf dust and malathion found to be poor. Baral (2002) found that 17 % grain damage by *A. indica* leaf dust treated but 0 % in bojho treated grains in 70 days against C. maculatus (F.).

Similarly moisture percent and germination percent were highly maintained in chickpea treated by *Sesamum* oil (13.10; 95.00), *C. camphora* balls (13.57; 93.67) and *A. calamus* rhizome dust (13.15; 93.33) till the end of the experiment as initial moisture percent and germination percent of chickpea was 12.30 and 96.00 respectively. *A. indica* leaf dust was poor for maintaining moisture percent (18.03) and germination percent (31.67). Malathion, too, could not show better performance in maintaining moisture percent (17.08) and germination percent (33.67). *X. armatum* fruit dust was intermediate among them.

COMPARATIVE STUDY OF STORAGE STRUCTURES

In the interaction with *A. calamus*, *C. camphora* and *Sesamum* oil, both the structures gave the similar excellent results. (Panthee, 1997a) reported that jute bag with inner plastic lining and tin were the best structures for wheat seed storage. Das et al. (1994) found that viability of the maize grain was the highest in polythene lined jute bag and traditional tin after 12 months of storage.

But, with the ineffective materials, as in case of *X. armatum* fruit dust, jute bag with plastic lining showed better performance in terms of percent grain damage (32.67), percent weight loss (2.72), moisture percent (15.27) and germination percent (73.33) in chickpea as compared to aluminium sheet bin (85.33, 15.93, 17.93, 48.00 respectively). Similar pattern of interaction effect was shown by other ineffective material like *A. indica* leaf dust, malathion dust and also in case of control treatment. Mall (2006) reported that the moisture of the maize grain was increased in all treatments but less in jute bag with inner plastic lining. Guritno et al. (1991) reported that moisture content of the shelled corn initially at 14 % increased to about 15.8 % and 15.5 % in jute and polypropylene bags, respectively after 90 days of storage at 90 % RH and 26.7 0 C. The low population of weevil and less grain infestation may be due to the low seed moisture absorption in jute bag with inner plastic lining because higher the seed moisture, higher the insect population. Rao et al. (1972) mentioned that polyster- polythene (400 gauge) lined canvas was resistant to all insect pests of stored grain. The use of polythene and polythene lined jute bags stored paddy safely for 6 months and gunny bags covered with non-porous polythene sheet served as barrier against storage insects (Prakash and Rao, 1987). The plastic coating or inner lining may acted as barrier against water, moisture vapor, gases and other chemicals (Khare, 2004). It might be due to weevil population and moisture content of the seed grain was less in jute bag with inner plastic lining. Baral (2002) reported high population build up of C. maculatus (F.) in the storage structure mud khote, jute bag and cloth bag consequences more kernel damage of cowpea seed, less germination, less 100-grain weight and less weight loss. This study has indicated similar result, where highest population was found in plastic bag, plastic jar and jute bag with increased loss, where as in jute bag with inner plastic lining resulted less population with less reduction in weight.

CONCLUSIONS

Among botanical materials tested, three safe botanical materials such as *A. calamus* rhizome dust @30g kg-1, *C. camphora* balls @1.5g kg-1 and *Sesamum* oil @5ml kg-1 can be explored as excellent alternatives over the poisonous pesticides for the management of *C. chinensis* L. in storage of chickpea. Both storage structures can give excellent result in combination of these three safe botanicals but analyzing the interaction effect of storage structures especially with less effective pesticidal materials i.e. *X. armatum* fruit dust, *A. indica* leaf dust and malathion dust, it can be concluded that jute bag with plastic lining can perform better than aluminium sheet bin and can be used as an idle storage structure.

Thus, both storage structures in combination with three safe botanical pesticides can be promoted as eco-friendly measures for the management of bruchid in chickpea and other related pulses. It is hoped they will reduce the development of pest resistance against malathion and detrimental effects of chemical fumigants used in storage structures.

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REFERENCES

ABPSD, 2005. Statistical information on Nepalese agriculture. Ministry of Agriculture and Cooperatives, Agri-Business Promotion and Statistic Division, Singh Durbar, Kathmandu, Nepal.

Ali, S. I. and R. Prasad, 2002. Rabi pulses: chickpea, lentil, Lathyrus and French bean. **In**: R. Prasad (ed.), Textbook of Field Crops Production. New Delhi: Directorate of Information and Publication of Agriculture, Indian Council of Agriculture Research, pp. 317-371.

Ali, S. I., O. P. Singh and U. S. Mishra, 1983. Effectiveness of plant oils against pulse beetle *Callosobruchus chinensis* Linn. Ind. J. of Ent., 45(1):6-9.

Baral, S., 2002. Study on host prefeffernce and eco-friendly management of cowpea beetle (*Callasobruchus maculatus* F., Coleoptera: Bruchidae) in Chitwan. MSc Thesis submitted to the Institute of Agriculture and Animal Science, Chitwan, Nepal.

Budavari, S. (ed), 1996. The Merck Index: An Encyclopedia of Chemicals, Drugs and Biologicals (twelveth edition). Whitehouse Station (NJ): Merck, PP. 1741.

Bullerman, L. B., F. Y. Lieu and S. A. Seier, 1977. Inhibition of growth and aflatoxin production by cinnamon and clove oils, cinnamic aldehyde and eugenol. J. of Food Sci., 46: 967-977.

Chiranjeevi, C. and T. R. Sudhakar, 1996. Effect of indigenous plant materials on the fecundity, adult emergence and development of pulse beetle (*Callosobruchus chinensis* L.) in black gram. J. of Res. ANGRAU., 24(3/4): 57-61.

Choudhary, B. S., 1990. Residual effect of eight vegetable oils in chickpea against pulse beetle (*Callosobruchus chinensis* Linnaeus). Indian J. of Plant Protec., 18: 89-91.

Credland, P., 1992. The structure of bruchid eggs may explain the ovicidal effect of oils. J. of Stored. Prod. Protec., 28(1): 1-9.

DARP, 2003. Database of Arthropods Resistant to Pesticides, Resistant Pest Management at Michigan State University. Available at: http:// www.pesticideresistance.org/DB/.

Das, U. R, M. I. M. Bhuiyah, J. C. S. Chaudhury and M. H. Islam, 1994. Effect of four selected indoor containers on insect damage and viability of stored seeds of three maize varieties. Bangladesh J. of Agri. Res., 19: 85-92.

Doharey, R. B., R. N. Katiyar and K. M. Singh, 1990. Eco-toxicological studies on pulse beetles infesting green gram. Bulletin of Grain Technology, 28(2): 116-119.

FAO, 2005. Year Book. Food and Agriculture Organization of the United Nations.

FAOSTAT, 2005. Statistical data on agricultural production. Crop Protection Compendium (data available in CD).

Grainge, M. and S. Ahmed, 1988. Handbook of Plants with Pest Control Properties. New York:John Wiley and Sons.

Guritno, P., E. Haque and D. S. Chung, 1991. Moisture absorption of store grain under tropical conditions. Transactions of the ASAE, 34: 2131-2134.

Hill, D. S., 1990. Pest of Stored Products and Their Control. London: Belhaver Press.

Ho, S. H., Y. Ma, H. T. W. Tan and H. Halid, 1997. Repellency of some plant extracts to the stored products beetles *Tribolium castaneum* Herbst and *Sitophilus zeamais* Motsch. Proceedings of the symposium on pest management for stored food and feed, BIOTROP (Special Publication), 59: 209-215.

Huang, Y. and S. H. Ho, 1998. Toxicity and antifeedant activities of cinnamaldehyde against the grain storage insects *Tribolium castaneum* Herbst and *Sitophilus zeamais* Motsch. J. of Stored Prod. Res., 34:11-17.

Joost, G., R. Harnisch and O. Muck, 1996. Manual on the preservation of post harvest grain losses. Post-harvest project, RFG.

Juneja, R. P. and J. R Patel, 1994. Botanicals materials as protectants of green gram, *Vigna radiata* L. Wilczek against pulse beetle *Callosobruchus analis* Fabr. Gujrat J. Agri. Univ.Res., 20(1): 84-87.

Karim, A. N. M. R., 1994. Status of botanical pest control in Bangladesh. Paper presented at the expert consultation on regional perspective for use of botanical pesticides in Asia and the Pacific, Bangkok, Thailand.

Khare, B. K., 1994. Storage Grain Pests and Their Management. India: Kalyani Publishers.

Khare, B. P., 2004. Stored grain pests and their management. Ludhiyana (India): Kalayani Publishers.

Malla, R. K., 2006. Integrated management components of maize weevil *Sitophilus zeamais* Motschulsky during storage in Chitwan. MSc thesis submitted to the Institute of Agriculture and Animal Science, Chitwan, Nepal.

NGLRP, 2005. Annual report. National Grain Legumes Research Program, Nepal Agricultural Research Council, Rampur, Chitwan, Nepal.

Obeng, O. D., C. H. Reichmuth,A. J. Bekele and A. Hassanali, 1998: Toxicity and protectant potential of camphor, a major component of essential oil of *Ocimum kilimandscharicum*, against four stored product beetles. Int. J. of Pest Mgmt., 44: 203-209.

Oliveira, J. V. and J. D. Vendramim, 1999. Repellency of essential oils and powders from plants on adults of *Zabrotes subtasciatus* Boh. on bean seeds. Anais da Sociedade Entomologica do Brasil, 28(3): 549-555.

Paneru, R. B., V. R. Duwadi and R. Khanal, 1997. Study on the effect of different doses of bojho (*A. calamus*) rhizome dust against weevil on stored wheat grains. Report No.173, Pakhribas Agriculture Centre, Dhankuta, Nepal.

Panthee, D. R.,1997a. Identification of a suitable indigenous storage structure for wheat seed storage. J. Inst. Agric. and Anim. Sci., 17-18: 55-62.

Panthee, D. R., 1997b. Efficacy of different indigenous pesticides for wheat seed storage. J. Inst. Agric. and Anim. Sci., Rampur, Chitwan. 17-18: 71-76.

Prakash, A., J. Rao, I. C. Pasalu and K. C. Mathur, 1987. Rice Storage and Insect Pest Management. Delhi: B. R. publishing corporation.

Rajapkse, R., S. G. J. N. Senanayake and D. Rathasekara, 1998. Effect of five botanicals on oviposition, adult emergence and mortality of *Callosobruchus maculates* F. infesting cow pea *Vigna ungiculata* L. Walp. J. Ent. Res., 22:117-122.

Shivanna, S., S. Lingappa and B.V. Patil, 1994. Effectiveness of selected plant materials as protectants against pulse beetle, *Callosobruchus chinensis* (Linn.) during storage of redgram. Karnataka J. of Agric. Sci., 7(3):285-290.

Shrestha, U. K., 2001. Need for chickpea cultivation in Nepal. **In**: S. Pande, C. Johansen, P. C. Stevenson and D. Grzwacz (eds.), Proceedings of the international workshop on planning and implementation of on farm IPM of chickpea in Nepal, 6-7 September, 2001, Kathmandu, pp.33-47. Natural Resource Institute, UK and International Crops Research Institute for the Semi-Arid Tropics, India.

Singh, S. C. and N. K. Pandey,1991. Effect of neem leaf powder on infestation of the pulse beetle, *Callosobruchus chinensis* Linn. in stored chickpea. J. of Appl. Zool. Res., 7(1): 49-50.

Singh, V. N., N. D. Pandey and Y. P. Singh, 1994. Effectiveness of vegetable oils on the development of *Callosobruchus chinensis* L. infesting stored grain. Indian J. Ent., 56 (3):216-219.

Southgate, B. J., 1978. The importance of the Bruchidae as pests of grain legumes, their distribution and control. **In**: S. R. Singh, H. F. Van Emden and T. A. Taylor (Eds.), Pests of Grain Legumes: Ecology and Control. London: Academic Press, pp. 219-229.

Sujatha, A. and K. C. Punnaiah, 1985. Effect of coating stored seed of greengram with vegetable oils on the development of pulse beetle. Indian J. Agric. Sci., 55(7):475-477.

Talekar, N. S., 1988. Biology, damage and control of bruchid pest of mungbean. Mungbean: Proceeding of the Second International Symposium. Asian Vegetable Research and Development Centre, Shanhua, Taiwan. AVRDC Publication No. 88-304.

Thirumeran, A. S. and M. A. Seralathan, 1988. Utilization of Mungbean. **In**: S. Shanmugasunderam and B. T. Mclean (Eds.), Mungbean: Proceedings of the Second Internatoinal Symposium. Asian Vegetable Research and Development Centre, Shanhua, Taiwan. AVRDC Publication No. 88-304.