Eco-Friendly Management of Pulse Beetle, *Callosobruchus chinensis* Linn. Using Botanicals 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 botanicals viz. dried leaf powder of neem @ 2.5 g/kg mungbean grains (T_1), bishkatali @ 2.5 g/kg mungbean grains (T_2), marigold @ 2.5 g/kg mungbean grains (T_3), dholkolmi @ 2.5 g/kg mungbean grains(T_4), chopped garlic bulb @ 1.0 g/kg mungbean grains (T_5) along with control (T_6). 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 dried leaf powder of neem @ 2.5 g/kg mungbean grains reduced the highest percent of grain infestation by number and weight (43.12% & 41.72%, respectively) over control than other botanicals. Conversely, T_5 reduced the highest percent of adult emergence (43.65%) and grain content loss (49.91%) over control, but increased the highest percent of seed germination (25.65%) over control. Therefore, it can be concluded that dried leaf powder of neem @ 2.5 g/kg mungbean grains was the most effective control measure applied against pulse beetle, *C. chinensis* on stored mungbean.

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). Plant-derived materials are more readily biodegradable, less toxic to mammals, more selective in action, and retard the development of resistance. 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 now-a-days. In Bangladesh, as many as 54 plant species have been evaluated for their bio-efficacy against different insect pests, pathogens and weeds (Karim, 1994). Bhuiyah (2001) reported that the oils of neem, royna and castor at 6 and 8 ml/kg and leaf powder of bishkatali, marigold and castor at 5% w/w were most effective in preventing the egg laying in lentil and chickpea and leaf powder of bishkatali, marigold, castor and mango at 5% were most effective in reducing the adult emergence in lentil and chickpea, whereas the adult emergence were nil in pre and post storage release methods. In considering hazards free management of *C. chinensis* using botanicals 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 botanicals against this insect pest

II. MATERIALS AND METHODS

The study was conducted to explore the efficacy of five botanicals viz. T_1=dried leaf of neem (*Azadirachta indica*), T_2=bishkatali (*Polygonum hydropiper* L.), T_3=marigold (*Calendula officinalis*), T_4=dholkolmi (*Ipomoea carnea)* and T_5=bulb of garlic (*Allium sativum*) applied against pulse beetle, *C. chinensis* L. infesting stored mungbean in the laboratory under the Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka 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 five botanicals was treated as an individual treatment. One kg of mungbean grains for each of the treatment was kept in plastic pot covered with lead. The dried leaf powder of neem, bishkatali, marigold and dholkolmi were applied at the rate of 2.5 g/kg (0.25% w/w) mungbean grains, where bulb of garlic was applied at the rate of 1 g/kg mungbean grains. Besides these botanicals, 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 botanicals viz. dried neem leaf powder, dried bishkatali leaf powder, dried marigold leaf powder, dried dholkolmi leaf powder and bulb of garlic 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 botanicals on grain infestation by number

The significant variations were observed among different botanical based management practices in terms of percent grain infestation by number throughout the storing period starting from 20 to 120 days after insect release (DAIR) considering 20 days interval during the management of pulse beetle, *C. chinensis* on mungbean. In case of 20 DAIR, the highest grain infestation (45.73%) was observed in T_6, which was statistically different from all other treatments followed by T_3 (40.57%). This was also followed by T_2 (31.57%) and T_5 (31.18%) (Table I). On the other hand, the lowest grain infestation (27.19%) was found in T_1 followed by T_4 (30.31%). In case of 40 DAIR, the highest grain infestation (51.40%) was recorded in T_6, which was statistically different from all other treatments followed by T_3 (46.32%). This was also followed by T_2 (37.12%) and T_4 (36.98%) (Table I). On the other hand, the lowest grain infestation (27.20%) was recorded in T_5 (36.79%). 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_6, which was statistically different from all other treatments followed by T_3 (48.41%). This was also followed by T_2 (39.47%). On the other hand, the lowest grain infestation (29.47%) in T_4 (38.24%) and T_5 (39.10%). In case of grain infestation reduction over control, the highest reduction (43.12%) was recorded in T_1 followed by T_4 (26.20%) and T_5 (24.54%). On the other hand, the lowest grain infestation reduction (6.57%) was observed in T_3 followed by T_2 (23.83%).

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

Treatment	% Grain infestation by number							% infestation reduction over control
	20 *DAIR	40 DAIR	60 DAIR	80 DAIR	100 DAIR	120 DAIR	Mean	
T_1	27.1e	27.2d	28.1d	29.5e	31.7e	33.0e	29.47e	43.12
T_2	31.5c	37.1c	38.8c	42.8c	42.6c	43.7c	39.47c	23.83
T_3	40.5b	46.3b	48.3b	50.7b	51.9b	52.5b	48.41b	6.57
T_4	30.3cd	36.9c	38.9c	40.5d	40.7d	41.9d	38.24d	26.20
T_5	31.1c	36.7c	39.7c	41.8c	41.9c	43.2c	39.10c	24.54
T_6	45.7a	51.4a	52.1a	52.5a	53.0a	55.9a	51.81a	--
$LSD_{(0.05)}$	1.32	1.22	1.02	1.11	1.35	0.94	0.91	--
CV(%)	3.32	2.16	3.14	3.24	3.11	2.54	3.26	--

*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=Dried neem leaf powder @ 2.5 g/kg mungbean grain, T_2= Dried bishkatali leaf powder @ 2.5 g/kg mungbean grain, T_3= Dried marigold leaf powder @ 2.5 g/kg mungbean grain, T_4= Dried dholkolmi leaf powder @ 2.5 g/kg mungbean grain. T_5=Bulb of garlic@1g/kg grain, T_6=Untreated control]

From the above findings it was revealed that among five botanical based treatments, the T_1 comprised of dried neem leaf powder @ 2.5 g/kg grain performed as the best treatment, which reduced the highest grain infestation (43.12%) over control followed by T_4 (26.20%) comprised of dried dholkolmi leaf powder @ 2.5 g/kg grain. On the other hand, the lowest grain infestation reduction over control (6.57%) was achieved in T_3 comprised of dried marigold leaf powder @ 2.5 g/kg grain followed by T_2 (23.83%) comprised of dried bishkatali leaf powder @ 2.5 g/kg grain. The order of effectiveness of different botanicals aganist *C. chinensis* in terms of percent reduction of grain infestation by number is $T_1 > T_4 > T_5 > T_2 > T_3$. More or less similar findings were also found by several researchers. Babu *et al*. (1989) reported that among neem, karanja, mustard, groundnut and castor oils, the karanja oil (5 and 10 ml/kg) and castor oil (10 l/kg) effectively reduced the oviposition by the *C. chinensis* under conditions of artificial infestation. After 24 months of storage, the infestation of neem oil treated seed was significantly lower. Similar findings were also obtained by Veer-Singh and Yadav (2003) and Dhakshinamoorthy and Selvanarayanan (2002) and they found that neem treatment against pulse beetle was more effective.

Effect of botanicals on grain infestation by weight

The significant variations were observed among different botanical based management practices in terms of percent 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 found in T_6 (42.08%), which was statistically different from all other treatments followed by T_3 (38.75%) and also followed by T_4 (36.25%) and T_2 (33.33%) (Table II). On the other hand, the lowest grain infestation by weight in T_1 (22.25%) followed by T_5 (27.19%). In case of 40 DAIR, the highest grain infestation (43.75%) was also recorded in T_6, which was statistically different from all other treatments followed by T_3 (42.92%) (Table II). This was also followed by T_4 (37.92%) and T_2 (35.00%). On the other hand, the lowest grain infestation was found in T_1 (22.08%). More or less similar trend of results were also observed 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_6, which was statistically different from all other treatments followed by T_3 (45.07%). This was also followed by T_4 (39.79%). On the other hand, the lowest grain infestation by weight was found in T_1 (26.88%) followed by T_5 (35.35%). In case of grain infestation reduction over control, the highest reduction (41.72%) was recorded in T_1 followed by T_5 (23.35%) and T_2 (15.67%). On the other hand, the lowest grain infestation reduction (2.25%) was recorded in T_3 followed by T_4 (13.70%).

Table II: Effect of botanicals on the mungbean grain infestation by weight against *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	21.25f	22.08f	23.33e	27.92e	32.92e	33.75d	26.88e	41.72
T_2	33.33d	35.00d	38.33c	40.83c	41.25c	44.58b	38.89c	15.67
T_3	38.75b	42.92b	45.00b	46.25b	47.75b	49.75a	45.07ab	2.255
T_4	36.25c	37.92c	38.33c	40.00c	41.67c	44.58b	39.79c	13.70
T_5	28.75e	32.08e	35.00d	37.08d	38.33d	40.83c	35.35d	23.35
T_6	42.08a	43.75a	45.83a	47.08a	47.92a	50.00a	46.11a	--
$LSD_{(0.05)}$	0.48	0.65	1.02	1.10	0.86	1.27	0.94	--
CV(%)	3.02	3.36	2.28	3.58	3.18	3.34	2.27	--

*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=Dried neem leaf powder @ 2.5 g/kg mungbean grain, T_2= Dried bishkatali leaf powder @ 2.5 g/kg mungbean grain, T_3= Dried marigold leaf powder @ 2.5 g/kg mungbean grain, T_4= Dried dholkolmi leaf powder @ 2.5 g/kg mungbean grain. T_5=Bulb of garlic@1g/kg grain, T_6=Untreated control]

From the above findings it was revealed that among five botanical based treatments, the T_1 comprised of dried neem leaf powder @ 2.5 g/kg grain also performed best result, which reduced the highest grain infestation (41.72%) over control followed by T_5 (23.35%) comprised of bulb of garlic @ 1.0 g/kg grain. On the other hand, the lowest grain infestation reduction over control (2.25%) was achieved in T_3 comprised of dried marigold leaf powder @ 2.5 g/kg grain followed by T_4 (13.70%) comprised of dried dholkolmi leaf powder @ 2.5 g/kg grain. The order of effectiveness of different botanicals against *C. chinensis* in terms of grain infestation reduction by weight is $T_1 > T_5 > T_2 > T_4 > T_3$. Similar findings were also obtained by Veer-Singh and Yadav (2003) and Dhakshinamoorthy and Selvanarayanan (2002) and they found that neem treatment against pulse beetle was more effective.

Effect of botanicals on the adult emergence of *C. chinensis* during its management

The significant variations were observed among different botanical based management practices in terms of adult emergence 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_6 (3.67/10 infested grains) which was statistically different from all other treatments followed by T_1 (3.33/10 infested grains) and also followed by T_2 (3.00/10 infested grains) (Table III). On the other hand, the lowest number of adult emergence was recorded in T_5 (1.00/10 infested grains) followed by T_3 (2.00/10 infested grains). In case of 60 DAIR, the highest number of adult emergence (6.00/10 infested grains) was recorded in T_6, which was statistically different from all other treatments followed by T_2 (5.33/10 infested grains) (Table III). This was also followed by T_1 (5.00/10 infested grains) and T_4 (4.67/10 infested grains). On the other hand, the lowest adult emergence was recorded in T_5 (3.33/10 infested grains). More or less similar trends of results were also recorded in case of 80, 100 and 120 DAIR regarding the number of adult emergence of pulse beetle during its management. Considering the mean adult emergence, the highest number adult emergence (6.27/10 infested grains) was recorded in T_6, which was statistically different from all other treatments followed by T_2 (5.33/10 infested grains). This was also followed by T_1 (5.13/10 infested grains). On the other hand, the lowest number of adult emergence was recorded in T_5 (3.53/10 infested grains) followed by T_4 (4.93/10 infested grains). In case of adult emergence reduction by number over control, the highest reduction (43.65%) as recorded in T_5 followed by T_4 (21.28/%) and T_1 (18.12%). On the other hand, the lowest adult emergence reduction by number (14.90%) was recorded in T_2 followed by T_3 (17.04%).

Table III: Effect of botanicals 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)						Percent reduction over control
	40 DAIR	60 DAIR	80 DAIR	100 DAIR	120 DAIR	Mean	
T_1	3.33b	5.00c	5.00d	5.33d	7.00c	5.13b	18.12
T_2	3.00c	5.33b	5.67c	6.00c	6.67d	5.33b	14.90
T_3	2.00d	4.00e	6.00b	6.67b	7.33b	5.20b	17.04
T_4	3.00c	4.67d	4.67e	5.33d	7.00c	4.93c	21.28
T_5	1.00d	3.33f	4.00f	4.33e	5.00e	3.53d	43.65
T_6	3.67a	6.00a	6.67a	7.33a	7.67a	6.27a	--
$LSD_{(0.05)}$	0.03	0.04	0.04	0.03	0.05	0.21	--
CV(%)	2.03	3.02	3.64	3.43	3.00	3.11	--

*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=Dried neem leaf powder @ 2.5 g/kg mungbean grain, T_2= Dried bishkatali leaf powder @ 2.5 g/kg mungbean grain, T_3= Dried marigold leaf powder @ 2.5 g/kg mungbean grain, T_4= Dried dholkolmi leaf powder @ 2.5 g/kg mungbean grain. T_5=Bulb of garlic@1g/kg grain, T_6=Untreated control]

From the above findings it was revealed that among five botanical based treatments, the T_5 comprised of bulb of garlic @ 1.0 g/kg grain performed as the best treatment, which reduced the highest adult emergence by number (43.65%) over control followed by T_4 (21.28%) comprised of dried dholkolmi leaf powder @ 2.5 g/kg grain. On the other hand, the lowest adult emergence reduction over control (14.90%) was achieved by T_2 comprised of dried bishkatali leaf powder @ 2.5 g/kg grain followed by T_3 (17.04%) comprised of dried marigold leaf powder @ 2.5 g/kg grain. The order of effectiveness of different botanicals against *C. chinensis* in terms of adult emergence reduction by number is $T_5 > T_4 > T_1 > T_3 > T_2$. The results obtained from Saxena and Saxena (2009) was not similar. They found that neem kernel was more effective than garlic. Two per cent concentration of garlic solvents also showed 50% mortality in mungbean crops. Similar result was also found by Singal and Chauhan (2008).

Effect of botanicals on the grain content loss caused by *C. chinensis*

Grain content losses by weight were significantly varied by different botanicals applied against pulse beetle, *C. chinensis* during its management. After 4 months (i.e. 120 DAIR), it was observed that the highest grain content loss was found in T_6 (48.33%), which was statistically different from all other treatments followed by T_3 (42.67%) and T_4 (34.00%) (Table IV). On the other hand, the lowest grain content loss by weight (24.21%) was recorded in T_5 followed by T_2 (28.55%). In case of grain content loss reduction over control, the highest reduction (49.91%) was recorded in T_5 followed by T_2 (40.93%) and T_1 (33.44%) (Table IV). On the other hand, the lowest grain content loss reduction over control (11.71%) was recorded in T_3 followed by T_4 (29.65%).

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

Treatment	% grain content loss by weight	% grain content loss reduction over control
T_1	32.17d	33.44
T_2	28.55e	40.93
T_3	42.67b	11.71
T_4	34.00c	29.65
T_5	24.21e	49.91
T_6	48.33a	--
$LSD_{(0.05)}$	1.03	--
CV(%)	2.00	--

Figures in a column accompanied by similar letter(s) do not differ significantly at 0.05 level of probability as per DMRT. [T_1=Dried neem leaf powder @ 2.5 g/kg mungbean grain, T_2= Dried bishkatali leaf powder @ 2.5 g/kg mungbean grain, T_3= Dried marigold leaf powder @ 2.5 g/kg mungbean grain, T_4= Dried dholkolmi leaf powder @ 2.5 g/kg mungbean grain. T_5=Bulb of garlic@1g/kg grain, T_6=Untreated control]

From the above findings it was revealed that among five botanical based treatments, the T_5 comprised of bulb of garlic @ 1.0 g/kg grain performed as the best treatment, which reduced the highest grain content loss (49.91%) over control followed by T_2 (40.93%) comprised of dried bishkatali leaf powder @ 2.5 g/kg grain. On the other hand, the lowest grain content loss reduction over control (11.71%) was achieved in T_3 comprised of dried marigold leaf powder @ 2.5 g/kg grain followed by T_4 (29.65%) comprised of dried dholkolmi leaf powder @ 2.5 g/kg grain. The order of effectiveness of different botanicals against *C. chinensis* in terms of grain infestation reduction is $T_5 > T_2 > T_1 > T_4 > T_3$. Under the present study, garlic showed the best result and it might be due to cause of its pungent smell and also its chemical properties that cause reduced attack of pulse beetle and as a result of lowest grain content loss.

Effect of botanicals on viability mungbean of seed

The significant variations were observed among different botanical based management practices in terms of percent germination by number of mungbean seed 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_5 (94.67%), which was statistically different from all other treatments followed by T_1 (92.67%) and also followed by T_4 (88.67%) (Table V). On the other hand, the minimum percent seed germination in T_6 (84.67%) followed by T_2 (88.00%). In case of 40 DAIR, the maximum germination by number (92.67%) was recorded in T_5 which was statistically different from all other treatments followed by T_3 (82.67%) (Table V). This was also followed by T_4 (80.00%) and T_1 (78.67). On the other hand, the minimum seed germination was recorded in T_6 (77.33%) followed by T_1 (78.67). More or less similar trends of results were also recorded in case of 60, 80, 100 and 120 DAIR in terms of per cent germination of mungbean seed. Considering the mean germination, the maximum germination of mungbean seed (91.45%) was observed in T_5, which was statistically different from all other treatments followed by T_3 (79.00%). This was also followed by T_1 (78.89%). On the other hand, the minimum germination was found in T_6 (72.78%) followed by T_2 (75.33%). In case of seed germination increase over control, the highest increase (25.65%) was recorded in T_5 followed by T_3 (8.55%) and T_1 (8.40%). On the other hand, the lowest percent germination increase (3.51%) over control was recorded in T_2 followed by T_4 (5.65%).

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

Treatment	% seed germination by number							% germination increase over control
	20 DAIR	40 DAIR	60 DAIR	80 DAIR	100 DAIR	120 DAIR	Mean	
T_1	92.6b	78.6d	78.0b	76.0b	76.0b	72.0c	78.8b	8.40
T_2	88.0c	78.6d	76.0d	71.3d	70.0d	68.0e	75.3d	3.51
T_3	88.0c	82.6b	78.6b	75.3c	76.0b	73.3b	79.0b	8.55
T_4	88.6c	80.0c	77.3c	75.3c	70.67d	69.3d	76.8c	5.65
T_5	94.6a	92.6a	91.3a	90.6a	90.0a	89.3a	91.4a	25.65
T_6	84.6d	77.3e	73.3e	70.0e	67.3e	64.0f	72.7e	--
$LSD_{(0.05)}$	0.68	0.74	0.82	0.64	0.66	0.58	0.67	--
CV(%)	3.12	2.66	2.10	3.38	2.11	3.00	3.01	--

*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=Dried neem leaf powder @ 2.5 g/kg mungbean grain, T_2= Dried bishkatali leaf powder @ 2.5 g/kg

mungbean grain, T_3= Dried marigold leaf powder @ 2.5 g/kg mungbean grain, T_4= Dried dholkolmi leaf powder @ 2.5 g/kg mungbean grain. T_5=Bulb of garlic@1g/kg grain, T_6=Untreated control]

From the above findings it was revealed that among five botanical based treatments, the T_5 comprised of bulb of garlic @ 1.0 g/kg grain performed as the best treatment, which increased the highest seed germination (25.65%) over control followed by T_3 (8.55%) comprised of dried marigold leaf powder @ 2.5 g/kg grain. On the other hand, the lowest seed germination increase over control (6.57%) was found in T_2 comprised of dried bishkatali leaf powder @ 2.5 g/kg grain followed by T_4 (5.65%) comprised of dried dholkolmi leaf powder @ 2.5 g/kg grain. The order of effectiveness of different botanicals against *C. chinensis* in terms of seed germination increase is $T_5 > T_3 > T_1 > T_4 > T_2$. This result might be due to cause of garlic's repulsive and chemical characters that cause reduced infestation of grains and resulted highest germination of seeds.

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

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