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Effects of Botanicals and Synthetic of Insecticides on Field Emergence and Crop Establishment in Mungbean [*Vigna radiata* (L.) Wilzeck]

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ABSTRACT

Mungbean, is a drought-resistant, green manure crop and suitable for dry land as a major pulse crop in India. India is the largest producer and consumer of pulses, which improve soil properties, provide nutritious fodder and prevent soil erosion. However, pests like bruchids can destroy 60% of production, necessitating the use of eco-friendly seed protectants. Laboratory studies were conducted at Acharya Narendra Deva University of Agricultural and Technology, Ayodhya, using mungbean seed *cv*. IPM-2-3. Seeds were mixed with seed protectants and stored in gunny bags. Field emergence and crop establishment were tested *and* data were analyzed using a Completely Randomized Design with three replications. Seed protectants and insecticides are effective in maintaining field emergence and crop establishment in mungbean. Emamectin benzoate, Sivanto prime and Gorakhmundi powder are the best treatments, with maximum field emergence and minimum establishment influenced by environmental factors. These findings are supported by various studies. Emamectin benzoate and Neemoz gold were found to be effective insecticides for field emergence and crop establishment in mungbean, with the latter recommended for storability and field establishment.

Key words: Crop establishment, Field emergence, Insecticides, Mungbean.

Mungbean, native to India and central Asia, is a major pulse crop in many Asian countries, including India and is closely related to adzuki and cowpea. It is the third most important pulse crop in India by Vavilov (1926). Mungbean, a drought-resistant crop, is widely cultivated in Asia, Africa and Australia. It serves as a green manure crop, excellent fodder for animals and is suitable for dry land farming. India is the largest producer and consumer of pulses, mainly grown in Rajasthan, Maharashtra Andhra Pradesh, Karnataka, Orrisa and Bihar. Pulses improve soil properties, use atmospheric nitrogen, provide nutritious fodder and are drought-resistant, preventing soil erosion. They are also known as the 'Marvel of Nature'. Mungbean, a vegetable protein rich in lysine, is a valuable component in many Indian subcontinent diets. Its green pods are eaten as vegetables, while mature seeds are used for pulse.

The mungbean flour is used as a soap substitute for body cleaning. Pulses grams are infested by *Callosobruchus chinensis* L. and maculate Fabricius, with green gram experiencing the highest damage (79.59%). Insect pests destroy 60% of total production, with pulse beetle being the major pest causing infestation in both field and storage. Burchids, a dangerous pest, can cause a significant loss of 10-90% in seed viability and nutritive value, rendering them unfit for human consumption and sowing according to Rathore *et al*. (2002). Seed protectants like Emamectin benzoate and Spinosad help maintain seed quality during ambient storage by preventing bruchid infestation and ensuring germination, viability *and* vigor by Patil *et al*. (2006). Seed viability and vigor are influenced by various physico-chemical factors such as moisture content, humidity, temperature, seed composition, gaseous exchange, storage structure, storage insects *and* packaging materials given by Doijode (1988). Seed quality hasn't been preserved by advancements in technology in seed production as a consequence of insect pest infestation during storage and escalating post-harvest losses. Eco-friendly seed protectants like Neem extracts, vegetative oil and plant species are used to protect seeds against pulse beetle for long storage periods (*Callosobruchus chinensis* L.) according to Golob and Webley (1980).

In the field and laboratory studies were conducted in Sixteen treatments including control with three replications (CRD) in the Seed Entomology Laboratory, Seed Science and Technology Section of Acharya Narendra Deva

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University of Agricultural and Technology, Kumarganj, Ayodhya during 2019-20. For this purpose, a disinfested seed of mungbean seed *cv.* IPM-2-3 was used. From the disinfested seed, five hundred grams of seed was mixed with the required quantities of seed protectant after diluting in water @ 5 ml/kg seed as per the technical program taken for each replication in each treatment for proper seed coating. After mixing the protectants and drying in the shade, a 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.

Per cent field emergence

Field emergence of graded seed was tested in the field. A hundred seeds of each treatment were sown in the well-prepared field in a randomized complete block design with three replicates. The seed were sown row to row and plant to plant with a spacing of 40×10 cm. Field emergence was recorded on the 15th day after sowing and the emergence percentage was calculated taking into account the number of seedlings emergence three centimeters above the soil surface.

Field emergence (%)=

$$\frac{\text{Number of seedling emerged on } 15^{th} \text{ days}}{\text{Total number of seed each treatmemt}} \times 100$$

Per cent crop establishment

The materials used for the study of field emergence were subjected to observe the plant establishment after the 30th day's percentage of over 100 seeds sown in three replications.

Statistical analysis

The data obtained from the various experiments were statistically analyzed in the appropriate program under completely randomized design with three replications with angular transformation given by Panse and Sukhante (1954).

Effect of seed protectants on per cent field emergence of stored mungbean seed at different storage periods

The differences in percent field emergence among tested different seed protectants were found statistically significant at 2, 4 and 6 months of storage during 2019 and 2020 (Table 1). At 2 months of storage, during 2019 and 2020, field emergence ranged from 75.33 to 86.66 and 79.66 to 92.00 per cent respectively. However, the maximum per cent field emergence was found in Emamectin benzoate @ 40 mg/kg^{-1} seed (86.66 and 92.00%) followed by Sivanto prime @ 0.01 ml/kg^{-1} seed (85.66 and 91.66%), Spinetorum @ 8.5 mg/kg^{-1} seed (83.66 and 90.66) and Neemoz gold @ 5 ml/kg^{-1} seed (81.66 and 89.66%) as compared to Deltamethrin 2.8 EC @ 0.04 ml/kg^{-1} seed (84.00 and 91.00%) and minimum percent field emergence was found in Gorakhmundi powder @ 5 g/kg^{-1} seed (76.00 and 80.33%) followed by Castor oil @ 5 ml/kg^{-1} seed (76.33 and 81.00%), Sesamum oil @ 5 ml/kg^{-1} seed (77.00 and 82.33%) and Coconut oil @ 5 ml/kg^{-1} seed (79.00 and 84.33%) respectively.

The pooled mean of both years at 2 months of storage of the percent field emergence ranged from 77.49 to 89.33. The maximum per cent field emergence was recorded in Emamectin benzoate @ 40 mg/kg^{-1} seed (89.33%) followed by Sivanto prime @ 0.01 ml/kg^{-1} seed (88.66%), Spinetorum @ 8.5 mg/kg^{-1} seed (87.16%), Neemoz gold @ 5 ml/kg^{-1} seed (85.66%) and Karanj oil @ 5 ml/kg^{-1} seed (84.99%) as compared to Deltamethrin 2.8 EC @ 0.04 ml/kg^{-1} seed (87.50%). The minimum per cent field emergence was found in Gorakhmundi powder @ 5 g/kg^{-1} seed (78.16%) followed by Castor oil @ 5 ml/kg^{-1} seed (78.66%), Sesamum oil @ 5 ml/kg^{-1} seed (79.66%), Coconut oil @ 5 ml/kg^{-1} seed (81.66%) and Neem kernel powder @ 5 g/kg^{-1} seed (83.16%).

At 4 months of storage, during 2019 and 2020, field emergence ranged from 70.33 to 83.00 and 71.00 to 87.66 per cent respectively. However, the maximum per cent field emergence was found in Emamectin benzoate @ 40 mg/kg^{-1} seed (83.00 and 87.66%) followed by Sivanto prime @ 0.01 ml/kg^{-1} seed (82.66 and 86.33%), Spinetorum @ 8.5 mg/kg^{-1} seed (81.33 and 84.00%) and Neemoz gold @ 5 ml/kg^{-1} seed (79.66 and 83.66%) as compared to Deltamethrin 2.8 EC @ 0.04 ml/kg^{-1} seed (81.66 and 85.66%) and minimum percent field emergence was found in Gorakhmundi powder @ 5 g/kg^{-1} seed (71.66 and 74.33%) followed by Castor oil @ 5 ml/kg^{-1} seed (72.66 and 75.00%), sesamum oil @ 5 ml/kg^{-1}seed (73.66 and 75.66%) and coconut oil @5 ml/kg^{-1} seed (74.33 and 76.00%) respectively.

The pooled mean of both years at 4 months of storage of the percent field emergence ranged from 70.66 to 85.33. The maximum percent field emergence was found in Emamectin benzoate @ 40 mg/kg^{-1} seed (85.33%) followed by Sivanto prime @ 0.01 ml/kg^{-1} seed (84.49%), Spinetorum @ 8.5mg/kg^{-1} seed (82.66%), Neemoz gold @ 5 ml/kg^{-1} seed (81.66%) and Karanj oil @ 5 ml/kg^{-1} seed (80.66%) as compared to Deltamethrin 2.8 EC @ 0.04 ml/kg^{-1} seed (83.66%). The minimum percent field emergence was found in Gorakhmundi powder @ 5 g/kg^{-1} seed (72.99%) followed by Castor oil @ 5 ml/kg^{-1} seed (73.83%), Sesamum oil @ 5 ml/kg^{-1} seed (74.66%), Coconut oil @ 5 ml/kg^{-1} seed (75.16%) and Neem kernel powder @ 5 g/kg^{-1} seed (78.00%).

At 6 months of storage, during 2019 and 2020, field emergence ranged from 67.66 to 81.33 and 65.66 to 82.33 percent respectively. However, the maximum percent field emergence was found in Emamectin benzoate @ 40 mg/kg^{-1} seed (81.33 and 82.33%) followed by Sivanto prime @ 0.01 ml/kg^{-1} seed (80.66 and 81.66%), Spinetorum @ 8.5 mg/kg^{-1} seed(79.33 and 80.33%) and Neemoz gold @ 5 ml/kg^{-1} seed (78.33 and 79.66%) as compared to Deltamethrin 2.8 EC @ 0.04 ml/kg^{-1} seed (79.66 and 81.33%) and minimum per cent field emergence was found in Gorakhmundi powder @ 5 g/kg^{-1} seed (70.33 and

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

	Treatment	Field emergence (%)								
		2 months			4 months			6 months		
		2019	2020	P.M	2019	2020	P.M	2019	2020	P.M
T1	Emamectinbenzoate @40 mg/kg	86.66 (68.33)	92.00 (73.73)	89.33	83.00 (65.70)	87.66 (69.62)	85.33	81.33 (64.41)	82.33 (65.80)	81.83
T2	Spinotorum (11.7% SC@8.5 mg/kg)	83.66 (66.17)	90.66 (72.34)	87.16	81.33 (64.44)	84.00 (66.62)	82.66	79.33 (62.96)	80.33 (63.72)	79.83
T3	Sivanto prime(17.09% SL@0.01 ml/kg)	85.66 (67.77)	91.66 (73.31)	88.66	82.66 (65.40)	86.33 (68.46)	84.49	80.66 (63.92)	81.66 (64.71)	81.16
T4	Deltamethrin (Decis(2.8% EC@0.04 ml/kg)Check	84.00 (66.44)	91.00 (72.72)	87.50	81.66 (64.67)	85.66 (67.97)	83.66	79.66 (63.21)	81.33 (64.52)	80.49
T5	Karanj oil@5 ml/kg	80.66 (63.92)	89.33 (71.08)	84.99	79.00 (62.71)	82.33 (65.26)	80.66	77.66 (61.79)	79.00 (62.74)	78.33
T6	Castor oil@5 ml/kg	76.33 (60.87)	81.00 (64.18)	78.66	72.66 (58.46)	75.00 (60.06)	73.83	72.00 (58.06)	70.33 (57.00)	71.16
T7	Sunflower oil@5 ml/kg	78.00 (62.01)	86.66 (68.59)	82.33	75.66 (60.45)	77.00 (61.35)	76.33	74.33 (59.57)	76.00 (60.69)	75.16
T8	Mustard oil@5 ml/kg	77.66 (61.79)	85.66 (67.76)	81.66	75.00 (59.98)	76.66 (61.17)	75.83	74.00 (59.35)	75.66 (60.46)	74.83
T9	Sesamum oil@5 ml/kg	77.00 (61.32)	82.33 (65.19)	79.66	73.66 (59.12)	75.66 (60.55)	74.66	72.33 (58.26)	73.00 (58.74)	72.66
T10	Neem oil@5 ml/kg	80.00 (63.51)	89.00 (70.80)	84.50	78.33 (62.24)	81.66 (64.75)	79.99	77.00 (61.37)	77.66 (61.81)	77.33
T11	Neemoz gold@5 ml/kg	81.66 (64.70)	89.66 (71.30)	85.66	79.66 (63.27)	83.66 (66.21)	81.66	78.33 (62.26)	79.66 (63.26)	78.99
T12	Coconut oil@5 ml/kg	79.00 (62.71)	84.33 (66.73)	81.66	74.33 (59.59)	76.00 (60.74)	75.16	73.00 (58.69)	74.66 (59.83)	73.83
T13	Neem leaf powder@5 g/kg	79.66 (63.24)	88.66 (70.37)	84.16	78.00 (62.06)	80.66 (63.97)	79.33	76.33 (60.1)	77.00 (61.36)	76.66
T14	Neem kernel powder@5 g/kg	79.33 (62.98)	87.66 (69.47)	83.16	77.00 (61.36)	79.00 (62.73)	78	75.66 (60.46)	76.66 (61.13)	76.16
T15	Gorakhmundi powder@5 g/kg	76.00 (60.68)	80.33 (63.69)	78.16	71.66 (57.84)	74.33 (59.58)	72.99	70.33 (57.00)	68.00 (55.55)	69.16
T16	Untreatedcontrol	75.33 (60.23)	79.66 (63.19)	77.49	70.33 (57.03)	71.00 (57.43)	70.66	67.66 (55.37)	65.66 (54.13)	66.66
	SEm±	1.68	1.66	1.72	1.95	2.71	2.33	1.93	2.25	2.09
	CD at 5%	4.87	4.83	5.01	5.68	7.87	6.77	5.60	6.53	6.06

*P.M.- Pooled Mean.

68.00%) followed by Castor oil @ 5 ml/ kg^{-1} seed (72.00 and 70.33%), Sesamum oil @ 5 ml/kg^{-1} seed (72.33 and 73.00%) and Coconut oil @5 ml/kg^{-1} seed (73.00 and 74.66%) respectively. The overall values concerning percent field emergence were statistically significant with protectants as well as storage periods.

The pooled mean of both years at 6 months of storage of the percent field emergence ranged from 66.66 to 81.83. The maximum percent field emergence was found in Emamectin benzoate @ 40 mg/kg^{-1} seed (81.83%) followed by Sivanto prime @ 0.01 ml/kg^{-1} seed (81.16%), Spinetorum @ 8.5 mg/kg^{-1} seed (79.83%), Neemoz gold @ 5 ml/kg^{-1} seed (78.99%) and Karanj oil @ 5 ml/kg^{-1} seed (78.33%) as compared to Deltamethrin 2.8 EC @ 0.04 ml/kg^{-1} seed (80.49%). The minimum percent field emergence was found in Gorakhmundi powder @ 5 g/kg^{-1} seed (69.16%) followed by Castor oil @ 5 ml/kg^{-1} seed (71.16%), Sesamum oil @ 5 ml/kg^{-1} seed (72.66%), Coconut oil @ 5 ml/kg^{-1} seed (73.83%) and Neem kernel powder @ 5 g/kg^{-1} seed (76.16%).

Effect of seed protectants on percent crop establishment of stored mungbean seed at different storage periods

The differences in per cent crop establishment among tested different seed protectants were found statistically significant at 2, 4 and 6 months of storage during 2019 and 2020 (Table 2).

At 2 months of storage, during 2019 and 2020, crop establishment ranged from 74.33 to 86.00 and 79.33 to 91.33 percent respectively. However, the maximum percent crop establishment was found in Emamectin benzoate @ 40 mg/kg^{-1} seed (86.00 and 91.33%) followed by Sivanto prime @ 0.01 ml/kg^{-1} seed (85.33 and 91.00%), Spinetorum @ 8.5 mg/kg^{-1} seed (82.66 and 90.33%) and Neemoz gold @ 5 ml/kg^{-1} seed (81.33 and 89.33%) as compared to Deltamethrin 2.8 EC @ 0.04 ml/kg^{-1} seed (83.66 and 90.66%) and minimum percent crop establishment was found in Gorakhmundi powder @ 5 g/kg^{-1} seed (75.33 and 80.00%) followed by Castor oil @ 5 ml/kg^{-1} seed (75.33 and 80.66%), Sesamum oil @ 5 ml/kg^{-1} seed (76.00 and 82.00%) and Coconut oil @5 ml/kg^{-1} seed (77.66 and 84.00%) respectively.

The pooled mean of both years at 2 months of storage and the per cent crop establishment ranged from 76.83 to 88.66. The maximum percent crop establishment was found in Emamectin benzoate @ 40 mg/kg^{-1} seed (88.66%) followed by Sivanto prime @ 0.01 ml/kg^{-1} seed (88.16%), Spinetorum @ 8.5 mg/kg^{-1} seed (86.49%), Neemoz gold @ 5 ml/kg^{-1} seed (85.33%) and Karanj oil @ 5 ml/kg^{-1} seed (84.66%) as compared to Deltamethrin 2.8 EC @ 0.04 ml/kg^{-1} seed (87.16%). The minimum percent crop establishment was found in Gorakhmundi powder @ 5g/kg^{-1} seed (77.66%) followed by Castor oil @ 5 ml/kg^{-1} seed (77.99%), Sesamum oil @ 5 ml/kg^{-1} seed (79.00%), Coconut oil @ 5 ml/kg^{-1} seed (80.83%) and Neem kernel powder @ 5 g/kg^{-1} seed (82.83%).

At 4 months of storage, during 2019 and 2020, crop establishment ranged between 70.00-82.33 and 70.33-87.33 per cent respectively. However, the maximum per cent crop establishment was found in Emamectin benzoate @ 40 mg/kg^{-1} seed (82.33 and 87.33%) followed by Sivanto prime @ 0.01 ml/kg^{-1}seed (82.00 and 86.33%), Spinetorum @ 8.5 mg/kg^{-1} seed (81.00 and 83.66%) and Neemoz gold @ 5 ml/kg^{-1} seed (79.33 and 83.00%) as compared to Deltamethrin 2.8 EC @ 0.04 ml/kg^{-1} seed (81.33 and 85.66%) and minimum per cent crop establishment was found in Gorakhmundi powder @ 5 g/kg^{-1} seed (71.33 and 74.00%) followed by Castor oil @ 5 ml/kg^{-1} seed (72.00 and 74.33%), Sesamum oil @ 5 ml/kg^{-1} seed (73.33 and 75.00%) and Coconut oil @5 ml/kg^{-1} seed (74.00 and 75.66%) respectively.

The pooled mean of both years at 4 months of storage and the per cent crop establishment ranged from 70.16 to 84.83. The maximum per cent crop establishment was found in Emamectin benzoate @ 40 mg/kg^{-1} seed (84.83%) followed by Sivanto prime @ 0.01 ml/kg^{-1} seed (84.16%), Spinetorum @ 8.5 mg/kg^{-1} seed (82.33%), Neemoz gold @ 5 ml/kg^{-1} seed (81.16%) and Karanj oil @ 5 ml/kg^{-1} seed (80.33%) as compared to Deltamethrin 2.8 EC @ 0.04 ml/kg^{-1} seed (83.49%). The minimum percent crop establishment was found in Gorakhmundi powder @ 5 g/kg^{-1} seed (72.66%) followed by Castor oil @ 5 ml/kg^{-1} seed (73.16%), Sesamum oil @ 5 ml/kg^{-1} seed (74.16%), Coconut oil @ 5 ml/kg^{-1} seed (74.83%) and Neem kernel powder @ 5 g/kg^{-1} seed (77.66%).

At 6 months of storage, during 2019 and 2020, crop establishment ranged from 66.33 to 80.66 and 65.00 to 82.00 per cent respectively. However, the maximum per cent crop establishment was found in Emamectin benzoate @ 40 mg/kg^{-1} seed (80.66 and 82.00%) followed by Sivanto prime @ 0.01 ml/kg^{-1} seed (80.33 and 81.33%), Spinetorum @ 8.5 mg/kg^{-1} seed (79.00 and 80.00%) and Neemoz gold @ 5 ml/kg^{-1} seed (78.00 and 79.33%) as compared to Deltamethrin 2.8 EC @ 0.04 ml/kg^{-1} seed (79.33 and 81.00%) and minimum percent crop establishment was found in Gorakhmundi powder @ 5 g/kg^{-1} seed (69.66 and 67.66%) followed by Castor oil @ 5 ml/kg^{-1} seed (70.66 and 70.00%), Sesamum oil @ 5 ml/kg^{-1}seed (71.33 and 72.66%) and Coconut oil @ 5 ml/kg^{-1} seed (72.33 and 74.00%) respectively. The overall values for per cent crop establishment were statistically significant with protectants as well as storage periods. By Ruxanabi *et al*. (2022) found that nine treatment combinations, including conventional tillage, zero tillage *and* zero tillage with chick pea residue, significantly improved soil chemical and microbial parameters. The seed inoculation with Rhizobium, PSB and AM Fungi was more effective.

The pooled mean of both years at 6 months of storage and the per cent crop establishment ranged from 65.66 to 81.33. The maximum percent crop establishment was found in Emamectin benzoate @ 40 mg/kg^{-1} seed (81.33%) followed by Sivanto prime @ 0.01 ml/kg^{-1} seed (80.83%), Spinetorum @ 8.5 mg/kg^{-1} seed (79.50%), Neemoz gold @ 5 ml/kg^{-1} seed (78.66%) and Karanj oil @ 5 ml/kg^{-1} seed (77.83%) as compared to Deltamethrin 2.8 EC @ 0.04 ml/kg^{-1}

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

	Treatment	Crop establishment (%)								
		2 months			4 months			6 months		
		2019	2020	P.M	2019	2020	P.M	2019	2020	P.M
T1	Emamectinbenzoate@ 40 mg/kg	86.00 (68.11)	91.33 (73.09)	88.66	82.33 (65.19)	87.33 (69.33)	84.83	80.66 (63.93)	82.00 (65.52)	81.33
T2	Spinotorum (11.7% SC@8.5 mg/kg)	82.66 (65.40)	90.33 (72.05)	86.49	81.00 (64.20)	83.66 (66.31)	82.33	79.00 (62.76)	80.00 (63.48)	79.50
T3	Sivanto prime (17.09% SL@0.01 ml/kg)	85.33 (67.55)	91.00 (72.58)	88.16	82.00 (64.94)	86.33 (68.46)	84.16	80.33 (63.68)	81.33 (64.44)	80.83
T4	Deltamethrin (Decis (2.8% EC@0.04 ml/kg) Check	83.66 (66.21)	90.66 (72.38)	87.16	81.33 (64.47)	85.66 (67.97)	83.49	79.33 (62.96)	81.00 (64.24)	80.16
T5	Karanj oil@5 ml/kg	80.33 (63.69)	89.00 (70.78)	84.66	78.66 (62.50)	82.00 (64.98)	80.33	77.00 (61.36)	78.66 (62.49)	77.83
T6	Castor oil@5 ml/kg	75.33 (60.21)	80.66 (63.93)	77.99	72.00 (58.06)	74.33 (59.59)	73.16	70.66 (57.21)	70.00 (56.80)	70.33
T7	Sunflower oil@5 ml/kg	77.33 (61.55)	86.33 (68.32)	81.83	75.33 (60.23)	76.66 (61.12)	75.99	74.00 (59.34)	75.66 (60.47)	74.83
T8	Mustard oil@5 ml/kg	77.00 (61.35)	85.66 (67.76)	81.33	74.66 (59.81)	76.33 (60.95)	75.49	73.66 (59.13)	75.33 (60.22)	74.49
T9	Sesamum oil@5 ml/kg	76.00 (60.66)	82.00 (64.94)	79.00	73.33 (58.93)	75.00 (60.08)	74.16	71.33 (57.65)	72.66 (58.53)	71.99
T10	Neem oil@5 ml/kg	80.00 (63.51)	88.66 (70.50)	84.33	78.33 (62.24)	81.33 (64.50)	79.83	76.66 (61.15)	77.33 (61.58)	76.99
T11	Neemozgold@5 ml/kg	81.33 (64.47)	89.33 (70.99)	85.33	79.33 (63.01)	83.00 (65.68)	81.16	78.00 (62.05)	79.33 (63.02)	78.66
T12	Coconut oil@5 ml/kg	77.66 (61.16)	84.00 (66.49)	80.83	74.00 (59.39)	75.66 (60.50)	74.83	72.33 (58.26)	74.00 (59.39)	73.16
T13	Neem leaf powder@5 g/kg	79.00 (62.77)	88.33 (70.10)	83.66	77.33 (61.60)	80.00 (63.47)	78.66	76.00 (60.71)	76.66 (61.13)	76.33
T14	Neem kernel powder@5 g/kg	78.00 (62.10)	87.66 (69.47)	82.83	76.66 (61.15)	78.66 (62.49)	77.66	75.33 (60.27)	76.33 (60.89)	75.83
T15	Gorakhmundi powder@5 g/kg	75.33 (60.23)	80.00 (63.52)	77.66	71.33 (57.44)	74.00 (59.36)	72.66	69.66 (56.60)	67.66 (55.34)	68.66
T16	Untreated control	74.33 (59.62)	79.33 (62.99)	76.83	70.00 (56.83)	70.33 (57.01)	70.16	66.33 (54.57)	65.00 (53.73)	65.66
	SEm±	2.15	1.86	2.00	2.36	2.57	2.46	2.29	2.21	2.25
	CDat 5%	6.25	5.41	5.83	6.84	7.47	7.15	6.64	6.40	6.52

*P.M.- Pooled Mean.

seed (80.16%). The minimum per cent crop establishment was found in Gorakhmundi powder @ 5 g/kg^{-1} seed (68.66%) followed by Castor oil @ 5 ml/kg^{-1} seed (70.33%), Sesamum oil @ 5 ml/kg^{-1} seed (71.99%), Coconut oil @ 5ml/kg^{-1} seed (73.16%) and Neem kernel powder @ 5 g/kg^{-1} seed (75.83%) respectively. Rajawat *et al*. (2017), tested various insecticides, finding Thiacloprid 21.7% SC most effective against white fly and aphids, outperforming Flubendiamide 24%+Thiacloprid 24% SC. The significant difference in percent crop establishment was found due to the nature of newer insecticides and botanical treatments as seed protectants during different storage periods. Thus we can say that the level of seed moisture content was directly related to the nature of seed coating and the environmental condition.

The results expressed seed protectants to newer molecules of insecticides and botanicals as the best anticipating treatment in maintaining the percent field emergence during environmental conditions. The per cent field emergence ranged from 66.66 to 81.83 per cent up to 6 months of storage period. However, the maximum per cent field emergence was recorded in Emamectin benzoate @ 40 mg/kg^{-1} seed followed by Sivanto prime @ 0.01 ml/kg^{-1} seed and the minimum per cent field emergence was recorded in Gorakhmundi powder @ 5 g/kg^{-1} seed as compared to Deltamethrin 2.8 EC @ 0.04 ml/kg^{-1} seed (check). The per cent field emergence was affected by the environmental factors at the field condition in mungbean. These results were also supported by Sharma *et al*. (2017), Singh *et al*. (2017) and Gadewar *et al*. (2017). The crop establishment ranged from 65.66 to 81.33 per cent up to 6 months of storage period. However, the maximum percent crop establishment was recorded in Emamectin benzoate @ 40 mg/kg^{-1} seed followed by Sivanto prime @ 0.01 ml/kg^{-1} seed and the minimum per cent crop establishment was recorded in Gorakhmundi powder @ 5 g/kg^{-1} seed followed by as compared to Deltamethrin 2.8 EC @ 0.04 ml/kg^{-1} seed (check). The crop establishment was affected by the environmental factors at the field condition in mungbean. These results were also additionally supported by Gadewar *et al*. (2017), Singh *et al*. (2017) and Sharma *et al*. (2017). Chinnasamy *et al*. (2022) classify seed vigor into high, medium and low vigor based on the correlation between mean germination time and field emergence.

CONCLUSION

The most effective per cent field emergence was recorded in seed-treated insecticides with Emamectin benzoate @ 40.0 mg/kg^{-1} seed followed by Sivanto prime @ 0.01 ml/kg^{-1} seed. Thus, botanical seed protectants were recorded in Neemoz gold @ 5 ml/kg seed and Karanj oil @ 5 ml/kg seed, respectively. The maximum crop establishment (%) was recorded in Emamectin benzoate @ 40.0 mg/kg^{-1} seed followed by Sivanto prime @ 0.01 ml/kg^{-1} seed. Thus, botanical seed protectants were recorded in Neemoz gold @ 5 ml/kg seed and Karanj oil @ 5 ml/kg seed, respectively. Along with better percent field emergence and per cent crop establishment in mungbean at field conditions. This can be recommended Emamectin benzoate @ 40.0 mg/kg^{-1} seed or Neemoz gold @ 5 ml/kg^{-1} seed as seed protectants before storage for storability and field establishment in mungbean crop establishment by maintaining upto six months of storage against *C. chinensis*.

Conflict of interest

All authors declare that they have no conflict of interest.

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