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Bio-efficacy of diatomaceous earth against pulse beetle, *Callosobruchus chinensis* (L.) infesting chickpea

Geeta Kumari Meena, Hemant Swami, Lekha and Gaurang Chhangani

Abstract

The present investigation on "Bio-efficacy of diatomaceous earth against pulse beetle, *Callosobruchus chinensis* (L.)" was carried out under laboratory conditions at Department of Entomology, Rajasthan College of Agriculture, MPUAT, Udaipur during 2020. The different organic products were evaluated against pulse beetle infesting chickpea in storage condition showed that diatomaceous earth @ 4 per cent was found most effective treatment with highest adult mortality (73.33%), lowest grain damage (6.67%) and lowest weight loss of grains (2.00%). It was followed by diatomaceous earth @ 3 per cent and diatomaceous earth @ 2 per cent and was found at par with each other. Though, application of diatomaceous earth @ 2 per cent was more preferred and suggested to farmers because of low cost and lower residual effect than diatomaceous earth @ 3 and 4 per cent. The next effective treatments were diatomaceous earth @ 1 per cent followed by neem seed kernel powder @ 1 per cent, mustard oil @ 2 per cent and groundnut oil @ 2 per cent and neem leaf powder @ 4 per cent. All the treatments were found to be superior over control in terms of increasing the adult mortality, reducing grain damage and weight loss; whereas there was no significant effect of these protectants on the moisture content of the stored chickpea.

Keywords: Storage pest, organic management, plant/ leaf powder and seed oils

Introduction

Pulses are an important constituent of daily Indian diet as a source of protein, carbohydrates, fiber, calcium, potassium, zinc, magnesium and iron. They also have inherent efficiency to fix atmospheric nitrogen, which improve soil fertility. India ranks first in pulse production in the world with an annual production of 23.15 million tons and contributes 70 per cent to total world pulse production with an average productivity of 817 kg/ha in 28.34 million ha area during 2019-20 (GOI, Data bank 2020). Among the Indian states, Rajasthan stands at third position in pulse production with an annual production of 3.68 million tons and productivity of 622 kg/ha (Agricultural Statistics at a Glance, 2020) [2]. Chickpea (*Cicer arietinum* L.) is among the most widely consumed legumes in the world, particularly in tropical and subtropical areas (Chhangani *et al.*, 2018) [5], having a share of around 40 per cent in the total production followed by pigeon pea *Cajanus cajan* (L.) Millsp (20%) and green gram, *Vigna radiata* (L.) Wilczek (8%) and black gram, *Vigna mungo* (L.) Hepper (10%) (NABARD Rural Pulse 2015) [13].

Post-harvest losses at farm level ranged between 2.20 per cent (pigeon pea) to 7.14 per cent (lentil) (DMI 2002) [7]. In storage, as many as twenty five species of insect pests have been recorded to infest pulses in India of which the important storage pests are *Callosobruchus chinensis* Linnaeus, *Pachymerus quadrimaculatus* Fabricius, *Bruchus analis* Fabricius, *Bruchus albocollis* Pic, *Bruchus phaseoli* Gyllenhal, *Laria affinis* Froelich and *Laria pisorum* Linnaeus (Pruthi and Singh, 1950) [19]. Among these the pulse beetle, *C. chinensis* (Bruchidae: Coleoptera) is one of the important storage pest which causes heavy quantitative and qualitative losses (Prabhakar, 1979, Pandey and Singh, 1997) [17, 15]. It causes 55-60 per cent seed weight loss and 45.50 to 66.30 per cent protein content loss (Hosamani *et al.* 2018) [10].

The uses of chemical pesticides have proved to be most powerful and highly effective tool for control of this pest. Though pesticides are adaptable to wide situations, flexible in almost all agronomic and ecological condition and relatively economical, the uses of these pesticides have also been associated with many problems as they are not ecologically sound. These situations tend to envisage finding a safe and ecological sound material for pest control in storage at farm level, which could easily be achieved by using diatomaceous earth (DE), the

fine powder of DE adsorbs lipids from the outer waxy layer of the exoskeleton of insect, thus causing death due to desiccation.

Materials and Methods

The experiment to study the bio-efficacy of diatomaceous earth against *C. chinensis* was conducted on chickpea grains in laboratory of Department of Entomology, RCA, MPUAT Udaipur during 2020-21. There were nine treatments viz. diatomaceous earth @ 1, 2, 3 and 4 per cent (w/w bases) along with mustard oil and groundnut oil (v/w) @ 2%, neem seed kernel powder (w/w) @ 1% and neem leaf powder (w/w) @ 4%, replicated three times.

Healthy grains of chickpea were sterilized at 60±5 °C temperature for eight hours with the help of heavy duty oven to clear off any hidden infestation. These grains were conditioned at least for a week in an environmental chamber maintaining 33±2 °C and 60±5 per cent relative humidity to raise moisture content from this 500 gram chickpea grains

were taken and the pre-treatment observations like moisture percent in grains and weight of 100 sound grains were recorded before treatment. The moisture content of each sample was determined with the help of digital moisture meter as per the procedure given in the manual of the equipment and the weight of grains was recorded with the automatic electrical weighing machine.

After the pre-treatment observations the 500 gram grains of chickpea for each treatment were treated with diatomaceous earth @ 1, 2, 3 and 4 per cent (w/w), mustard and groundnut oil (2%, v/w), neem seed kernel powder (1%, w/w) and neem leaf powder (4%, w/w). These treated 500 gram grains for each treatment were kept in one liter capacity of plastic jars and were replicate three times under Completely Randomized Design (CRD) and ten pairs of freshly emerged adults from stock culture were released into the treated host grains for each treatment and were kept in laboratory for the 120 days. The mouth of jars was covered with muslin cloth and tightened with rubber band.

Table 1: Treatments details

S. No.	Treatment	Dose (%)
1.	Diatomaceous earth	4.0 (w/w)
2.	Diatomaceous earth	3.0 (w/w)
3.	Diatomaceous earth	2.0 (w/w)
4.	Diatomaceous earth	1.0 (w/w)
5.	Mustard oil	2.0 (v/w)
6.	Groundnut oil	2.0 (v/w)
7.	Neem seed kernel powder	1.0 (w/w)
8.	Neem leaf powder	4.0 (w/w)
9.	Control	-

Observations and analysis

The observations to evaluate the bio-efficacy of different treatments were recorded on per cent mortality, per cent grains damage and per cent weight loss of grains. The data so obtained from different treatments were subjected to suitable statistical analysis to find out the most effective treatment for the management of pulse beetle infestation in storage chickpea. The observations on different parameters were recorded as under.

I. Mortality counts of pulse beetle (%)

Ten pairs of pulse beetle were released in each jar to assess the efficacy of the different treatments on the mortality of pulse beetle. The number of dead beetles in each replicate jar was counted after 24, 48, 72 and 96 hours after release of insect:

$$\text{Mortality per cent} = \frac{\text{No. of insect died}}{\text{Total number of insect released}} \times 100$$

II. Grains damage by pulse beetle (%)

The numbers of grain damaged by pulse beetle in each treatment replication were counted after 30, 60, 90 and 120 days after treatment. Per cent grain damage was computed as suggested by Adams and Schulten method (1978) [1]:

$$\text{Grain damage (\%)} = \frac{\text{Number of holed grains}}{\text{Total grains}} \times 100$$

III. Weight loss in grains (%): Weight loss in grains was calculated by using the following equation:

$$\text{Weight loss (\%)} = \frac{\text{Initial weight of grains} - \text{final weight of grains}}{\text{Initial weight of grains}} \times 100$$

Results and Discussion

The bio-efficacy of different treatments products viz., diatomaceous earth (w/w) @ 1 per cent, 2 per cent, 3 per cent and 4 per cent, mustard oil and groundnut oil (v/w) @ 2 per cent, neem seed kernel powder (w/w) @ 1 per cent and neem leaf powder (w/w) @ 4 per cent against pulse beetle, *C. chinensis* on chickpea grains were evaluated under present investigation. The results of bio-efficacy of different treatments against pulse beetle are discussed as under:

Mortality (%) of pulse beetle

The data in Table 2 and Fig. 1 shows that the application of all the treatments resulted in significantly increasing the adult mortality during storage of chickpea. Chickpea grains treated with diatomaceous earth @ 4 per cent resulted in maximum mortality at 24, 48, 72 and 96 hours after release of pulse beetle, with a mean mortality per cent ranging from 23.33 to 73.33 per cent. The next effective treatment with increasing mortality was diatomaceous earth @ 3 per cent (21.67 to 68.33%) which was followed by the treatment diatomaceous earth @ 2 per cent (20.00 to 65.00%), diatomaceous earth @ 1 per cent (13.33 to 55.00%) and neem seed kernel powder @ 1 per cent (11.67 to 48.33 per cent). The treatment of mustard oil @ 2 per cent (10.00 to 46.67%) and groundnut oil @ 2 per cent (8.33 to 45.00%) were next in order to increase the mortality of pulse beetle during the storage of chickpea. The treatment of neem leaf powder @ 4 per cent (6.67 to 45.00%) resulted the minimum mortality per cent. All the treatments

were found to be superior over control in increasing the mortality per cent as compare to control.

These findings are in line with the result of Praasantha *et al.*, (2003) [18]; Parsaeyan *et al.*, (2012) [16]; Badii *et al.*, (2014) [4]; Kabir and Wolgo (2014) [11] who recorded that mortality of *C. maculatus* increased with increasing exposure interval and temperature. Prolonged exposure time may be needed to increase mortality in adults because more dust particles are trapped by insect bodies with increasing exposure time and in turn insects lose more water and died of desiccation (Arthur, 2002; Fields and Korunic, 2000; Rigaux *et al.*, 2001; Shams *et al.*, 2011) [3, 8, 21, 22].

Similarly, Singh (2017) [23] reported that custard apple leaf powder @ 5 gm/kg seed, neem leaf powder @ 5 gm/kg, diatomaceous earth @ 5 gm/kg seed and cow dung ash @ 5 gm/kg seed treated green gram seeds resulted in pulse beetle mortality of 10.49, 8.64, 23.61 and 5.52 per cent at 7 days after release, which also confirms the results of the present investigation.

Moisture content (%)

The data presented in Table 3 revealed that there was no significant effect of various treatments on the moisture content per cent of chickpea after the storage period. The grains treated with diatomaceous earth @ 4 per cent resulted in minimum moisture content of grains at 30, 60, 90 and 120 days after treatment having 8.20, 8.20, 8.40 and 8.47 per cent moisture, respectively. The next effective treatments were diatomaceous earth @ 3 per cent and diatomaceous earth @ 2 per cent, which resulted in 8.23, 8.23, 8.43 and 8.50; 8.27, 8.30, 8.47 and 8.50 per cent moisture content in grains at 30, 60, 90 and 120 days after treatment application, respectively. Application of groundnut oil @ 2 per cent, mustard oil @ 2 per cent, diatomaceous earth @ 1 per cent, neem seed kernel powder @ 1 per cent resulted in 8.30, 8.37, 8.50 and 8.60; 8.37, 8.40, 8.53 and 8.63; 8.40, 8.43, 8.57 and 8.67; 8.43, 8.47, 8.60 and 8.70 per cent moisture content in grains at 30, 60, 90 and 120 days after treatment application, respectively. The maximum moisture content in grains was observed in treatments of neem leaf powder @ 4 per cent, which was 8.47, 8.50, 8.63 and 8.73 per cent at 30, 60, 90 and 120 days after treatment, respectively. The data showed no significant variation in level of per cent moisture among various treatments.

The findings confirming the results of present investigation have been reported by Gularte (2005) [9], who observed that the use of diatomaceous earth on conventionally processed or parboiled rice did not interfere in the assessed gravimetric yield parameters. Moras *et al.* (2006) [12] also stated that the all diatomaceous earth treated grain had statically equivalent water absorption and yield.

Grain damage (%)

The data presented in Table 4 and Fig. 1 revealed that all the treatments application significantly reduces the grain damage of chickpea grains during storage. Chickpea grains treated with diatomaceous earth @ 4 per cent resulted in minimum per cent damage at 30, 60, 90 and 120 days after treatments, with mean grain damage per cent ranging from 2.33 to 6.67 per cent, it was followed by the treatments of diatomaceous

earth @ 3 per cent (2.67 to 7.33%) and the treatments diatomaceous earth @ 2 per cent (3.00 to 8.00%), which were statistically at par with each in terms of reducing the grain damage of chickpea during storage. The treatments of diatomaceous earth @ 1 per cent (4.67 to 11.67%) neem seed kernel powder @ 1 per cent (5.00 to 13.33%), mustard oil @ 2 per cent (5.00 to 13.33%) and groundnut oil @ 2 per cent (5.67 to 13.67%) proved next effective treatment in reducing the grain damage during the storage of chickpea. The treatments of neem leaf powder @ 4 per cent (6.00 to 14.33%) proved least effective in reducing the grain damage during the storage of chickpea. All the treatments were found to be superior over control in minimizing per cent grain damage compared to control.

The results corroborate the findings of Singh (2017) [23], who reported that green gram seed/grain damage in treatments comprising of diatomaceous earth @ 5 gm/kg seed, custard apple leaf powder @ 5 gm/kg seed, neem leaf powder @ 5 gm/kg seed and cow dung ash @ 5 gm/kg seed were 3.28, 20.99, 24.98 and 28.99 per cent, respectively. Similarly, Oztekin and Mutlu (2020) [14] also suggested that the local diatomaceous earth product (Ankara and Aydin) have a high potential to be used for control of *C. maculatus* adults damage for storage bean.

Weight loss (%)

The data presented in Table 5 and Fig. 1 shows that all the treatments significantly reduce the weight loss of chickpea grains during storage. Chickpea grains treated with diatomaceous earth @ 4 per cent resulted minimum per cent weight loss at 30, 60, 90 and 120 days after treatments with a mean weight loss per cent ranging from 0.33 to 2.00 per cent and the next effective treatments were diatomaceous earth @ 3 per cent (0.67 to 2.33%) followed by diatomaceous earth @ 2 per cent (1.00 to 2.67%), which were statistically at par with each in terms of reducing the weight loss of chickpea during storage. The treatments of diatomaceous earth @ 1 per cent (3.00 to 5.00%), neem seed kernel powder @ 1 per cent (3.33 to 5.33%), mustard oil @ 2 per cent (3.67 to 6.00%) and groundnut oil @ 2 per cent (4.00 to 6.33%) proved to be next effective treatments. The treatment of and neem leaf powder @ 4 per cent (4.33 to 6.67%) proved least effective in reducing the weight loss during the storage of chickpea. All the treatments were found to be superior over control in minimizing per cent grain weight loss of chickpea compared to control.

Singh (2017) [23] reported that weight loss of green gram seeds due to pulse beetle infestation in treatments of diatomaceous earth @ 5 gm/kg, custard apple leaf powder @ 5 gm/kg seed, neem leaf powder @ 5 gm/kg seed and cow dung ash @ 5 gm/kg seed treated seeds were 3.28, 6.27, 13.46 and 13.65 per cent, respectively. Similarly, Ramya *et al.* (2017) [20] reported that minimum per cent weight loss was recorded in neem oil treatments at all three dosages (3, 5, 7 ml/kg seed) of 2.36, 0.41 and 0.16 followed by karanj oil (2.73, 0.91 and 0.58%), castor oil (3.33, 1.83 and 1.33%), mustard oil (4.56, 2.66 and 1.53%) and sunflower oil (4.90, 2.93 and 2.36%), which confirms the present results and supports the findings of present investigation.

Table 2: Bio-efficacy of different treatment on per cent mortality of pulse beetle, *C. chinensis* on chickpea during 2020-21

Sl. No.	Treatment	Mortality % of pulse beetle			
		24HAR*	48 HAR	72 HAR	96 HAR
T ₁	Diatomaceous earth@ 4%	23.33(28.86)**	38.33(38.24)	50.00(45.00)	73.33(58.93)
T ₂	Diatomaceous earth@ 3%	21.67(27.71)	36.67(37.26)	48.33(44.04)	68.33(55.82)
T ₃	Diatomaceous earth@ 2%	20.00(26.57)	35.00(36.27)	46.67(43.09)	65.00(53.76)
T ₄	Diatomaceous earth@ 1%	13.33(21.34)	26.67(31.07)	35.00(36.24)	55.00(47.88)
T ₅	Mustard oil @ 2%	10.00(18.43)	23.33(28.86)	30.00(33.21)	46.67(43.09)
T ₆	Groundnut oil @ 2%	8.33(16.60)	20.00(26.57)	26.67(31.07)	45.00(42.13)
T ₇	Neem seed kernel powder @ 1%	11.67(19.89)	25.00(30.00)	33.33(35.25)	48.33(44.04)
T ₈	Neem leaf powder @ 4%	6.67(14.76)	18.33(25.31)	23.33(28.86)	45.00(42.12)
T ₉	Control	0.00	1.67(4.31)	3.33(8.61)	5.00(12.92)
	S.Em ±	1.229	1.651	1.815	1.330
	C.D. (p =0.05)	3.651	4.906	5.392	3.951

** Figures in parentheses are retransformed per cent values; * HAR: Hours after release

Table 3: Bio-efficacy of different treatments on per cent moisture content of chickpea during 2020-21

Sl. No.	Treatment	Moisture content (%)			
		30 DAT*	60 DAT	90 DAT	120 DAT
T ₁	Diatomaceous earth@ 4%	8.20(16.64)**	8.20(16.64)	8.40(16.85)	8.47(16.92)
T ₂	Diatomaceous earth@ 3%	8.23(16.67)	8.23(16.67)	8.43(16.88)	8.50(16.95)
T ₃	Diatomaceous earth@ 2%	8.27(16.71)	8.30(16.74)	8.47(16.92)	8.53(16.98)
T ₄	Diatomaceous earth@ 1%	8.40(16.85)	8.43(16.88)	8.57(17.02)	8.67(16.12)
T ₅	Mustard oil @ 2%	8.37(16.81)	8.40(16.85)	8.53(16.98)	8.63(17.09)
T ₆	Groundnut oil @ 2%	8.30(16.74)	8.37(16.81)	8.50(16.95)	8.60(17.05)
T ₇	Neem seed kernel powder @ 1%	8.43(16.88)	8.47(16.92)	8.60(17.05)	8.70(17.15)
T ₈	Neem leaf powder @ 4%	8.47(16.92)	8.50(16.95)	8.63(17.09)	8.73(17.19)
T ₉	Control	8.50(16.95)	8.53(16.98)	8.67(17.12)	8.77(17.22)
	S.Em ±	0.071	0.079	0.068	0.090
	C.D. (p =0.05)	0.211	0.234	0.203	0.268

** Figures in parentheses are retransformed per cent values; * DAT: Days after treatment

Table 4: Bio-efficacy of different treatments on per cent grain damage due to pulse beetle, *C. chinensis* on chickpea during 2020-21

Sl. No.	Treatment	Grain damage (%)			
		30 DAT*	60 DAT	90 DAT	120 DAT
T ₁	Diatomaceous earth@ 4%	2.33(8.74)**	3.67(10.76)	5.00(12.81)	6.67(14.78)
T ₂	Diatomaceous earth@ 3%	2.67(9.27)	4.33(12.00)	5.67(13.76)	7.33(15.68)
T ₃	Diatomaceous earth@ 2%	3.00(9.97)	5.00(12.92)	6.33(14.57)	8.00(16.41)
T ₄	Diatomaceous earth@ 1%	4.67(12.46)	7.00(15.32)	8.67(17.08)	11.67(19.95)
T ₅	Mustard oil @ 2%	5.00(12.92)	7.67(16.07)	9.67(18.11)	13.33(21.41)
T ₆	Groundnut oil @ 2%	5.67(13.69)	8.33(16.77)	10.33(18.75)	13.67(21.69)
T ₇	Neem seed kernel powder @ 1%	5.00(12.75)	7.33(15.70)	9.33(17.78)	12.00(20.26)
T ₈	Neem leaf powder @ 4%	6.00(14.18)	8.33(16.77)	10.67(19.05)	14.33(22.24)
T ₉	Control	23.67(29.10)	37.33(37.66)	50.67(45.38)	70.67(57.21)
	S.Em ±	0.810	0.707	0.705	0.788
	C.D. (p =0.05)	2.408	2.099	2.095	2.343

** Figures in parentheses are retransformed per cent values; * DAT: Days after treatment

Table 5: Bio-efficacy of different treatments on per cent weight loss of due to pulse beetle, *C. chinensis* on chickpea during 2020-21

Sl. No.	Treatment	Weight loss (%)			
		30 DAT*	60 DAT	90 DAT	120 DAT
T ₁	Diatomaceous earth@ 4%	0.33(1.91)**	1.00(5.74)	1.33(6.54)	2.00(7.95)
T ₂	Diatomaceous earth@ 3%	0.67(3.83)	1.33(6.54)	2.00(8.13)	2.33(8.74)
T ₃	Diatomaceous earth@ 2%	1.00(5.74)	1.67(7.33)	2.33(8.74)	2.67(9.27)
T ₄	Diatomaceous earth@ 1%	3.00(9.97)	3.33(10.50)	4.00(11.48)	5.00(12.88)
T ₅	Mustard oil @ 2%	3.67(10.53)	4.00(11.28)	4.67(12.36)	6.00(14.15)
T ₆	Groundnut oil @ 2%	4.00(11.54)	4.33(12.00)	5.00(12.88)	6.33(14.57)
T ₇	Neem seed kernel powder @ 1%	3.33(10.40)	3.67(10.96)	4.33(11.94)	5.33(13.34)
T ₈	Neem leaf powder @ 4%	4.33(12.00)	4.67(12.46)	5.33(13.30)	6.67(14.95)
T ₉	Control	8.67(17.12)	14.00(21.91)	17.00(24.34)	21.67(27.73)
	S.Em ±	1.279	0.923	0.803	0.753
	C.D. (p =0.05)	3.800	2.742	2.386	2.236

** Figures in parentheses are retransformed per cent values; * DAT: Days after treatment

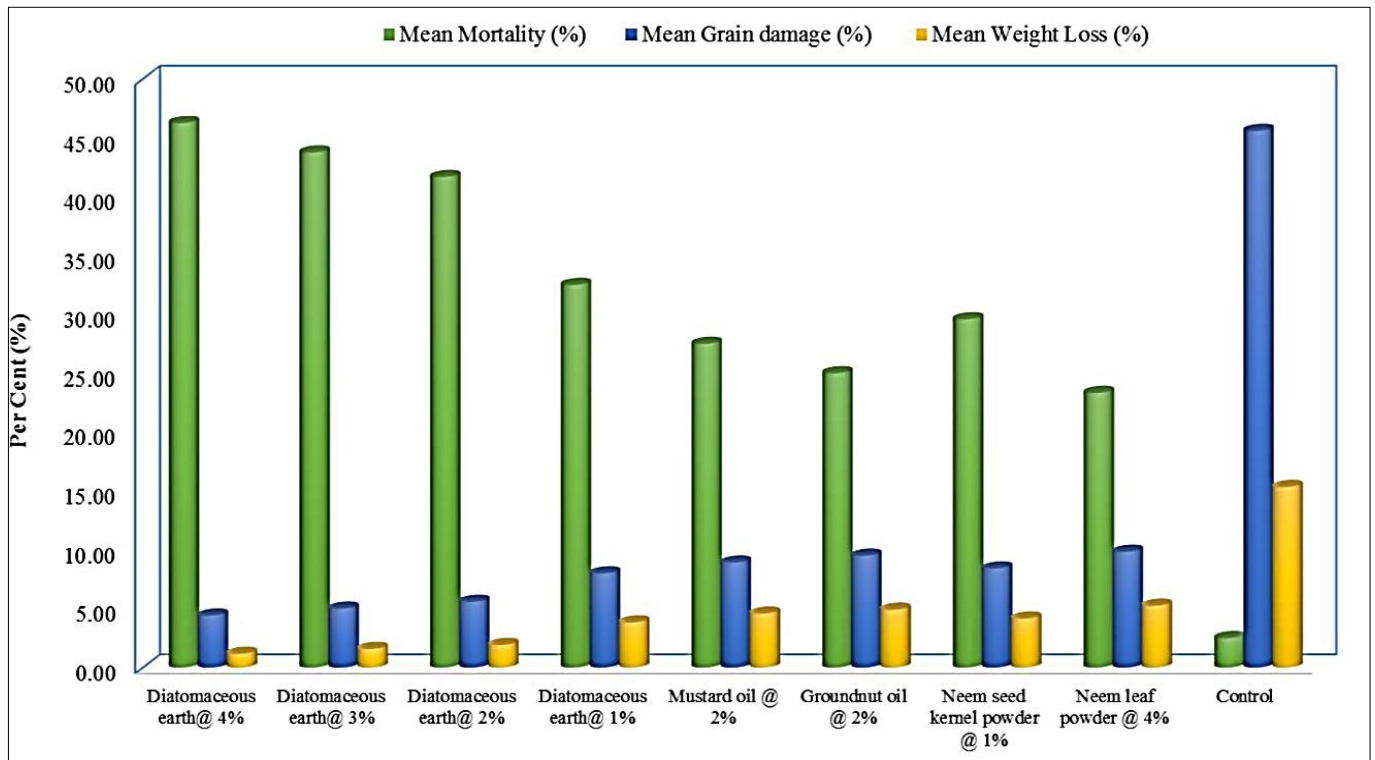


Fig 1: Bio-efficacy of different treatments against pulse beetle, *Callosobruchus chinensis* infesting chickpea during 2020-21

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