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Assessment of eco-friendly approaches for pulse beetle *Callosobruchus chinensis* L. on mungbean

Nirma Pawara, Sanjeev Bantewad and Kanchan Shete

Abstract
Assessment of different eco-friendly approaches for their efficacy against pulse beetle (*Callosobruchus chinensis* L.) on mungbean under storage condition during the year 2017-18 at Department of Entomology, Agril. Research Station, Badnapur. Based on the biological parameters of the pulse beetle viz., (Oviposition, number of holes, adult emergence, per cent insect infestation and per cent weight loss), significant variation was observed among the treatments with respect to seed damage. Among the treatments castor oil @ 5 ml/kg was found significantly superior over the others and followed by karanj oil @ 5 ml/kg seeds and sesamum oil @ 5 ml/kg seed were found effective against pulse beetle for minimum ovipositional preference, adult emergence, seed infestation and weight loss etc. All the treatments found to be superior over untreated control. In eco-friendly protectants can be used as sustainable, safer human and environment, alternative to protectants for long term storage of pulses. Hence, they may be recommended in food security programme as eco-friendly alternatives of synthetic pesticides against pulse beetle of mungbean.

Keywords: *Callosobruchus*, botanicals, mungbean, eco-friendly approaches

Introduction
Greengram (*Vigna radiata* L.) belonging to the family leguminaceae commonly known as mungbean or moong is grown in the Asian subcontinent. It is the third important pulse crop of India after chickpea and pigeon pea.

One of the eco-friendly and economic approaches to keep the stored food grains free from insect attack, is the use of plant products as grain protectants. The growing awareness of environmental hazards due to synthetic insecticides has attracted attention towards products of plant origin. Plant products are known to have many advantages, as they are safe to environment and consumer. Inability of the insect pest to develop resistance against them is an added advantage. There are encouraging reports on the use of certain indigenous plant products as grain protectants and impregnation of packaging materials with plant products. These conventional practices needed scientific evaluation. This situation dictates the need for safe, locally available and less expensive materials for pest control in storage. There are encouraging reports on the use of certain indigenous plant products as grain protectants (Bajiya, 2010 and Sharma, 2014) [3, 17] but definite information on mortality doses, efficacy of oils and extracts by treatment of packaging materials and direct feeding with the seed and their residual life is meager, hence needs detailed investigations.

The main causes of low yield in greengram are due to its indeterminate growth, non-synchronous maturity and losses due to pests and diseases. Feeding by insect larvae and adult accounts to 35 % of the crop losses annually which accounted to billions of rupees every year. Bruchids are a major and growing problem in stored green gram in all regions. They are most often not detected until seed has been stored for a reasonable period (*e.g*. for longer than three months). They breed rapidly in storage and by the time they are detected, the infested grain is usually unmarketable. Bruchid infestation results in substantial reduction in the quantity and quality of the seed. Although bruchids start attacking seeds of host plants in the field, there is only minor damage. However, when the infested seeds that harboured bruchid larvae at varying stages of development are stored, the adults emerge and lay eggs on neighboring seeds.

The most destructive bruchid species to green gram are *Callosobruchus chinensis* (Linn.) and *C. maculatus* (Fabricius.) both belonging to order Coleoptera, family Bruchidae. *Callosobruchus chinensis* is a direct pest affecting stored green gram causing quantitative and

qualitative loss. Feeding of larvae on the cotyledons causes significant loss in seed weight and viability. It reduces the biochemical characters for seed quality which leads to lack of storability of seeds in storage. The larvae of the bruchid feed on the pulse seed contents reducing their degree of usefulness making them unfit either for planting or for human consumption (Ali *et al.*, 2004) [1].

It was reported that when mixed with stored-grains, leaf, bark, seed powder or oil extracts reduce oviposition rate and suppress adult emergence of bruchids, and also reduced seed damage rate (Keita *et al*., 2001; Shaaya *et al*., 1997; Onu and Aliyu, 1995 and Talukder and Howse, 1994) [9, 16, 13, 20]. Bhuiyah (2001) [5] reported that the oils of neem, royna and castor at 6 and 8 ml/kg and leaf powder of marigold and castor at 5% w/w were most effective in preventing the egg laying in lentil and chickpea and leaf powder of 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 order to preserve the seed material several measures have been employed from time to time. To manage this storage pest, different strategies are tried by the scientists. But still it continued to be a threatening pest in storage. The use of pesticides has been employed by the farmers. Though this pesticides have positive effect on the pests, they continued to remain hazardous to man and the environment. With the objective of providing quality food for general public the interest of this research have been directed towards finding alternative to pesticide that are environmentally friendly and does not pose dangers to man. 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 pulse beetle.

Material and Methods

This experiment conducted in Completely Randomized Design with eight treatments and three replications by using the mungbean variety BM 2003-2 against pulse beetle *(Callosobruchus chinensis*) during the year 2017-18 at Department of Agril. Entomology, ARS, Badnapur, under laboratory conditions. The treatment details are as given below as T_1 castor oil @ 5 ml/ kg seed, T_2 Karanj oil @ 5 ml/ kg seed, T_3 sesamum oil @ 5 ml/ kg seed, T_4 neem seed kernel powder @ 10 g/ kg seed, T_5 cow dung cake ash @ 10 g/ kg seed, T_6 custard leaf powder @ 10 g/kg seed, T_7 tobacco leaf powder @ 10 g/kg seed and T_8 untreated control etc.

Preparation of treatment material

Among the different botanicals used in the research viz. *A. indica* and *Annona reticulate, Nicotiana tabacum,* were obtained from nearly village and sesamum oil, karanj oil, castor oil were purchased from market and cow dung collected from caw shed. All the botaniacals *(A. indiaca, Annona reticulate & Nicotiana tabacum)* were dried under shade, to avoid loss of active ingredients, for 20 days until the moisture content was completely removed from those material and make powder using grinder machine.

External identification of male and female bruchids

Male and female can be identified on the basis of their antennae. Males are having pectinate antennae and pygidium without dark patches. While females are having strongly serrate antennae and pygidium with two dark patches, one on each side of the line. Generally female is slightly larger than male. The length of male adult measured with an average 3.25 ± 0.23 mm and breadth is 2.16 ± 0.05mm whereas the length and breadth of female adult measured with an average 3.60 ± 0.08mm 2.02 ± 0.04mm, respectively (Devi and Devi, 2014).

Application of the treatments

Mass culture of *C. chinensis* was maintained in the laboratory for experimental purpose. Half kg (500g) of freshly harvested seeds with moisture content (<10%) was taken for each treatments and seeds with treatments material as per the required quantity was taken.

Procedure

500g mungbean seeds for each treatment taken in one kg capacity of plastic container. However, treatment material in adequate quantity was added in the plastic container then mix thoroughly by hand by inoculating 15 pair of adult pulse beetle in the plastic container. Then the plastic container covered with muslin cloth tide with rubber band. The procedure was repeated thrice for each treatment. These plastic containers were stored under ambient condition.

The observations was recorded on per cent mortality, No. of adult emergence, per cent grain damage and per cent weight loss etc.

First observation was recorded 48 hours after release of insects on per cent mortality of beetle's upto 15 DAT. Moribund insect was taken as dead. Whatever the egg laid on each container upto 100 per cent mortality of released pulse beetle, adult emerged (both live and dead) in each container at 1st and 2nd generation i.e. 45 and 75 DAT, was count. Counted adults were thrown out at each time.

Per cent adult mortality

Number of survived and dead insects was collected, counted and recorded after 48 hrs interval upto 15 DAT after release of insects. Moribund insects were taken as dead. Per cent mortality of *C. chinensis* was calculated with the help of following formula.

$$\text{Mortality (\%)} = \frac{\text{No. of dead beetle}}{\text{Total no. of released beetle}} \times 100$$

Number of eggs laid by pulse beetle

Average number of eggs per grain laid by pulse beetle was calculated to check the effect of treatment on its oviposition/fecundity. Ten grain was randomly selected from each replication and eggs laid on those grains were counted. At end, their average was calculated to determine number of eggs per grain in each jar.

No. of adult emergence

The 45 DAT and 75 DAT plastic container was observe for the no. of adult emerged (both live and dead) counted the F_1 generation and F_2 generation respectively and recorded. Counted adults were thrown out at each time. The per cent adult emergence was calculated using following formulae (Howe, 1971) [8].

$$\text{Adult emergence (\%)} = \frac{\text{No. of adult emerged}}{\text{No. of eggs laid}} \times 100$$

Number of holes on seed by pulse beetle

Average number of holes per grain was calculated by counting the number of holes made by pulse beetle. For this, Ten grain was randomly selected from each jar and holes on those grains were counted. Then average was taken to determine number of holes per grain in each replication.

Per cent seed infestation

Total number of seed counted then number of seed damaged by pulse beetle was recorded and infestation was calculated with the following formula.

$$\text{Per cent seed infestation} = \frac{\text{No. of damaged grains}}{\text{Total no. of grains}} \times 100$$

Per cent seed weight loss

The number and weight of damaged and undamaged grains of composite sample of 100 grains was taken from each experimental unit at final observation. The per cent weight loss was calculated using following equation:

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

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

Results and Discussions

1. Per cent adult mortality of pulse beetle

The results obtained in respect to per cent adult mortality of the pulse beetles (Table 1) at 2, 4, 6, 8 and 10 day after treatments under different botanical oils and plant products *viz.* castor oil, karanj oil, sesamum oil, neem seed kernal powder, cow dung cake ash, custard leaf powder and tobacco leaf powder etc. The highest per cent adult mortality was recorded on treatments castor oil @ 5 ml/kg of seeds i.e. (41.11 per cent, 32.22 per cent and 26.66 per cent) adult mortality at 2, 4 and 6 days after treatments, respectively. The next effective treatments as karanj oil @ 5ml/kg of seed of (33.33 per cent, 32.22 per cent, 27.77 per cent and 6.66 per cent) adult mortality at 2, 4, 6 and 10 days after treatments. The lowest adult mortality was observed on 2, 4, 6, 8 and 10 day untreated control. The findings of present investigation are in close conformity with of Bhargava and Meena (2002) who evaluated the efficacy of six vegetables oil viz., castore, mustard, groundnut, sesamum, coconut and sunflower against *C. chinensis* (L.) on cowpea and reported that castor oil was most effective which caused 80.7 % mortality at the highest dose of 1.0 ml/ 100 g seeds. Similarly, Dhakshinamoorthy and Selvanarayan (2002) [7] results revealed that the mortality of the beetle at 7 days after treatment was highest (100 per cent) in castor oil, followed by neem leaf powder (91.66 per cent).

Table 1: Effect of treatments on per cent adult mortality of pulse beetle on mungbean.

Sr. No.	Name of Treatment	Dose (g/ml)	% Adult Mortality/50 g seeds (**)				
			2 DAT	4DAT	6DAT	8DAT	10 DAT
1	Castor oil	5 ml/kg	41.11 (39.87)	32.22 (34.56)	26.66 (31.04)	0.00 (0.52)	0.00 (0.52)
2	Karanj oil	5 ml/kg	33.33 (35.26)	32.22 (34.56)	27.77 (31.78)	6.66 (14.95)	0.00 (0.52)
3	Sesamum oil	5 ml/kg	30.00 (33.19)	32.22 (34.56)	27.77 (31.78)	9.99 (18.40)	0.00 (0.52)
4	Neem seed kernel powder	10 g/kg	13.33 (21.30)	17.77 (24.90)	25.55 (30.34)	29.93 (33.16)	13.33 (21.41)
5	Cow dung cake ash	10 g/kg	0 (0.52)	11.11 (19.42)	18 (25.10)	39.66 (39.23)	31.11 (33.90)
6	Custard leaf powder	10 g/kg	10 (18.42)	15.55 (23.18)	20 (26.56)	28.88 (32.50)	24.55 (29.70)
7	Tobacco leaf powder	10 g/kg	18.88 (25.73)	21.11 (27.32)	25.55 (30.34)	23.33 (28.84)	11.11 (19.46)
8	Untreated control	--	0 (0.52)	0 (0.52)	14.44 (22.29)	43.33 (41.16)	42.22 (40.52)
	SE (m) ±		0.68	0.74	0.71	0.71	0.07
	CD at 5%		2.00	2.18	2.08	2.08	0.20
	CV 5%		5.46	5.21	4.31	4.74	0.68

****** Value in parenthesis are angular transformed value. DAT – Day after treatment.

Table 2: Effect of treatments on fecundity, adult emergence and number of holes against pulse beetle on mungbean seeds.

Sr. No.	Name of Treatment	Dose (g/ml)	No. of Egg Laid / 50 g Seeds	Adult Emergence/ 20 seeds*		Number of holes /20 Seeds *	
				45 DAT	75 DAT	45 DAT	45 DAT
1	Castor oil	5 ml/kg	55.66 (7.56)	3.66 (2.15)	4.66 (2.37)	2.33 (1.67)	4.66 (2.37)
2	Karanj oil	5 ml/kg	58.33 (7.67)	4.66 (2.37)	5.33 (2.51)	3.33 (1.95)	5.00 (2.44)
3	Sesamum oil	5 ml/kg	60.33 (7.80)	7.33 (2.88)	5.66 (2.58)	4.00 (2.12)	5.33(2.51)
4	Neem seed kernel powder	10 g/kg	94.66 (9.75)	9.66 (3.26)	10.33 (3.36)	4.66 (2.27)	8.66 (3.10)
5	Cow dung cake ash	10 g/kg	132.33 (11.52)	14.33 (3.91)	16.33 (4.16)	9.66 (3.18)	10.33 (3.36)
6	Custard leaf powder	10 g/kg	131.33 (11.48)	12.66 (3.69)	14.33 (3.91)	7.00 (2.73)	9.33 (3.21)
7	Tobacco leaf powder	10 g/kg	91.66 (9.60)	8.66 (3.10)	9.66 (3.26)	4.33 (2.19)	7.33 (2.88)
8	Untreated control	--	148.66 (12.21)	16.33 (4.16)	17.66 (4.32)	10.66 (3.34)	14.66 (3.95)
	SE (m) ±		0.03	0.05	0.07	0.06	0.06
	CD at 5%		0.11	0.17	0.16	0.18	0.20
	CV 5%		0.68	3.06	2.83	4.54	3.91

* Value in parenthesis are square root transformed value. DAT: Days after treatment

Table 3: Effect of treatments on per cent seed infestation and per cent weight loss due to pulse beetle on mungbean seeds.

Sr. No.	Name of Treatment	Dose (g/ml)	Per cent seed infestation /20 seeds **		Per cent weight loss / 20 Seeds (**)	
			45 DAT	75 DAT	45 DAT	75 DAT
1	Castor oil	5 ml/kg	23.33 (28.85)	28.33 (32.14)	10.83 (19.21)	21.19 (27.40)
2	Karanj oil	5 ml/kg	24.33 (29.55)	28.66 (32.37)	11.96 (19.95)	22.22 (28.12)
3	Sesamum oil	5 ml/kg	25.33 (30.21)	30.33 (33.41)	15.24 (22.97)	23.70 (29.12)
4	Neem seed kernel powder	10 g/kg	35.00 (36.23)	57.33 (49.21)	22.79 (28.51)	33.85 (38.58)
5	Cow dung cake ash	10 g/kg	68.33 (48.83)	70.66 (57.20)	33.24 (35.20)	48.82 (44.32)
6	Custard leaf powder	10 g/kg	56.99 (36.07)	69.66 (56.58)	32.74 (34.90)	46.02 (42.71)
7	Tobacco leaf powder	10 g/kg	34.66 (36.07)	56.66 (48.83)	21.45 (27.58)	32.26 (34.61)
8	Untreated control	--	81.66 (64.69)	91.00 (72.59)	47.22 (43.40)	75.08 (60.05)
	SE (m) ±		0.91	0.64	0.34	0.24
	CD at 5%		2.92	1.89	1.01	0.75
	CV 5%		4.19	2.34	2.07	1.11

** Value in parenthesis are angular transformed value. DAT : Days after treatment

2. Ovipositional preference of pulse beetle

The ovipositional preference of pulse beetle on seed of mungbean in the range of 55.66 eggs to 148.66 eggs/50g seeds (Table 2). Among the treatments castor oil @ 5 ml/kg of seeds were recorded significantly the lowest number of eggs laid by pulse beetle (55.66 eggs/50g seeds) and which was at par with karanj oil @ 5ml/kg seeds (58.33 eggs/50g seeds). The maximum eggs were recorded on (148 eggs/50g seeds) in untreated control.

This result supports the findings of Sharanabasappa and Kulkarni (2008) [18] who studied the efficacy of neem, catore, karanj, mustard, sunflower, oils palm and coconut oils against the fecundity of *C. chinensis* in greem gram and they reported that among the oils neem oil, castore oil and karanj oil recorded the lowest number of egg per 50 seeds and similar trend was observed at 60, 90 and 20 days after treatment. Similarly, Lakhanpal *et al*. (1995) [10] who evaluated nine edible oils (Sesame, cotton seed, mustard, rapeseed, groundnut, coconut, linseed, soybean and sunflower as grain protectants against *Callosobruchus analis* infesting blackgram seeds. When applied at 1, 2 and 4 ml/kg. cotton seed oil was the most effective followed by sesame, groundnut and coconut oil which resulted in low fecundity. Whereas, Negi *et al*.(1997) [11] studied the effect of different concentration of pongam (*Pongamia pinnata*) oil against pulse beetle on green gram and reported that egg-laying and adult emergence percentage was decreased with increase in dose of oil.

3. Per cent adult emergence

Per cent of adult emergence at 45 and 75 days after treatments as per (Table 2) and the minimum F_1 and F_2 adults emerged on (3.66 and 4.66 adults/ 20 seeds) were recorded in grains treated with castor oil @5ml/kg seed which was found statistically significantly superior over the other treatments followed by karanj oil @ 5 ml/kg seeds (4.66 & 5.33 adults/ 20 seeds) and sesamum oil @ 5 ml/kg seeds (7.33 & 5.66 adults/ 20 seeds) as compared to untreated seeds (16.33 & 17.66 adults/ 20 seeds), respectively.

Present findings are similar with the study of Singh *et al*., (1994) [19] reported that oils of sesame, karanj, castor, groundnut were evaluated as grain protectants at 1 and 3 ml/kg seed of gram against *C. chinensis*. Adult emergence was lowest from the seeds treated with castor, groundnut at 1 ml/kg seed, while at 3 ml there was no adult emergence from the seeds treated with oils of castor. Similarly, Negi *et al*., (1997) [11] studied the effect of different concentration of pongam oil against *C. chinensis* (Linn.) on green gram (*Vigna radiata*) and reported that adult emergence percentage was decreased with increase in dose of oil. Babu *et al*., (1989) [2] reported that castor oil 10 ml/kg admixed with mung bean and stored for 18 months prevented the emergence of F1 adult *C. chinensis* following artificial inoculation with adult insects.

4. Number of holes on seeds

Number of holes on seeds at 45 and 75 days after treatments the data tabulated in (Table 2) and the seeds treated with castor oil @ 5 ml/kg seed showed the minimum holes (2.33 and 4.66 holes/20 seeds) followed by karanj oil @ 5 ml/ kg seed (3.33 and 5.00 holes/ 20 seeds).

The present findings are accordance with Ramazeame *at al*., (2014) [14] who reported among all the botanicals and oils, Neem kernel powder was highly effective and bore holes present in the pulses seeds were gradually increase every month. Maximum bore of 32.66 per cent was observed in leaf powder treatment and increase trend in bore holes per cent was recorded invariably in all treatment the per cent of reduction in bore holes clay were collected from the local market.

5. Per cent seed infestation

The data presented in (Table 3 and plate. 1) per cent seed infestation at 45 and 75 day after treatment was compare to untreated seeds, the per cent seed infestation was recorded significantly lowest in castor oil @5 ml/ kg seeds (23.33 and 28.33 per cent/20 seeds) which was at par with karanj oil 5ml/kg seeds (24.33 and 28.66 per cent/20 seeds) followed by sesamum oil @ 5 ml/ kg seeds (25.33 and30.33 per cent /20 seed), respectively. The highest per cent seed infestation was recorded (81.66 and 91.00 per cent /20 seeds) in untreated control.

This result supports the findings of Yadhav *et al*., (2004) who worked with 9 edible / non-edible oils (10 g/kg seed) against *Callosobruchus chinensis* L. in green gram and found that were significantly higher in oil-treated seeds compared with the control. Castor oil was the most effective treatment, recording no adult emergence, seed damage and seed weight loss. Similarly, Sahoo and Chandrakar (2013) [15] reported the effectiveness of some edible and non-edible oils on chickpea seeds. The seed damage in coconut oil treated seeds at 0.25 ml/ 100g seed was found highest (20.50 and 43.79 per cent) while lowest (9.25 and 30.39 per cent) in karanj oil treated seeds 0.25ml/100g seeds after 45 days and 90 days, respectively.

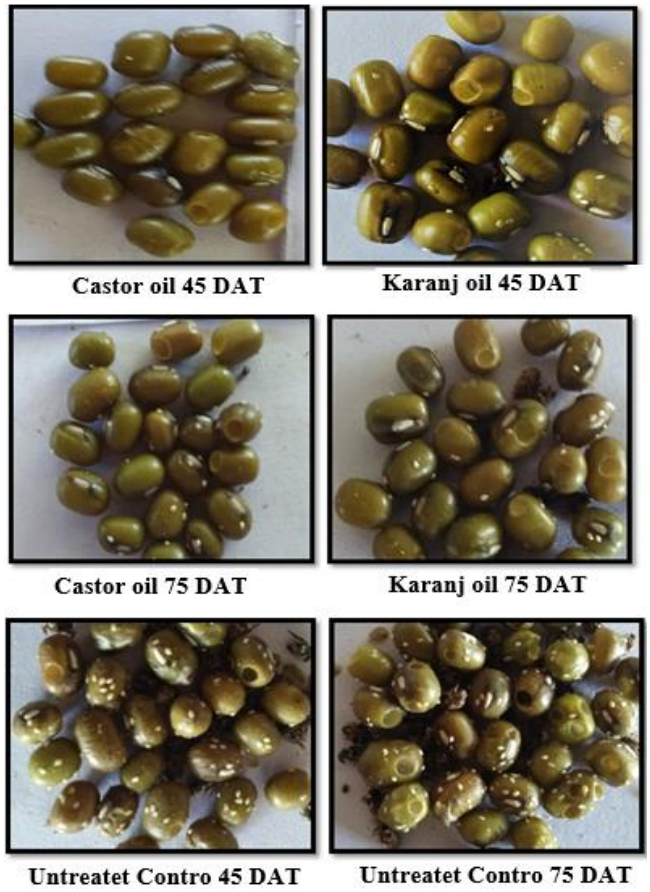

Plate 1: Effect of treatments at 45 and 75 DAT on seed infestation due to pulse beetle

6. Per cent weight loss

The data tabulated in (Table 3) seed weight loss at 45 and 75 day after treatment significantly lowest weight loss recorded in castor oil @ 5 ml/kg seeds (10.83 and 21.19 per cent) followed by karanj oil 5ml/kg seeds (11.96 and 22.22 per cent) and sesamum oil @ 5 ml/kg seeds (15.24 & 23.70 per cent) and highest per cent weight loss was recorded in control (47.22 and 75.08 per cent).

This result supports the findings of Neog and Singh, (2012) [12] who evaluated eight vegetable oils *viz*., neem, castor, clove, mustard, sunflower, sesamum, coconut and groundnut oil @ 1% v/w were evaluated as grain protectants against *Callosobruchus chinensis* (L.) on green gram seeds. All the vegetable oils provided maximum protection up to 2 months resulting in 1.13 to 5.10% weight loss only as against 30.77 to 32.60% in untreated seeds. Similarly, Yadhav *et al*., (2004) who worked with 9 edible / non-edible oils (10 g/kg seed) against *C. chinensis* L. in green gram and found that were significantly higher in oil-treated seeds compared with the control. Castor oil was the most effective treatment, recording no adult emergence, seed damage and seed weight loss.

Conclusion

The plant based protectants in base of oils as castor oil, karanj oil and sesamum oil was found to be significantly reducing the adult mortality, minimum ovipositional preference as well as adult emergence and seed infestation in comparison with untreated seeds. The plant based protectants is eco-friendly, sustainable, safer human and environment and beast management of pulse beetle/ bruchids in mungbean.

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References

1. Ali SM, Mahgoub SM, Hamed MS, Gharib MSA. Infestation potential of *Callosobruchus chinensis* and *C. maculatus* on certain broad bean seed varieties. Egyptian Journal of Agricultural Reearch. 2004; 82(3):1127-1135.
2. Babu TR, Reddy VS, Hussaini SH. Effect of edible and non-edible oils on the development of the pulse beetle, *Callosobruchus chinensis* and on viability and yield of mungbean *Vigna radiata* L. (Wikzek). Tropical Sci. 1989; 29:215-220.
3. Bajiya RS. Bio-ecology and Management of Pulse Beetle, *Callosobruchus chinensis* (Linn.) on Mungbean, *Vigna radiate* (Linn.) Wilczek Ph.D. Thesis submitted to Dept. of Agril. Zoology and Entomology, S.K.N. College of Agriculture, Jobner, 2010.
4. Bhargava MC, Meena BL. Efficacy of some vegetable oils against pulse beetle, *Callosobruchus chinensis* (Linn.) on cowpea, *Vigna unguiculata* (L.). Indian Journal of Plant Protection. 2002; 30:46-50.
5. Bhuiyah M, Mia I. Damage of some stored pulses by the pulse beetle, *Callosobruchus chinensis* L. and its control with botanicals. Ph.D. Thesis, Depart. of Entomology, Bangladesh Agricultural University, Mymensingh, 2001, p.149.
6. Devi MB, Devi NV. First record of *Callosobruchus orientalis* (Bruchidae: Coleoptera) from Tamenglong district of Manipur, India. Journal of Entomology and Zoology Studies, 2014, 318-320.
7. Dhakshinamoorthy G, Selvanarayanan V. Evaluation of certain natural products against pulse beetle, *Callosobruchus maculatus* (Fab.) infesting stored green gram. Insect Environ. 2002; 8(1):29-30.
8. Howe RW. A parameter for expressing the suitability of an environment for insect development. Journal of Stored Products Research. 1971; **7**(1):63-65.
9. Keita SM, Vincent C, Schmit JP, Arnason JT, Belanger, A. (2001).Efficacy of essential oil of *Ocimum basilicum* L. and *O. gratissimum* L. applied as an insecticidal fumigant and powder to control *Callosobruchus maculatus* (Fab.) (Coleoptera: Bruchidae). J Stored Prod. Res. 1971; 37(4):339-349.
10. Lakhanpal GC, Kashyap NP, Mehta PK. Efficacy of different edible oils as grain protectants against pulse beetle, *Callosobruchus analis* F. in black gram. Vigna mungo L. J Insect Sci. 1995; 8(1):66-69.
11. Negi RS, Srivastava M, Saxena MM. Egg-laying and adult emergence of *Callosobruchus chinensis* on green gram (*Vigna radiata*) treated with pongam oil. Indian Journal of Entomology. 1997; 59(2):170-172.
12. Neog P, Singh HK. Efficacy of plant powders and vegetable oils against *Callosobruchus chinensis* (L.) on stored green gram. Indian Journal of Entomology. 2012; 74(3):267-273.
13. Onu I, Aliyu M. Evaluation of powdered fruits of four peppers (*Capsicum spp.*) for the control of *Callosobruchus maculatus* (F) on stored cowpea seed. International J Pest Manage. 1995; 41(3):143-145.
14. Ramazeame L, Adiroubane D, Govindan K,

Jagatheeswari J. Management of Pulse beetle, *Callosobruchus chinensis* Linn. Using botanicals Journal of Entomology and Zoology Studies. 2014; 2(4):299-309.
15. Sahoo AK, Chandrakar HK. Efficacy of edible and non-edible oils against pulse beetle *Callosobruchus chinensis* L. in stored chickpea. International Journal of plant protection. 2013; 6(2):299-303
16. Shaaya E, Kostjukovski M, Eilberg J, Sukprakarn C. Plant oils as fumigants and contact insecticides for the control of stored product insects. J Stored Prod. Res. 1997; 33(1):7-15.
17. Sharma SR. Bio-ecology and management of groundnut bruchid, *Caryedon serratus* (Olivier) on groundnut, *Arachis hypogaea* (Linnaeus). *Ph.D.* Thesis, submitted to SKRAU, Bikaner, 2014.
18. Shranabasappa DVK, Kulkarni VV. Efficacy of oils of plant origin against pulse *Callosobruchus chinensis* on greengram and their effect on germination. Journal of Ecobiology. 2008; 22(4):315-319.
19. Singh VN, Pandey ND, Singh YP. Effectiveness of vegetable oils on the development of *Callosobruchus chinensis* (L.) infesting stored gram. Indian Journal of Entomology. 1994; 56(3):216-219.
20. Talukder FA, Howse PE. Repellent, toxic and food protectant effects of pithraj, *Aphanamixis polystachya* extracts against the pulse beetle, *Callosobruchus chinensis* in storage. J Chemical Ecol. 1994; 20(4):7-11.
21. Yadav AS, Bhadauria NS, Jakhmola SS. Efficacy of edible / non-edible vegetable oils against pulse beetle, *Callosobruchus chinensis* (Fab.) in green gram. Indian Journal of Entomology. 2004; 66(4):365-366.