Original Research Article

Comparative studies of seed protectants for longterm ambient storage of mungbean against *Callosobruchus chinensis* (L.)

ABSTRACT

A Comparative study was carried out to evaluate the newer insecticides and botanicals as seed protectants for long term ambient storage of mungbean (*Vigna radiata* (L.) Wilczek) against *Callosobruchus chinensis* (L.) under ambient condition at Seed Entomology laboratory of Seed Science and Technology, Acharya Narendra Deva University of Agricultural and Technology, Kumarganj, Ayodhya during 2019-2020. Sixteen included control newer insecticides and botanicals *viz*. Emamectin benzoate @ 40.0 mg/kg^{1} seed, Spinetorum @ 8.5 mg/kg^{-1} seed, Sivanto prime @ 0.01 ml/kg^{-1} seed, Karanj oil@ 5ml/kg seed, Castor oil @ 5 ml/kg seed, Sunflower oil @ 5 ml/kg seed, Mustard oil @ 5 ml/kg seed, Sesamum oil @ 5 ml/kg seed, Neem oil @ 5 ml/kg seed, Neemoz gold @ 5 ml/kg^{-1} seed , Coconut oil @ 5 ml/kg seed, Neem leaf powder @ 5g/kg seed, Neem kernel powder @ 5g/kg seed and Gorakhmundi powder @5g/kg seed as seed protectants along with Deltamethrin 2.8 EC @ 0.04ml/kg seed as check were tried to evaluated under ambient condition. Among tested seed protectants, Emamectin benzoate @ 40.0 mg/kg^{1}seed followed by Sivanto prime @ 0.01 ml/kg^{-1} seed, Spinetorum @ 8.5 mg/kg^{-1} seed, Neemoz gold @ 5 ml/kg^{-1} seed and Karanj oil@ 5ml/kg seed was found most effective treatment against *Callosobruchus chinensis* (L.) due to least seed damage (1%) and weight loss (0.84%) with high germination percent (86.83%) in mungbean for long term (upto 6 months) under ambient storage condition .

Key word: Storability, Seed protectants , mungbean

Comment [71]: Mention the design of the experiment and the results.

INTRODUCTION

Mungbean (*Vigna radiata* (L.) Wilczek) is under cultivation since prehistoric time in India. It is also known as mung, mungo, golden gram, green

gram, chick saw pea and oregon pea (Chhabra and Kooner, 1998). *Vigna radiata* (L.) Wilczek, often known as green gram or mungbean, is the third most popular and important pulse crop throughout south Asia including India. About 70% of the world's production of green gram is from India wherein, it is cultivated annually in an area of about 3 million hectares with total production and average productivity of 0.25 MT and 425 kg/ha, respectively (Bairwa and Singh, 2015). The important green gram growing states in the country are Rajasthan, Maharashtra, Madhya Pradesh, Tamil Nadu, Andhra Pradesh, Karnataka, Orissa, Bihar and Uttar Pradesh (Soren *et al*., 2012). As many as 65 different insect species attack green gram at its different pre- and post-harvest stages (Lal, 1985). Among these, the pulse beetle, *Callosobruchus chinensis* (L.) (Coleoptera : Bruchidae) is the major and most destructive pest causing 50 to 60% damages in green gram seeds under storage condition (Ramzan *et al*., 1990). According to (Chowdhury 1961), the extent of damage in green gram seeds due to bruchids can be up to 100% during a period of one year of storage.

A number of insect-pests attack the stored grains, seeds and other products. Among the important insect pests of stored grains, the pulse beetle, *Callosobruchus chinensis* L. (Bruchidae: Coleoptera), causes substantial losses to the pulses in the storage though the initial infestation occurs in the field itself. It causes weight loss, decreased germination potential and reduction in the commercial value of the seed (Booker, 1967; Okunola, 2003 and Bhardwaz and Verma, 2012). Botanicals can be used to keep the stored grains free from pulse beetle attack and for long term storability and quality parameters of stored grains. Various locally available plant products have been tried recently with good degree of success against a number of stored grain insect pests (Gill and Lewis, 1971; Dhulia *et al*., 1999; Verma and Dubey, 1989; Swain and Baral, 2004 and Mazi *et al*., 2014).

MATERIALS AND METHODS

Comment [72]: Explain the experimental design and the applied statistical tests.

The laboratory studies were conducted in CRD with Sixteen treatments included control with three replications in Seed Entomology Laboratory, Seed Science and Technology Section of Acharya Narendra Deva University of Agricultural and Technology, Kumarganj, Ayodhya during 2019-20. For this purpose, disinfested seed of mungbean seed cv IPM-2-3 was used. From disinfested seed five hundred gram of seed was mix with required quantities of

seed protectant after diluting inwater @ 5 ml/kg seed as per technical programme taken for each replication in each treatment for proper seed coating. After mixing the protectants and drying in shade, seed was packed in 1kg capacity of gunny (Jute) bags. The packed bags were kept on racks under ambient conditions in the laboratory of seed entomology for observations. The observations were recorded at 2, 4 and 6 months of storage periods. From each replication of seed treatments three hundred seed was randomly selected carefully to short out the healthy and unhealthy seed with the help of magnifying lens (10X). By using a given formula (Mohan and Sundarbabu, 1999).

$$\text{Percent seed damage (bored seed)} = \frac{\text{Number of bored seed in a sample}}{\text{Total number of seed in a sample}} \times 100$$

To evaluate the percent loss of weight mungbean seed, 100 seed was taken from each replication of each treatment and carefully examined with the help of a magnifying lens (10X) to separate those damaged (bored) seed by using the given formula (Dawae, 2008).

$$\text{Percent weight loss in seed} = \frac{\text{Wt of the damaged seed of sample}}{\text{Total wt of seed in sample}} \text{x} 100$$

Seed moisture content of mungbean in each replication of each seed protectants was recorded with the help of MAC Digital Moisture Meter.

Obtaining the germination percent of mung bean seed by (ISTA, 1976) given formula

$$\text{Percent Seed germination} = \frac{\text{Total number of germinated seed}}{\text{Total number of seed plated}} \times 100$$

RESULTS AND DISCUSSION

Comment [73]: It is recommended to make a graphic representation in order to show the behavior of the variables.

Percent Seed damage

The results revealed that (Table-1and Fig.-1) seed damage percentage was influenced by the nature of seed protectants, storage durations and environmental condition of storage.

At 2 months of storage, pooled mean of both years the percent seed damage was ranged from 0.11to 25.16 percent. The maximum percent seed damage was found in Gorakhmundi powder @ 5g/kg^{-1} seed (2.77%) followed by Castor oil @ 5ml/kg^{-1} seed (2.44%), Sesamum oil @ 5ml/kg^{-1} seed (2.22%), Coconut oil @ 5ml/kg^{-1} seed (2.00%) and Neem kernel powder @ 5g/kg-1 seed (1.55%).The minimum percent seed damage was found in Emamectin benzoate @ 40.0 mg/kg^{-1}

seed (0.11%) followed by Sivanto prime @ 0.01 ml/kg^{-1} seed (0.22%), Spinetorum @ 8.5mg/kg^{-1} seed (0.55%), Neemoz gold @ 5ml/kg^{-1} seed (0.78%) and Karanj oil @ 5ml/kg^{-1} seed (1.00%) as compared to Deltamethrin 2.8 EC @ 0.04 mlkg-1 seed (0.38%).

At 4 months of storage, pooled mean of both years the percent seed damage was ranged from 0.27 to 32.83. The maximum percent seed damage was found in Gorakhmundi powder @ 5g/kg^{-1} seed (3.61%) followed by Castor oil @ 5ml/kg^{-1} seed (2.88%), Sesamum oil @ 5ml/kg^{-1} seed (2.50%), Coconut oil @ 5ml/kg^{-1} seed(2.22%) and Neem kernel powder @ 5g/kg^{-1} seed (1.78%). The minimum percent seed damage was found in Emamectin benzoate @ 40.0 mg/kg^{-1} seed (0.27%) followed by Sivanto prime @ 0.01 ml/kg^{-1} seed (0.44%), Deltamethrin 2.8 EC @ 0.04 ml kg-1 seed (0.55%),Spinetorum @ 8.5mg/kg^{-1} seed (0.66%) and Neemoz gold @ 5ml/kg^{-1} seed (0.94%), respectively.

At 6 months of storage, pooled mean of both years the seed damage ranged 0.44-47.05 per cent. The maximum percent seed damage was found in Gorakhmundi powder @ 5g/kg^{-1} seed (5.00%) followed by Castor oil @ 5ml/kg^{-1} seed (4.89%), Sesamum oil @ 5ml/kg-1 seed (4.60%), Coconut oil @ 5ml/kg-^{1} seed (3.94%) and Neem kernel powder @ 5g/kg^{-1} seed (2.33%).The minimum percent seed damage was found in Emamectin benzoate @ 40.0 mg/kg^{-1} seed (0.44%) followed by Sivanto prime @ 0.01 ml/kg^{-1} seed (0.61%), Spinetorum @ 8.5mg/kg^{-1} seed (0.83%), Neemoz gold @ 5ml/kg-^{1} seed (1.38%) and Karanj oil @ 5ml/kg^{-1} seed (1.66%) as compared to Deltamethrin 2.8 EC @ 0.04 mlkg^{-1} seed (0.72%). These findings were also supported by Kumar *et al.* (2017) in mungbean, whereas Rajasri and Rao (2012) in bengal gram.

All treatment was significantly superior then the untreated control that has maximum insect damage (47.05%) at 6 months of storage period. Seed damage was increased significantly as increased storage period and value of the damage per cent less to higher from starting to till 6 months of storage.

Percent weight loss

The result (Table-2 and Fig.-2) showed the variation pooled mean of both years in percent loss of seed weight in mungbean seed at different storage periods. All the seed protectants at 6 months were found significant over control.

At 2 months of storage, pooled mean of both years the percent loss of seed weight ranged between 0.04 to 15.33 percent. The maximum percent loss of seed weight was found in Gorakhmundi powder @ 5g/kg^{-1} seed (1.42%) followed by Castor oil @ 5ml/kg^{-1} seed (1.23%), Sesamum oil @ 5ml/kg-1 seed (1.10%), Coconut oil @ 5ml/kg-^{1} seed (1.02%) and Neem kernel powder @ 5g/kg^{-1} seed (0.70%).The minimum percent loss of weight was found in Emamectin benzoate @ 40.0 mg/kg^{-1} seed (0.04%) followed by Sivanto prime @ 0.01 ml/kg^{-1} seed (0.09%), Spinetorum @ 8.5mg/kg^{-1} seed (0.21%), Neemoz gold @ 5ml/kg-^{1} seed (0.31%) and Karanj oil @ 5ml/kg^{-1} seed (0.44%) as compared to Deltamethrin 2.8 EC @ 0.04 mlkg^{-1} seed (0.15%).

At 4 months of storage, pooled mean of both years the percent loss of seed weight ranged from 0.11 to 30.18 per cent. The maximum percent loss of seed weight was found in Gorakhmundi powder @ 5g/kg^{-1} seed (1.81%) followed by Castor oil @ 5ml/kg^{-1} seed (1.47%), Sesamum oil @ 5ml/kg-1 seed (1.28%), Coconut oil @ 5ml/kg-^{1} seed (1.15%) and Neem kernel powder @ 5g/kg^{-1} seed (0.78%).The minimum percent seed damage were recorded in Emamectin benzoate @ 40.0 mg/kg^{-1} seed (0.11%) followed by Sivanto prime @ 0.01 ml/kg^{-1} seed (0.17%), Spinetorum @ 8.5mg/kg^{-1} seed (0.27%), Neemoz gold @ 5ml/kg-^{1} seed (0.45%) and Karanj oil @ 5ml/kg^{-1} seed (0.57%) as compared to Deltamethrin 2.8 EC @ 0.04 mlkg^{-1} seed (0.24%).

At 6 months of storage, pooled mean of both years the loss of seed weight was ranged from 0.18 to 44.53 percent. The maximum percent loss of seed weight was found in Gorakhmundi powder @ 5g/kg^{-1} seed (2.57%) followed by Castor oil @ 5ml/kg^{-1} seed (2.55%), Sesamum oil @ 5ml/kg-1 seed (2.25%), Coconut oil @ 5ml/kg-^{1} seed (2.01%) and Neem kernel powder @ 5g/kg^{-1} seed (1.17%). The minimum percent loss of seed weight was found in Emamectin benzoate @ 40.0 mg/kg^{-1} seed (0.18%) followed by Sivanto prime @ 0.01 ml/kg^{-1} seed (0.27%), Spinetorum @ 8.5mg/kg^{-1} seed (0.37%), Neemoz gold @ 5ml/kg-^{1} seed (0.69%) and Karanj oil @ 5ml/kg^{-1} seed (0.80%) as compared to Deltamethrin 2.8 EC @ 0.04 mlkg^{-1} seed (0.31%). The loss of seed weight in control was 44.53 per cent significantly higher than all treatments.

These findings were also supported by Kumari *et al.* (2014) in pigeon pea, whereas Tabu *et al.* (2012) in chickpea.

Percent Seed moisture content

The result (Table-3 and Fig.-3) showed the variation pooled mean of both years in percent seed moisture content in mungbean seed at different storage periods. All the seed protectants at 6 months were found significant over control.

At 2 months of storage, perusal of the result revealed that pooled mean of both years the seed moisture content ranged from 10.75-11.62 percent. The maximum percent seed moisture with 11.62% was found in Neem leaf powder @ 5g kg-1 followed by Neem kernel powder @ 5g kg-1 seed (11.59%) as compared to Deltamethrin 2.8 EC @ 0.04 ml kg-1 seed (11.28) as a check The minimum percent seed moisture content with 10.75% was found in Castor oil @ 5ml kg-1 seed followed by Sesamum oil @ 5ml kg-1 seed (10.79%) and Coconut oil @ 5ml/kg-1 seed (10.82) respectively.

At 4 months of storage, pooled mean of both years the percent seed moisture content was ranged from 11.48-12.26 per cent. The maximum percent seed moisture with 12.26% was recorded in Neem leaf powder @ 5g kg-1 followed by Neem kernel powder @ 5g kg-1 seed (12.20%) was recorded as compared to Deltamethrin 2.8 EC @ 0.04 ml kg-1 seed (11.82%) as a check. The minimum seed moisture content was found 11.48% in Castor oil @ 5ml kg-1 seed followed by Sesamum oil @ 5ml kg-1 seed (11.53%) and Coconut oil @ 5ml/kg-1 seed (11.56%) respectively.

At 6 months of storage pooled mean of both years the percent seed moisture content was range from 11.91-12.77. The maximum seed moisture per cent was observed in Neem leaf powder @ 5g kg-1 seed (12.77%) followed by Neem kernel powder @ 5g kg-1 seed (12.72%) as compared to Deltamethrin 2.8 EC @ 0.04 ml kg-1 seed (12.48) as a check. The minimum percent seed moisture content was found 11.91% in Castor oil @ 5ml kg-1 seed followed by Sesamum oil @ 5ml kg-1 seed (11.97%) and Coconut oil @ 5ml/kg-1 seed (12.02) respectively.

Similary findings have been reported by several workers such as Chirag *et al.* (2016) and Neupane *et al.* (2016) in mungbean.

The significant difference in seed moisture content percent due to botanicals treatments and months of storage period. The seed moisture content was directly related to the environmental condition with a significant effect of seed coating.

Percent seed germination

The results (Table-4 and Fig.-4) showed the significant differences in percent seed germination among different protectants were found at 2, 4 and 6 months of storage during 2019 and 2020.

At 2 months of storage pooled mean of both years the percent seed germination was ranged from 83.99-93.83. The maximum percent seed germination was recorded in Emamectin benzoate @ 40.0 mg/kg^{-1} seed (93.83%) followed by Sivanto prime @ 0.01 ml/kg^{-1} seed (93.16%), Spinetorum @ 8.5 mg/kg^{-1} seed (92.49%), Neemoz gold @ 5 ml/kg^{-1} seed (92.00%) as compared to Deltamethrin 2.8 EC @ 0.04 ml kg^{-1} (92.83%). The minimum percent seed germination was recorded in Gorakhmundi powder @ 5g/kg^{-1} seed (86.99%) followed by castor oil @ 5ml/ kg^{-1} seed (87.66%), Sesamum oil @ 5 ml/kg^{-1}seed (87.99%) and Coconut oil @5ml/kg^{-1} seed (89.16%).

At 4 months of storage pooled mean of both years the percent seed germination was ranged from 76.49-90.99. The maximum percent seed germination was recorded in Emamectin benzoate @ 40.0 mg/kg^{-1} seed (90.99%) followed by Sivanto prime @ 0.01 ml/kg^{-1} seed (90.50%), Spinetorum @ 8.5mg/kg^{-1} seed (89.49%), Neemoz gold @ 5ml/kg^{-1} seed (88.83%) and Karanj oil @ 5ml/kg^{-1} seed (87.99%) as compared to Deltamethrin 2.8 EC @ 0.04 mlkg-1 seed (89.83%).The minimum percent seed germination was recorded in Gorakhmundi powder @ 5g/kg^{-1} seed (82.83%) followed by Castor oil @ 5ml/kg^{-1} seed (83.83%), Sesamum oil @ 5ml/kg^{-1} seed (84.16%), Coconut oil @ 5ml/kg^{-1} seed (84.49%) and Neem kernel powder @ 5g/kg-1 seed (85.66%).

At 6 months of storage pooled mean of both years the percent seed germination was ranged from 69.83-86.83. The maximum percent seed germination was recorded in Emamectin benzoate @ 40.0 mg/kg^{-1} seed (86.83%) followed by Sivanto prime @ 0.01 ml/kg^{-1} seed (85.66%), Spinetorum @ 8.5mg/kg^{-1} seed (84.66%), Neemoz gold @ 5ml/kg^{-1} seed (84.33%) and Karanj oil @ 5ml/kg^{-1} seed (82.83%) as compared to Deltamethrin 2.8 EC @ 0.04 mlkg-1 seed (85.16%). The minimum percent seed germination was recorded in Gorakhmundi powder @ 5g/kg^{-1} seed (77.66%) followed by Castor oil @ 5ml/kg^{-1} seed (78.66%), Sesamum oil @ 5ml/kg^{-1} seed (79.33%), Coconut oil @ 5ml/kg^{-1} seed (79.83%) and Neem kernel powder @ 5g/kg-1 seed (81.33%). These findings were also supported by Shaheen *et al.* (2016) and Chitra and Sreeja (2013) in mungbean.

Table-1: Effect of newer insecticides and botanicals against *Callosobruchus chinensis* as seed protectants on percent seed damage in mungbean at 2, 4 and 6 months of ambient storage during 2019 and 2020.

	Treatment	Seed Damage (%)								
		2 months			4 months			6 months		
		2019	2020	P.M	2019	2020	P.M	2019	2020	P.M
T_1	Emamectin benzoate@40mg/kg	0.11 (1.09)	0.11 (1.09)	0.11	0.33 (3.29)	0.22 (2.19)	0.27	0.55 (4.22)	0.33 (3.29)	0.44
T_2	Spinotorum (11.7%SC@8.5mg/kg)	0.67 (4.69)	0.44 (3.76)	0.55	0.78 (5.04)	0.55 (4.22)	0.66	0.89 (5.39)	0.78 (5.04)	0.83
T_3	Sivanto (17.09%SL@0.01ml/kg)	0.22 (2.19)	0.22 (2.19)	0.22	0.55 (4.22)	0.33 (3.29)	0.44	0.67 (4.69)	0.55 (4.22)	0.61
T_4	Deltamethrin (Decis (2.8%EC@0.04ml/kg) Check	0.44 (3.76)	0.33 (2.29)	0.38	0.67 (4.69)	0.44 (3.76)	0.55	0.78 (5.04)	0.67 (4.69)	0.72
T_5	Karanj oil@5ml/kg	1.22 (6.32)	0.78 (5.04)	1.00	1.44 (6.89)	0.89 (5.39)	1.16	1.89 (7.89)	1.44 (6.88)	1.66
T_6	Castor oil@5ml/kg	2.67 (9.40)	2.22 (8.56)	2.44	3.22 (10.33)	2.55 (9.16)	2.88	4.89 (12.77)	4.89 (12.77)	4.89
T_7	Sunflower oil@5ml/kg	1.89 (7.89)	1.44 (6.88)	1.66	2.00 (8.13)	1.89 (7.89)	1.94	3.66 (11.03)	2.11 (8.34)	2.88
T_8	Mustard oil@5ml/kg	2.00 (8.13)	1.78 (7.65)	1.89	2.11 (8.34)	2.00 (8.12)	2.05	4.11 (11.69)	2.22 (8.56)	3.16
T_9	Sesamum oil@5ml/kg	2.33 (8.78)	2.11 (8.32)	2.22	2.67 (9.38)	2.33 (8.77)	2.50	4.66 (12.46)	4.55 (12.32)	4.60
T_{10}	Neem oil@5ml/kg	1.33 (6.62)	1.11 (6.03)	1.22	1.56 (7.15)	1.22 (6.32)	1.39	2.22 (8.56)	1.44 (6.88)	1.83
T_{11}	Neemoz gold@5ml/kg	0.89 (5.39)	0.67 (4.69)	0.78	1.11 (6.03)	0.78 (5.04)	0.94	1.66 (7.39)	1.11 (6.03)	1.38
T_{12}	Coconut oil@5ml/kg	2.11 (8.34)	1.89 (7.89)	2.00	2.33 (8.77)	2.11 (8.34)	2.22	4.22 (11.85)	3.66 (11.02)	3.94
T_{13}	Neem leaf powder@5g/kg	1.44 (6.89)	1.22 (6.32)	1.33	1.78 (7.66)	1.44 (6.88)	1.61	2.66 (9.38)	1.67 (7.42)	2.16
T_{14}	Neem kernel powder@5g/kg	1.78 (7.66)	1.33 (6.62)	1.55	1.89 (7.89)	1.67 (7.42)	1.78	2.78 (9.59)	1.89 (7.89)	2.33
T_{15}	Gorakhmundi powder@5g/kg	3.22 (10.33)	2.33 (8.77)	2.77	3.56 (10.86)	3.66 (11.03)	3.61	5.00 (12.91)	5.00 (12.91)	5.00
T_{16}	Untreated control	24.78 (29.84)	25.55 (30.35)	25.16	32.55 (34.77)	33.11 (35.11)	32.83	46.88 (43.20)	47.22 (43.39)	47.05
	SEm±	0.15	0.13	0.14	0.13	0.12	0.12	0.15	0.13	0.14
	CD at 5%	0.43	0.39	0.41	0.38	0.36	0.37	0.45	0.38	0.41

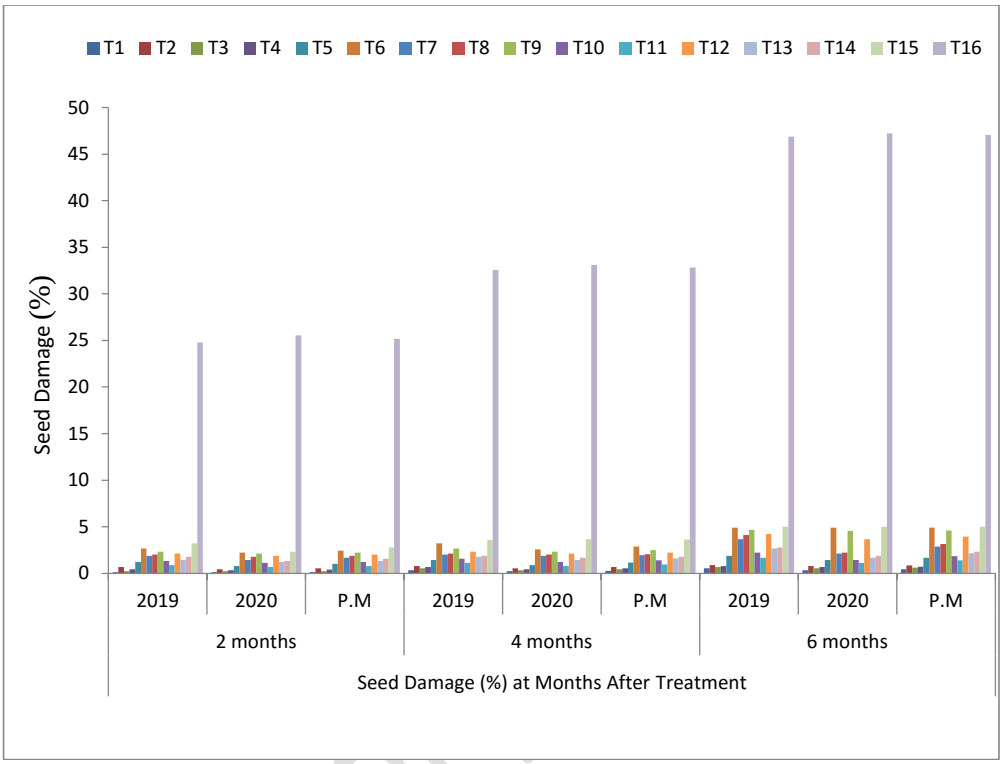

Fig.-1 Effect of newer insecticides and botanicals against *Callosobruchus chinensis* as seed protectants on percent seed damage in mungbean at 2, 4 and 6 months of ambient storage during 2019 and 2020.

Table-2 Effect of newer insecticides and botanicals against *Callosobruchus chinensis* as seed protectants on percent weight loss in mungbean at 2, 4 and 6 months of ambient storage during 2019 and 2020.

	Treatment	Weight loss (%)								
		2 months			4 months			6 months		
		2019	2020	P.M	2019	2020	P.M	2019	2020	P.M
T_1	Emamectin benzoate@40mg/kg	0.04 (0.66)	0.05 (0.71)	0.04	0.13 (2.03)	0.10 (1.50)	0.11	0.21 (2.61)	0.15 (2.19)	0.18
T_2	Spinotorum (11.7%SC@8.5mg/kg)	0.25 (2.88)	0.18 (2.39)	0.21	0.32 (3.22)	0.22 (2.69)	0.27	0.40 (3.57)	0.35 (3.38)	0.37
T_3	Sivanto (17.09%SL@0.01ml/kg)	0.09 (1.43)	0.10 (1.48)	0.09	0.19 (2.49)	0.15 (2.24)	0.17	0.27 (2.96)	0.28 (3.07)	0.27
T_4	Deltamethrin (Decis (2.8%EC@0.04ml/kg) Check	0.17 (2.30)	0.13 (2.06)	0.15	0.29 (3.10)	0.19 (2.46)	0.24	0.34 (3.31)	0.29 (3.10)	0.31
T_5	Karanj oil@5ml/kg	0.57 (4.31)	0.32 (3.19)	0.44	0.74 (4.91)	0.41 (3.65)	0.57	0.93 (5.53)	0.68 (4.74)	0.80
T_6	Castor oil@5ml/kg	1.25 (6.42)	1.21 (6.30)	1.23	1.56 (7.16)	1.38 (6.74)	1.47	2.56 (9.19)	2.55 (9.24)	2.55
T_7	Sunflower oil@5ml/kg	0.81 (5.15)	0.66 (4.67)	0.73	1.01 (5.76)	1.01 (5.74)	1.01	1.76 (7.61)	1.14 (6.12)	1.45
T_8	Mustard oil@5ml/kg	0.92 (5.50)	0.88 (5.36)	0.90	1.02 (5.78)	1.13 (6.09)	1.07	1.97 (8.07)	1.21 (6.30)	1.59
T_9	Sesamum oil@5ml/kg	1.12 (6.07)	1.08 (5.91)	1.10	1.30 (6.53)	1.27 (6.47)	1.28	2.11 (8.34)	2.40 (8.91)	2.25
T_{10}	Neem oil@5ml/kg	0.65 (4.62)	0.50 (4.02)	0.57	0.79 (5.10)	0.59 (4.38)	0.69	1.08 (5.97)	0.69 (4.76)	0.88
T_{11}	Neemoz gold@5ml/kg	0.37 (3.48)	0.25 (2.84)	0.31	0.57 (4.34)	0.33 (3.24)	0.45	0.84 (5.23)	0.54 (4.19)	0.69
T_{12}	Coconut oil@5ml/kg	1.01 (5.77)	1.03 (5.81)	1.02	1.12 (6.07)	1.19 (6.26)	1.15	2.07 (8.26)	1.95 (8.01)	2.01
T_{13}	Neem leaf powder@5g/kg	0.68 (4.71)	0.56 (4.27)	0.62	0.80 (5.11)	0.69 (4.75)	0.74	1.29 (6.51)	0.76 (4.99)	1.02
T_{14}	Neem kernel powder@5g/kg	0.76 (5.00)	0.65 (4.61)	0.70	0.82 (5.21)	0.75 (4.96)	0.78	1.35 (6.67)	1.00 (5.78)	1.17
T_{15}	Gorakhmundi powder@5g/kg	1.59 (7.25)	1.25 (6.51)	1.42	1.80 (7.71)	1.83 (7.77)	1.81	2.59 (9.26)	2.56 (9.20)	2.57
T_{16}	Untreated control	15.82 (23.43)	14.84 (22.64)	15.33	29.97 (33.17)	30.39 (33.44)	30.18	44.38 (41.76)	44.68 (41.93)	44.53
	SEm±	0.03	0.07	0.05	0.07	0.07	0.07	0.11	0.06	0.08
	CD at 5%	0.10	0.21	0.15	0.21	0.20	0.20	0.32	0.19	0.25

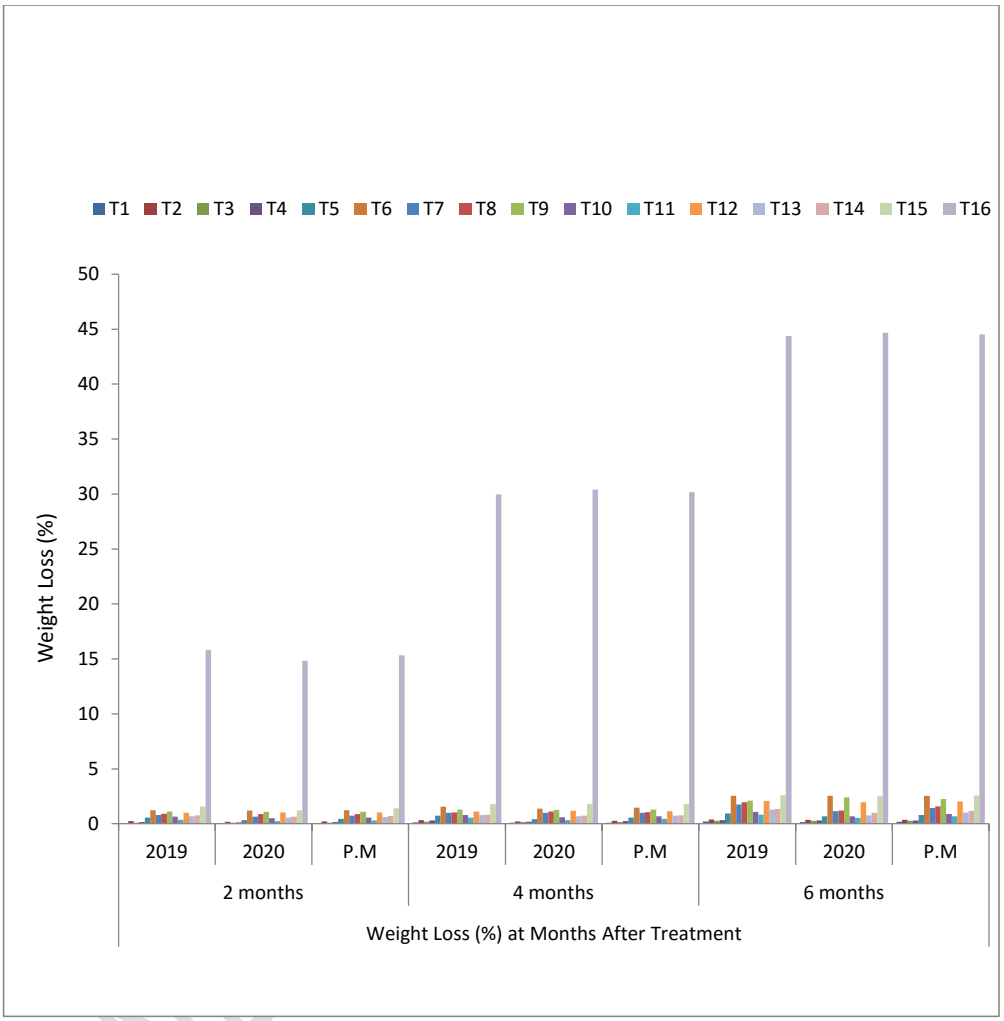

Fig.-2 Effect of newer insecticides and botanicals against *Callosobruchus chinensis* as seed protectants on percent weight loss in mungbean at 2, 4 and 6 months of ambient storage during 2019 and 2020.

Table-3: Effect of newer insecticides and botanicals against *Callosobruchus chinensis* as seed protectants on percent seed Moisture content in mungbean at 2, 4 and 6 months of ambient storage during 2019 and 2020.

	Treatment	Seed Moisture content (%)								
		2 months			4 months			6 months		
		209	2020	P.M	2019	2020	P.M	2019	2020	P.M
T_1	Emamectin benzoate@40mg/kg	11.47 (19.79)	11.50 (19.82)	11.48	11.85 (20.13)	12.02 (20.28)	11.93	12.57 (20.75)	12.67 (20.28)	12.62
T_2	Spinotorum (11.7%SC@8.5mg/kg)	11.08 (19.43)	11.20 (19.55)	11.14	11.75 (20.04)	11.79 (20.08)	11.77	12.43 (20.64)	12.49 (20.08)	12.46
T_3	Sivanto (17.09%SL@0.01ml/kg)	11.35 (19.68)	11.37 (19.70)	11.36	11.80 (20.08)	11.91 (20.18)	11.85	12.52 (20.71)	12.61 (20.18)	12.56
T_4	Deltamethrin (Decis (2.8%EC@0.04ml/kg) Check	11.25 (19.59)	11.32 (19.65)	11.28	11.77 (20.06)	11.88 (20.16)	11.82	12.47 (20.67)	12.58 (20.16)	12.52
T_5	Karanj oil@5ml/kg	10.90 (19.27)	11.00 (19.36)	10.95	11.67 (19.97)	11.70 (20.00)	11.68	11.95 (20.21)	12.39 (20.00)	12.17
T_6	Castor oil@5ml/kg	10.73 (19.11)	10.77 (19.16)	10.75	11.48 (19.80)	11.48 (19.76)	11.48	11.69 (19.98)	12.14 (19.76)	11.91
T_7	Sunflower oil@5ml/kg	10.85 (19.22)	10.91 (19.28)	10.88	11.61 (19.91)	11.66 (19.96)	11.63	11.85 (20.13)	12.33 (19.96)	12.09
T_8	Mustard oil@5ml/kg	10.81 (19.19)	10.88 (19.25)	10.84	11.58 (19.89)	11.64 (19.94)	11.61	11.81 (20.09)	12.29 (19.94)	12.05
T_9	Sesamum oil@5ml/kg	10.75 (19.13)	10.83 (19.20)	10.79	11.53 (19.84)	11.54 (19.85)	11.53	11.75 (20.04)	12.19 (19.85)	11.97
T_{10}	Neem oil@5ml/kg	10.88 (19.25)	10.94 (19.31)	10.91	11.65 (19.95)	11.68 (19.98)	11.66	11.89 (20.16)	12.36 (19.98)	12.12
T_{11}	Neemoz gold@5ml/kg	10.95 (19.31)	11.04 (19.40)	10.99	11.72 (20.01)	11.76 (20.05)	11.74	12.04 (20.29)	12.46 (20.05)	12.25
T_{12}	Coconut oil@5ml/kg	10.79 (19.16)	10.85 (19.23)	10.82	11.55 (19.86)	11.57 (19.88)	11.56	11.79 (20.07)	12.25 (19.88)	12.02
T_{13}	Neem leaf powder@5g/kg	11.54 (19.85)	11.71 (20.00)	11.62	11.97 (20.23)	12.56 (20.74)	12.26	12.75 (20.91)	12.79 (20.74)	12.77
T_{14}	Neem kernel powder@5g/kg	11.51 (19.82)	11.68 (19.97)	11.59	11.92 (20.19)	12.49 (20.68)	12.20	12.69 (20.86)	12.75 (20.68)	12.72
T_{15}	Gorakhmundi powder@5g/kg	11.48 (19.80)	11.57 (19.88)	11.52	11.88 (20.15)	12.36 (20.57)	12.12	12.61 (20.79)	12.69 (20.57)	12.65
T_{16}	Untreated control	10.92 (19.29)	11.01 (19.37)	10.96	11.69 (19.99)	11.73 (20.02)	11.71	12.01 (20.27)	12.42 (20.02)	12.21
	SEm±	0.008	0.013	0.01	0.009	0.011	0.01	0.010	0.011	0.06
	CD at 5%	0.023	0.038	0.03	0.027	0.032	0.03	0.029	0.031	0.16

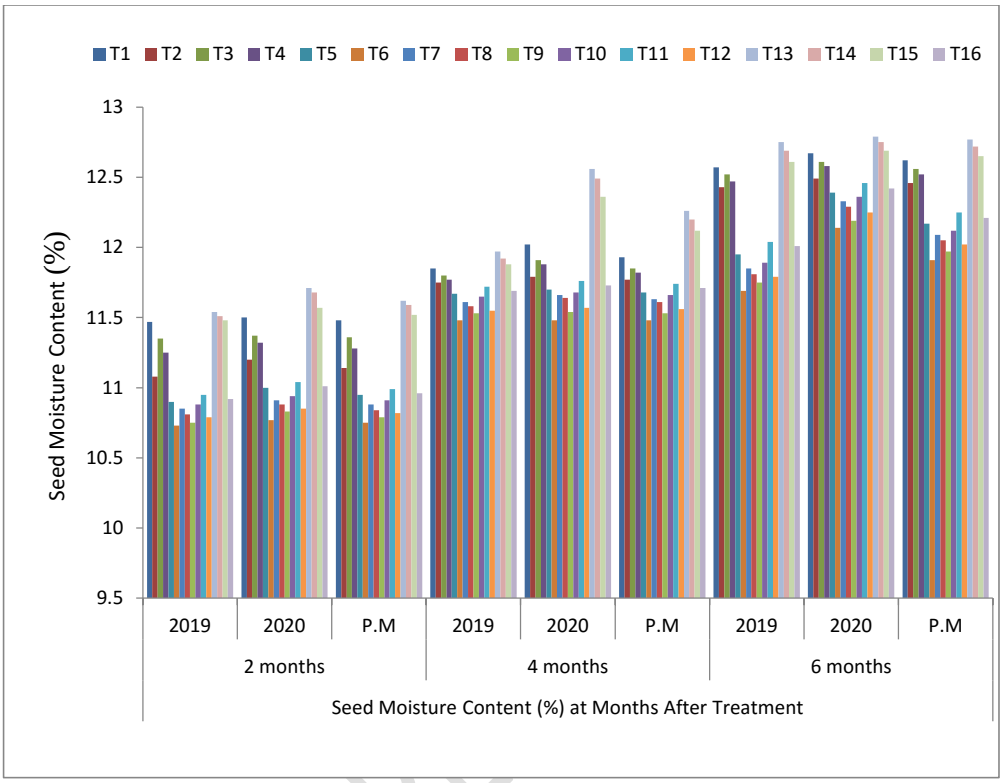

Fig.-3 Effect of newer insecticides and botanicals against *Callosobruchus chinensis* as seed protectants on percent seed Moisture content in mungbean at 2, 4 and 6 months of ambient storage during 2019 and 2020.

Table-4: Effect of newer insecticides and botanicals against *Callosobruchus chinensis* as seed protectants on percent seed Germination in mungbean at 2, 4 and 6 months of ambient storage during 2019 and 2020.

	Treatment	Seed Germination (%)								
		2 months			4 months			6 months		
		2019	2020	P.M	2019	2020	P.M	2019	2020	P.M
T_1	Emamectin benzoate@40mg/kg	94.33 (76.24)	93.33 (75.01)	93.83	91.33 (72.89)	90.66 (72.18)	90.99	86.00 (68.00)	87.66 (69.41)	86.83
T_2	Spinotorum (11.7%SC@8.5mg/kg)	93.33 (75.07)	91.66 (73.23)	92.49	89.66 (71.22)	89.33 (70.91)	89.49	84.33 (66.67)	85.00 (67.19)	84.66
T_3	Sivanto (17.09%SL@0.01ml/kg)	94.00 (75.82)	92.33 (73.90)	93.16	91.00 (72.53)	90.00 (71.55)	90.50	85.00 (67.19)	86.33 (68.28)	85.66
T_4	Deltamethrin (Decis (2.8%EC@0.04ml/kg) Check	93.66 (75.40)	92.00 (73.56)	92.83	90.00 (71.55)	89.66 (71.22)	89.83	84.66 (66.93)	85.66 (67.74)	85.16
T_5	Karanj oil@5ml/kg	92.66 (74.29)	89.66 (71.22)	91.16	87.66 (69.42)	88.33 (70.00)	87.99	82.00 (64.88)	83.66 (66.14)	82.83
T_6	Castor oil@5ml/kg	89.33 (70.96)	86.00 (68.00)	87.66	84.00 (66.40)	83.66 (66.14)	83.83	78.00 (62.00)	79.33 (62.94)	78.66
T_7	Sunflower oil@5ml/kg	91.33 (71.91)	88.33 (70.00)	89.83	85.33 (67.47)	85.00 (67.19)	85.16	80.00 (63.18)	81.66 (64.63)	80.83
T_8	Mustard oil@5ml/kg	91.00 (72.53)	88.00 (69.71)	89.50	85.00 (67.19)	84.66 (66.92)	84.83	79.66 (63.18)	81.33 (64.38)	80.49
T_9	Sesamum oil@5ml/kg	89.66 (71.28)	86.33 (68.28)	87.99	84.33 (66.66)	84.00 (66.40)	84.16	78.66 (62.47)	80.00 (63.41)	79.33
T_{10}	Neem oil@5ml/kg	92.33 (73.90)	89.33 (70.91)	90.83	87.33 (69.15)	86.33 (68.28)	86.83	81.00 (64.13)	83.00 (65.63)	82.00
T_{11}	Neemoz gold@5ml/kg	93.00 (74.65)	91.00 (72.53)	92.00	89.00 (70.61)	88.66 (70.32)	88.83	84.00 (66.40)	84.66 (66.92)	84.33
T_{12}	Coconut oil@5ml/kg	90.66 (72.20)	87.66 (69.41)	89.16	84.66 (66.93)	84.33 (66.66)	84.49	79.00 (62.70)	80.66 (63.89)	79.83
T_{13}	Neem leaf powder@5g/kg	92.00 (73.56)	89.00 (70.61)	90.50	86.66 (68.56)	86.00 (68.00)	86.33	80.66 (63.90)	82.66 (65.38)	81.66
T_{14}	Neem kernel powder@5g/kg	91.66 (73.23)	88.66 (70.32)	90.16	86.00 (68.00)	85.33 (67.47)	85.66	80.33 (63.66)	82.33 (65.13)	81.33
T_{15}	Gorakhmundi powder@5g/kg	88.66 (70.32)	85.33 (67.45)	86.99	83.00 (65.63)	82.66 (65.37)	82.83	77.00 (61.32)	78.33 (62.23)	77.66
T_{16}	Untreated control	85.33 (67.47)	82.66 (65.38)	83.99	76.66 (61.10)	76.33 (60.87)	76.49	69.33 (56.35)	70.33 (56.98)	69.83
	SEm±	0.80	0.55	0.67	0.55	0.56	0.55	0.74	0.63	0.68
	CD at 5%	2.32	1.60	1.96	1.60	1.67	1.63	2.16	1.84	2.00

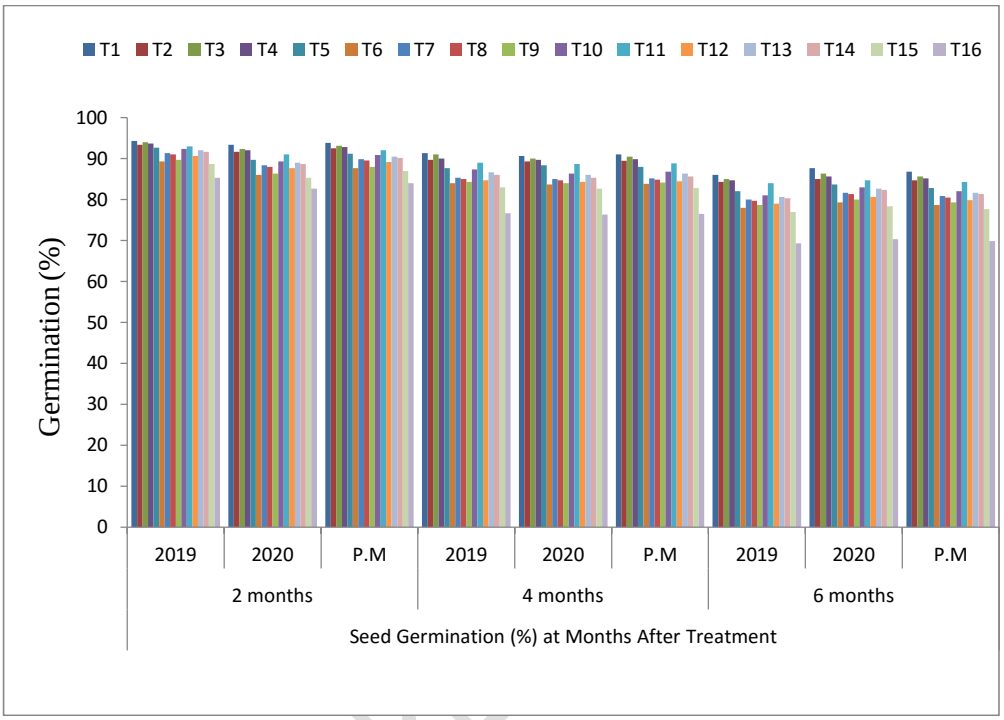

Fig.-4 Effect of newer insecticides and botanicals against *Callosobruchus chinensis* as seed protectants on percent seed Germination in mungbean at 2, 4 and 6 months of ambient storage during 2019 and 2020.

Conclusion

The results revealed that percent seed moisture content, percent seed germination, percent seed damage and percent seed weight loss was directly propionate to storage duration. However, decreased in percent seed germination was inversely propionate to percent damage of seed. Among various tested newer insecticides and botanicals as seed protectants were capable to maintain the seed germination above IMSCS (Indian Minimum Seed Certification Standard) up to six months of storage with minimum percent seed damage and percent loss of weight, which was significantly superior over control during ambient storage of mungbean seed. Among tested newer insecticides and botanicals Emamectin

benzoate @ 40.0 mg/kg^{-1} seed, Sivanto prime @ 0.01 ml/kg^{-1} seed, Neemoz gold @ 5ml/kg^{-1} seed and karanj oil @ 5ml/kg seed against *Callosobruchus chinensis* with (86.83%), (85.66%), (84.33%) and (82.83%) maintained maximum seed germination with comparatively minimum bruchids infestation and percent weight loss up to six months of storage. Thus, the present investigation advocated that Emamectin benzoate @ 40.0 mg/kg^{-1} seed, Sivanto prime @ 0.01 ml/kg^{-1} seed, Neemoz gold @ 5ml/kg^{-1} seed and karanj oil @ 5ml/kg seed may be utilizing as seed protectants in stored mungbean against pulse beetle *Callsobruchus chinensis* Linn for a long period of storage *i.e.* up to 6 months storage.

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