Eco-Friendly Management of Pulse Beetle, *Callosobruchus chinensis* Linn. Using Fumigants on Stored Mungbean

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Abstract- The experiment was conducted in the laboratory under the Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from April to July, 2011 to find out the eco-friendly management of pulse beetle, *Callosobruchus chinensis* Linn. on stored mungbean using some promising fumigants viz. Camphor @ 1.0 g /kg mungbean grains (T_1), Phostoxin tablet @ 200 mg /kg mungbean grains (T_2) and Naphthalene @ 500 mg /kg mungbean grains (T_3) and control (T_4). The experiment was laid out in Completely Randomized Design with four replications. From this study, it was observed that the treatment T_1 comprised with Camphor @ 1.0 g /kg mungbean grains reduced the highest percent of grain infestationby number and weight (49.65% & 49.54%, respectively) over control than other fumigants. Conversely, T_1 reduced the highest percent of adult emergence (77.66%) and grain content loss (95.18%) over control, but increased the highest percent of seed germination (26.57%) over control. Therefore, it can be concluded that Camphor @ 1.0 g /kg mungbean grains was the most effective control measure applied against pulse beetle, *C. chinensis* on stored mungbean.

Index Terms- Callosobruchus chinensis Linn., eco-friendly management, fumigants.

I. Introduction

Pulses serve as one of the main sources of protein and minerals as well as play a vital socio-economic role in the diet of common people of Bangladesh. Among pulses, mungbean, *Vigna radiata* Linn. Wileazek has come up an important pulse crop in Bangladesh. It contains 51% carbohydrate, 26% protein, 4% minerals, 3% vitamins (Yadav *et al.*, 1994). Its sprout is a high quality vegetable and rich in vitamin-C and iron. Mungbean plant fixes atmospheric nitrogen in symbiosis with soil bacteria to enrich soil fertility as well as it provides useful fodder (Afzal *et al.*, 2004). The traders mostly store the pulses at least for few months before they sell it. Unfortunately, in storage, pulses suffer enormous losses due to bruchid attack, which infestation starts either in the field on the maturing pod and is carried to the stores with the harvested crops or it originates in the storage itself (Fletcher and Ghosh, 2002). Three species of pulse beetles, viz., *Callosobruchus chinensis* Linn., *C. analis* Fab., and *C. maculatus* Fab. have been reported from Bangladesh as the pests of stored pulses (Begum *et al.*, 1984; Rahman *et al.*, 1981 and Alam, 1971). However, Alam (1971) reported that *Callosobruchus chinensis* to cause enormous losses to almost all kind of pulses in storage condition. Rahman (1971) reported 12.5% loss due to pulse beetles infestation in pulses stored in warehouses. Ali *et al.* (1999) reported that mungbean, *Vigna radiata* appeared to be the most common and suitable host for *C. chinensis* in respect of oviposition, egg deposition, adult emergence (66.11-70.29%) and caused 50.37 - 57.58% grain content loss in storage. Synthetic chemicals have become a common practice among the farmers and stockholders to control the storage pests of pulses (Dilwari *et al.*, 1991; Chandra *et al.*, 1989; Singh *et al*., 1989; Prakash and Rao, 1983; Yadav, 1983). It is now widely known that the chemical method has several problems, which include health hazards to the users and grain consumers. It causes residual toxicity, environmental pollution and development of pesticide resistance against bruchids (Srivastava, 1980). Hence, search for the alternative method of pulse beetle control utilizing some non-toxic, environment friendly and human health hazard free methods are being pursued such as fumigants. In Bangladesh Camphor ($C_{10}H_{16}O$) that extracted from the leaves and wood of Camphor tree (*Cinamomum camphora*). Chauvin *et al.* (1994) reported that camphor has fumigation properties and has got a very low mammalian toxicity. Rahman *et al.,* (2001) reported the fumigation action of camphor against pulse beetle, *C. chinensis.* Miah (2007) reported that camphor @ 2 gm/kg seeds performed the best results in respect of percent reduction (100%) of larvae and pupae, grain infestation and grain content loss over control for both *C. chinensis*. In Bangladesh, very little study has so far been reported on the efficacy of camphor against pulse beetles. Another fumigant, the phostoxin is available in the market at its tablet or pellet form. The chemical name phostoxin is aluminium phosphide (Onu and Aliyu, 1995),which is used as a rodenticide, insecticide, and fumigant for stored cereal grains (Mahadi and Hamoudi, 2010). Naphthalene is a household fumigant also, which build up vapors that are toxic to both the adult and larval forms of many insects that attack textiles (Bryn, 2002) and other stored products. In considering hazards free management of *C. chinensis* using fumigants in storage aiming to assess the extent of damage of stored mungbean grains infested by *C. chinensis* as well as determining the efficacy of some fumigants against this insect pest.

II. Materials and Methods

The study was conducted to explore the efficacy of fumigants camphor, phostoxin tablet and naphthalene for eco-friendly management of pulse beetle, *Callsobruchus chinensis* L.on stored mungbean grain in the laboratory under the Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period of April, 2011 to July, 2011. The experiment was laid out in the ambient condition of the laboratory considering Completely Randomized Design (CRD) and the experiment was replicated four times for each treatment. Each of three fumigants was treated as an individual treatment. One kg of mungbean grains for each of the treatment was kept in plastic pot covered with lead. Camphor was applied at the rate of 1.0 g /kg mungbean grains, Phostoxin tablet was applied at the rate of 200 mg /kg mungbean grains and Naphthalene was applied at the rate of 500 mg /kg mungbean grains. Besides these fumigants, one untreated control was also considered. The experiment was replicated four times for each of the treatments. The hundred pairs of adult pulse beetle, *C. chinensis* Linn. were released in the mungbean grains kept in all plastic containers, which were then covered with their lids and preserved in ambient temperature of the laboratory up to 120 days after insect release (DAIR) for recording data. The data on grain infestation by number and weight, adult emergence, grain content loss, and seed germinations were recorded. The data were collected and recorded at 20 days intervals started from 20 DAIR and continued up to 120 DAIR. The percent grain infestation and percent reduction of grain infestation over control were then calculated using the following formulae (Khosla, 1997):

$$\% \text{ grain infestation} = \frac{\text{Number of infested grains}}{\text{Number of total grains observed}} \times 100$$

$$\% \text{ reduction of grain infestation over control} = \frac{X_2 - X_1}{X_2} \times 100$$

Where, X_1 = Mean value of treated pot, X_2 = Mean value of untreated pot

III. RESULTS AND DISCUSSION

The study was conducted to find out the efficacy of some promising fumigants viz. camphor, phostoxin tablet and naphthalene for eco-friendly management of pulse beetle, *Callosobruchus chinensis* Linn. infesting mungbean in the laboratory under the Department of Entomology at Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from April, 2011 to July, 2011. The findings of the study have been interpreted and discussed under the following sub-headings:

Effect of fumigants on grain infestation by number

The significant variations were observed among different fumigant based management practices in terms of percent grain infestation by number throughout the storing period starting from 20 to 120 (DAIR) considering 20 days interval during the management of pulse beetle, *C. chinensis* on mungbean. In case of 20 DAIR, the highest grain infestation by number (45.73%) was recorded in T_4 comprised of untreated control, which was statistically different from all other treatments followed by T_3 (31.57%) comprised of napthlene (Table I). On the other hand, the lowest grain infestation by number (20.29%) was recorded in T_1. In case of 40 DAIR, the highest grain infestation by number (51.40%) was recorded in T_4 comprised of untreated control, which was statistically different from all other treatments followed by T_3 (32.04%) (Table I). On the other hand, the lowest grain infestation (22.59%) was recorded in T_1 (36.79%) followed by T_2 (28.51%). More or less similar trends of results were also recorded in case of 60, 80, 100 and 120 DAIR in terms of percent grain infestation by number. Considering the mean grain infestation by number, the highest grain infestation (51.81%) was recorded in T_4, which was statistically different from all other treatments followed by T_3 (34.77%). On the other hand, the lowest grain infestation (26.09%) was recorded in T_1 followed by T_2 (29.47%). In case of grain infestation reduction over control, the highest reduction (49.65%) was recorded in T_1 followed by T_2 (43.13%). On the other hand, the lowest grain infestation reduction (32.89%) was recorded in T_3.

Table I: Effect of fumigants on the mungbean grain infestation by number aganist *C. chinensis*during April to July, 2011

Treatments	% Grain infestation by number							%infestation reduction over control
	20 *DAIR	40 DAIR	60 DAIR	80 DAIR	100 DAIR	120 DAIR	Mean	
T_1	20.29d	22.59d	24.63d	29.28c	29.76c	29.98c	26.09d	49.65
T_2	27.80c	28.51c	29.45c	30.17c	30.23c	30.63c	29.47c	43.13
T_3	31.57b	32.04b	33.17b	35.98b	37.12b	38.74b	34.77b	32.89
T_4	45.73a	51.40a	52.17a	52.58a	53.05a	55.93a	51.81a	--
$LSD_{(0.05)}$	1.37	1.01	1.32	2.06	1.58	1.62	1.99	--
CV(%)	2.12	2.38	3.20	3.22	3.04	3.15	3.27	--

*DAIR= Days after insect release. Figures in a column accompanied by similar letter(s) do not differ significantly at 0.05 level of probability as per DMRT. [T_1=Camphor @ 1 g/kg mungbean grain, T_2=Phostoxin @ 200 mg/kg mungbean grain, T_3=Napthlene @ 500 mg/kg mungbean grain, T_4= Untreated control]

From the above findings it was revealed that among three fumigant based treatments, the T_1 comprised of camphor @ 1 g/kg mungbean grain performed as the best treatment, which reduced the highest grain infestation (49.65%) over control followed by T_2 (43.13%) comprised of phostoxin @ 200 mg/kg grain. On the other hand, the lowest grain infestation reduction over control (32.89%) was achieved in T_3 comprised of napthalene @ 500 mg/kg grain. The order of efficacy of different fumigants against *C. chinensis* in terms of grain infestation reduction by number is $T_1 > T_2 > T_3$. Another findings obtained by Ahmed *et al*. (2006) was similar. They experimented in mungbean seeds and were stored for two years in different containers with two types of chemicals (naphthalene and camphor) and two types of indigenous materials (sand and neem leaf powder). They observed that camphor provided better protection than other materials for all the containers and storage period.

Effect of fumigants on grain infestation by weight

The significant variations were observed among different fumigants based management practices in terms of grain infestation by weight throughout the storing period starting from 20 to 120 DAIR considering 20 days interval during the management of pulse beetle, *C. chinensis* on mungbean. In case of 20 DAIR, the highest grain infestation was recorded in T_4 (42.08%) which was statistically different from all other treatments followed by T_3 (31.25%) (Table II). On the other hand, the lowest grain infestation (19.17%) was recorded in T_1. In case of 40 DAIR, the highest grain infestation by weight (43.75%) was recorded in T_4 which was statistically different from all other treatments followed by T_3 (32.92%) (Table II). On the other hand, the lowest grain infestation was recorded in T_1 (20.00%). More or less similar trends of results were also recorded in case of 60, 80, 100 and 120 DAIR in terms of percent grain infestation by weight. Considering the mean grain infestation by weight, the highest grain infestation (46.11%) was recorded in T_4, which was statistically different from all other treatments followed by T_3 (34.86%). On the other hand, the lowest grain infestation was recorded in T_1 (23.27%). In case of grain infestation reduction over control, the highest reduction (49.54%) was recorded in T_1 followed by T_2 (26.80%). On the other hand, the lowest grain infestation reduction (24.40%) over control was recorded in T_3.

Table II: Effect of fumigants on the mungbean grain infestation by weight aganist *C. chinensis* during April to July, 2011

Treatment	% Grain infestation by weight							%infestation reduction over control
	20 *DAIR	40 DAIR	60 DAIR	80 DAIR	100 DAIR	120 DAIR	Mean	
T_1	19.1d	20.0c	22.5c	25.00c	26.2c	26.67c	23.27c	49.54
T_2	26.6c	31.6b	32.5b	36.25b	37.5b	37.92b	33.75b	26.80
T_3	31.2b	32.9b	33.3b	35.00b	38.3b	38.33b	34.86b	24.40
T_4	42.0a	43.7a	45.8a	47.08a	47.9a	50.00a	46.11a	--
LSD $_{(0.05)}$	1.15	1.68	1.88	1.49	2.01	1.81	1.65	--
CV(%)	3.22	3.62	3.29	2.55	3.23	2.86	3.85	--

*DAIR= Days after insect release. Figures in a column accompanied by similar letter(s) do not differ significantly at 0.05 level of probability as per DMRT. [T_1=Camphor @ 1 g/kg mungbean grain, T_2=Phostoxin @ 200 mg/kg mungbean grain, T_3=Napthlene @ 500 mg/kg mungbean grain, T_4= Untreated control]

From the above findings it was revealed that among three fumigant based treatments, T_1 comprised of camphor @ 1 g/kg grain performed as the best treatment, which reduced the highest grain infestation (49.54%) over control followed by T_2 (26.80%) comprised of phostoxin tablet @ 200 mg/kg grain. On the other hand, the lowest grain infestation reduction (24.40%) over control was achieved by T_3 comprised of napthlene @ 500 mg/kg mungbean grain. The order of efficacy of different fumigants against *C. chinensis* in terms of grain infestation reduction by weight is $T_1 > T_2 > T_3$. Ahmed *et al*. (2006) found similar findings in mungbean seeds taht were stored for two years in different containers with two types of chemicals (naphthalene and camphor) and two types of indigenous materials (sand and neem leaf powder). They observed that camphor provided better protection than other materials for all the containers and storage period.

Effect of fumigants on the adult emergence of *C. chinensis*

The significant variations were observed among different fumigant based management practices in terms of adult emergence by number throughout the storing period starting from 40 to 120 DAIR considering 20 days interval during the management of pulse beetle, *C. chinensis* on mungbean. In case of 40 DAIR, the highest number of adult emergence was recorded in T_4 (3.67/10 infested seed) which was statistically different from all other treatments followed by T_3 (0.67/10 infested seed) (Table III). On the other hand, no adult was emerged from T_1 (0.00/10 infested seed) and T_2 (0.00/10 infested seed).In case of 60 DAIR, the highest number of adult emergence (6.00/10 infested seed) was recorded in T_4 which was statistically different from all other treatments followed by T_3 (1.00/10 infested seed) (Table III). On the other hand, the lowest number of adult emergence was recorded in T_1 (0.33/10 infested seed). More or less similar trends of results were also recorded in case of 60, 80, 100 and 120 DAIR in terms of adult emergence by number of pulse beetle during its management.Considering the mean adult emergence, the highest number of adult emergence (6.27/10 infested seed) was recorded in T_4, which was statistically different from all other treatments followed by T_3 (1.73/10 infested seed). On the other hand, the lowest number of adult emergence was recorded in T_1 (1.40/10 infested seed). In case of adult emergence reduction over control, the highest reduction (77.66%) was recorded in T_2 followed by T_1 (74.47%).

On the other hand, the lowest adult emergence reduction (72.37%) was recorded in T_3.

Table III: Effect of fumigants on adult emergence during 40 days after insect release to 120 days after insect release of *C. chinensis*

Treatment	Adult emergence (No./10 infested seeds)					Mean	%reduction over control
	40 *DAIR	60 DAIR	80 DAIR	100 DAIR	120 DAIR		
T_1	0.00c	0.33c	0.67d	2.33b	3.67b	1.40c	77.66
T_2	0.00c	0.33c	1.67b	2.33b	3.67b	1.60b	74.47
T_3	0.67b	1.00b	1.33c	2.33b	3.33c	1.73b	72.37
T_4	3.67a	6.00a	6.67a	7.33a	7.67a	6.27a	--
$LSD_{(0.05)}$	0.03	0.08	0.07	0.09	0.08	0.18	--
CV(%)	2.67	3.34	3.23	3.66	3.11	3.25	--

*DAIR= Days after insect release. Figures in a column accompanied by similar letter(s) do not differ significantly at 0.05 level of probability as per DMRT. [T_1=Camphor @ 1 g/kg mungbean grain, T_2=Phostoxin @ 200 mg/kg mungbean grain, T_3=Napthlene @ 500 mg/kg mungbean grain, T_4= Untreated control]

From the above findings it was revealed that among three fumigant based treatments, the T_1 comprised of camphor @ 1 g/kg mungbean grain performed as the best treatment, which reduced the highest adult emergence by number (77.66%) over control followed by T_2 (74.47%) comprised of phostoxin @ 200 mg/kg grain. On the other hand, the lowest adult emergence reduction over control (72.37%) was achieved by T_3 comprised of napthalene @ 500 mg/kg grain. The order of efficacy of different fumigants against *C. chinensis* in terms of adult emergence reduction is $T_1 > T_2 > T_3$. Similar finding was found by Latif *et al*. (2005) in case of rice weevil, *Sitophilus oryzae* Linn. (Curculionidae: Coleoptera) in parboiled polished rice grains against camphor and they found that there exists a very sharp difference. The LD_{50} camphor against adult, egg, larva and pupa was the lowest.

Effect of fumigants on the grain content loss

Percent (%) grain content loss was also significantly varied among different fumigants applied against pulse beetle, *C. chinensis* during its management.

Table IV: Effect of fumigants on mungbean grain content loss during 120 days after insect release of *C. chinensis*

Treatment	% grain content loss by weight	%grain content loss reduction over control
T_1	2.33c	95.18
T_2	3.00b	93.79
T_3	3.00b	93.79
T_4	48.33a	--
$LSD_{(0.05)}$	0.06	--
CV(%)	3.12	--

Figures in a column accompanied by similar letter(s) do not differ significantly at 0.05 level of probability as per DMRT. [T_1=Camphor @ 1 g/kg mungbean grain, T_2=Phostoxin @ 200 mg/kg mungbean grain, T_3=Napthlene @ 500 mg/kg mungbean grain, T_4= Untreated control]

After the completion of the experiment (i.e. at 120 DAIR), it was observed that the highest grain content loss was achieved by T_4 (48.33%), which was statistically different from all other treatments followed by T_2 (3.00%) (Table IV). On the other hand, the lowest grain content loss (2.33%) was observed in T_1. In case of grain content loss reduction over control, the highest reduction (95.18%) was recorded in T_1, which was more or less similar but significant with other two fumigants such as T_2 (93.79) and T_3 (93.79). From the above findings it was revealed that among three fumigant based treatments, the T_1 comprised of camphor @ 1 g/kg grain performed as the best treatment, which reduced the highest grain content loss (95.18%) over control. On the other hand, the lowest grain content loss reduction over control (93.79%) was achieved by T_2 comprised of phostoxin tablet @ 200 mg/kg grain. The order of efficacy of different fumigants against *C. chinensis* in terms of grain content loss reduction is $T_1 > T_2$, T_3. The better performance from camphor under the present study might be due to cause of its chemical action which is comparatively better than the others against pulse beetle in mungbean and gave ultimately the best results. Here camphor effectively reduced the pulse beetle infestation and that causes reduced grain content loss.

Effect of fumigants on germination of mungbean seed

The significant variations were also observed among three fumigant based management practices in terms of percent seed germination throughout the storing period starting from 20 to 120 DAIR considering 20 days interval during the management of pulse beetle, *C. chinensis* on mungbean. In case of 20 DAIR, the maximum seed germination was recorded in T_1 (94.67%) which was statistically identical with all other treatments (Table V). On the other hand, the lowest seed germination in T_4 (84.67%).In case of 40 DAIR, the maximum seed germination (94.00%) was observed in T_1 which was statistically different from all other treatments followed by T_2 (92.67%) (Table V). On the other hand, the lowest seed germination was recorded in T_4 (77.33%). More or less similar trends of results were also recorded in case of 60, 80, 100 and 120 DAIR in terms of percent mungbean seed germination.

Table V: Effect of fumigants on the germination of mungbean during 20 days after insect release to 120 days after insect release of *C. chinensis*

Treatment	% seed germination							%germination increase over control
	20 *DAIR	40 DAIR	60 DAIR	80 DAIR	100 DAIR	120 DAIR	Mean	
T_1	94.6a	94.0a	93.3a	90.6a	90.0a	90.0a	92.1a	26.57
T_2	94.6a	92.6b	91.3b	90.6a	90.0a	89.3a	91.4b	25.65
T_3	92.6b	91.3c	91.0b	90.0a	90.0a	87.3b	90.3c	24.20
T_4	84.6c	77.3d	73.3c	70.0b	67.3b	64.0c	72.7d	--
LSD $_{(0.05)}$	0.31	0.18	0.26	0.21	0.38	0.26	0.22	--
CV(%)	3.17	3.39	3.29	2.55	3.69	3.16	3.63	--

*DAIR= Days after insect release. Figures in a column accompanied by similar letter(s) do not differ significantly at 0.05 level of probability as per DMRT. [T_1=Camphor @ 1 g/kg mungbean grain, T_2=Phostoxin @ 200 mg/kg mungbean grain, T_3=Napthlene @ 500 mg/kg mungbean grain, T_4= Untreated control]

Considering the mean germination, the maximum seed germination (92.11%) was recorded in T_1, which was statistically different from all other treatments followed by T_2 (91.45%). On the other hand, the lowest percent germination in T_4 (72.78%). In case of increase in percent germination of mungbean seed over control, the highest increase (26.57%) was recorded in T_1 followed by T_2 (25.65%). On the other hand, the lowest percent germination increase (24.20%) was recorded in T_3.

From the above findings it was revealed that among three fumigant based treatments, the T_1 comprised of camphor @ 1 g/kg mungbean grain performed as the best treatment, which increased the maximum seed germination (26.57%) over control followed by T_2 (25.65%) comprised of phostoxin tablet @ 200 mg/kg grain. On the other hand, the lowest grain germination increase over control (24.20%) was achieved by T_3 comprised of napthlene @ 200 mg/kg grain. The order of efficacy of different fumigants in terms of seed germination increase over control is T_1> T_2> T_3. Generally seed viability is damaged with insect infection during storage condition. The better performance from camphor under the present study in terms of seed viability might be due to cause of its chemical action which is comparatively better than the others fumigant materials that were used against pulse beetle in mungbean and gave ultimately the best results. Similar findings were also found by Ahmed *et al*. (2006).

Considering the findings of the study, on stored mungbean camphor may be recommended for eco-friendly management of *Callosobruchus chinensis* Linn.

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