

Emamectin Benzoate: A Promising Seed Treating Insecticide to Control Bruchids in Storage of Green Gram

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ABSTRACT: The laboratory experiment was conducted to assess the effect of newer insecticides on seed quality and management of pulse beetle (*Callosobruchus chinensis* L) during storage of green gram seeds cv. DGGV-2 at the Department of Seed Science and Technology, UAS, Dharwad during 2021-22. The study involved seed treatment with five newer insecticides at two concentrations stored in cloth bags under ambient conditions. The experiment results revealed that seed treated with emamectin benzoate 5 SG (4 ppm/kg of seed) was most effective in controlling insect infestation recording the highest adult mortality (87.75%), lowest seed damage (3.67%) and weight loss (1.10%) and was on par with spinetoram 11.7 SC at 4 ppm per kg of seed (87.25%, 5.00% and 1.65%, respectively) compared to untreated (29.25%, 23.67% and 10.65%, respectively) at the end of nine months. The study concluded that the green gram seeds treatment with emamectin benzoate 5 SG was found most effective against pulse beetle infestation along with other insecticide under study which were on par in maintaining seed quality parameters above Indian Minimum Seed Certification Standards for at least six months under ambient condition.

Keywords: Emamectin benzoate, Green gram, Bruchids

INTRODUCTION

Pulse crops are significant to Indian agriculture since they not only produce foods with higher protein content but also improve soil health by fixing atmospheric nitrogen. Pulses are the best way to address issues of malnutrition in the vegetarian Indian diet because of 20–30 per cent protein content in general, with elevated lysine in particular.

Green gram (*Vigna radiata* L. Wilczek) is native to India and Central Asia. It is highly nutritious, containing 24.6 per cent protein, 1.0 per cent fat, 57.5 per cent carbohydrate, calcium 0.08 g, phosphorous 0.045 g, Fe 5.7 mg, vitamin A 750 IU, thiamine 0.525 mg, riboflavin 300 mg, fiber 2.2 g per 100 g of seed and provides 234 calorie energy [1]. Protein content in pulses is thrice higher than in cereals. Globally, green gram is grown in an area of 7.3 million hectares and worldwide production is about 5.3 million tonnes with an average productivity of 0.73 tonnes per hectare. India and Myanmar each supply about 30 per cent of global production [2]. India is

the major producer of green gram in the world. It is grown in almost all the states. Important green gram growing states in the country are Rajasthan, Maharashtra, Karnataka, Andhra Pradesh, Madhya Pradesh and Bihar.

Infestations by coleopteran pests in the field and storage are the prime prevailing challenges to pulse production, storage and protection. The most notable insect pests that target pulses are bruchids (*Callosobruchus* spp.), known for causing significant storage losses and severe damage [3]. *Callosobruchus chinensis* L. is the most extensive and destructive pulse beetle species. This beetle is expected to account for 40–50 per cent pulse losses in storage because of its relative short life cycle and high level of reproduction potential [4].

Pesticides alone, which is the most effective strategy for pest management, have been mainly responsible for the successful suppression of the stored of pests. Because of their selective and on-going usage of earlier chemical molecules, this pest has developed a wide range of resistance against the frequently used insecticides,

resulting in more often outbreaks. This has emphasised the need for the search of newer, safer and more effective pesticides that could offer practical and efficient management of insect pests.

Both the quality and the quantity of the stored pulses are impacted by bruchids. The bruchid-infested pulses exhibit qualitative deterioration, including germination loss, an increase in moisture, reduction in crude protein, decrease in total nitrogen and uric acid. Therefore, an effort was made to quantify and evaluate the losses of pulse seeds caused by bruchid infestation. Considering these points, the present investigation was carried out to evaluate the most effective insecticide molecules on bruchids infestation during storage of green gram seeds.

MATERIALS AND METHODS

The storage study of green gram variety DGGV-2 was conducted from December 2021 to August 2022 and it was laid out in a completely randomized design with twelve treatments and three replications. twelve treatments. i.e. T₁: Spinetoram at 2 ppm/kg, T₂: Spinetoram at 4 ppm/kg, T₃: Flupyradifurone at 2 ppm/kg, T₄: Flupyradifurone at 4 ppm/kg, T₅: Emamectin benzoate at 2 ppm/kg, T₆: Emamectin benzoate at 4 ppm/kg, T₇: Deltamethrin at 2 ppm/kg, T₈: Deltamethrin at 4 ppm/kg, T₉: Spinosad at 2 ppm/kg, T₁₀: Spinosad at 4 ppm/kg, T₁₁: Castor oil at 5 ml/kg and T₁₂: Control to understand the effect of seed treatments with the insecticide on storage insect (*Callosobruchus chinensis*) mortality, seed damage, seed weight loss and seed germination in Department of Seed Science and Technology, College of Agriculture, Dharwad (during 2021-22).

Seeds of green gram variety DGGV-2 were dried to less than 10 per cent moisture and treated with the insecticide as per treatments by mixing the 1000 gm of seeds with the insecticide and the treated seeds were kept overnight for shade drying. Treated seeds were stored under ambient conditions for a period of nine months.

The mass culturing was initiated by confining with 10-20 freshly emerged beetles in the plastic containers having 500 g of green gram and it was covered with muslin cloth and secured tightly with rubber band. Mass culturing of *Callosobruchus chinensis* was done at room temperature in the plastic container. Ten pairs of adult beetles were collected and used for releasing in insecticide and castor oil treated seeds. The culture was maintained throughout the study period to ensure a constant supply of beetles as and when required.

Adult mortality (%) was recorded at 1, 3, 7, 11 and 15 days after release. After 15 days, a total number of died beetles were calculated and converted to a percentage by the following formula.

$$\text{Adult mortality (\%)} = \frac{\text{Number of died beetles}}{\text{Total number of beetles released}} \times 100$$

Percentage of seed damage was calculated by taking a random sample of 100 seeds and counting the number of bored seeds affected by pulse beetle (*Callosobruchus chinensis*) and converted into percentage.

$$\text{Percentage of seed damage} = \frac{\text{Number of seeds damaged}}{\text{Total number of seeds in a sample}} \times 100$$

The count and weight method was used to determine the weight loss by using the formula.

$$W (\%) = \frac{(W_u \times N_d) - (W_d \times N_u)}{W_u \times (N_d + N_u)} \times 100$$

Where,

W = Weight loss (%), W_u = Weight of undamaged seeds, N_u = Number of undamaged seeds, W_d = Weight of damaged seeds, N_d = Number of damaged seeds

The seed germination test was conducted by following the ISTA procedure (5), following between paper method using paper towel. One hundred seeds were equidistantly placed on the germination paper in four replications (100 x 4) and these rolled paper towels were placed in a slanting position in the walk-in seed germinator and maintained at a constant temperature of 25 ± 1°C and 95 per cent relative humidity. On seventh day of germination test (final count), number of normal seedlings was counted and expressed in percentage.

$$\text{Germination (\%)} = \frac{\text{Number of normal seedlings}}{\text{Total number of seeds kept for germination}} \times 100$$

The seedling vigour index I were calculated and expressed in number as suggested by using formula (6). Were shoot and root length of ten randomly selected ten seedlings from each treatment were measured to calculate the vigour index I.

$$\text{Seedling vigour index-I} = \frac{\text{Germination (\%)} \times [\text{shoot length (cm)} + \text{root length (cm)}]}{100}$$

RESULTS AND DISCUSSION

Adult mortality percentage

Results revealed that mortality (100%) of adult insects in all the treatments after three MAS (Months after storage)

Table 1. Initial seed quality of green gram cv. DGGV-2

Parameters	Details
Germination (%)	97.33
Seedling vigour index- I	4272
Seed infestation (%)	NIL
Seed infection (%)	NIL

Table 2. Effect of insecticide seed treatment on adult mortality percentage in green gram cv. DGGV-2 during storage

Treatments	1MAS	3 MAS	6 MAS	9 MAS
T ₁	100.00 (90.00)*	100.00 (90.00)	97.00 (80.61)	86.75 (68.7)
T ₂	100.00 (90.00)	100.00 (90.00)	97.50 (81.73)	87.25 (69.13)
T ₃	100.00 (90.00)	100.00 (90.00)	95.25 (77.54)	85.00 (67.23)
T ₄	100.00 (90.00)	100.00 (90.00)	95.50 (77.83)	85.25 (67.42)
T ₅	100.00 (90.00)	100.00 (90.00)	97.75 (81.72)	87.50 (69.39)
T ₆	100.00 (90.00)	100.00 (90.00)	98.00 (82.04)	87.75 (69.61)
T ₇	100.00 (90.00)	100.00 (90.00)	94.00 (76.06)	83.75 (66.27)
T ₈	100.00 (90.00)	100.00 (90.00)	94.50 (76.65)	84.25 (66.65)
T ₉	100.00 (90.00)	100.00 (90.00)	96.00 (79.21)	85.75 (67.9)
T ₁₀	100.00 (90.00)	100.00 (90.00)	96.50 (80.52)	86.25 (68.35)
T ₁₁	85.50 (67.81)	78.75 (62.64)	68.25 (55.73)	52.50 (46.43)
T ₁₂	35.00 (36.27)	33.50 (35.36)	31.75 (34.29)	29.25 (32.74)
S. Em.±	0.696	0.563	2.086	1.186
CD @ 1%	2.75	2.23	8.25	4.69

Note: *Figures in parentheses are arc sine transformed values
MAS- Months after storage

except castor oil (78.75%) and control (33.50%). The mortality gradually declined in treated seeds with the lapse of time during storage. After nine months of the storage period, emamectin benzoate @ 4 ppm of seed treatment recorded maximum mortality (87.75%) in treated green gram seeds, which was on par with emamectin benzoate @ 2 ppm (87.50%) and spinetoram @ 4 ppm (87.25%), followed by spinetoram @ 2 ppm (86.75%), spinosad @ 4 ppm (86.25%), spinosad @ 2 ppm (85.75%) and flupyradifurone @ 4 ppm (85.25%) for the corresponding period. Among the treatments, control was less effective and recorded 29.25 per cent killing of the pest in green gram seeds.

Some potent insecticides affect the nervous system of arthropods by raising chloride ion flux at the neuromuscular junction, reducing feeding behaviour, further leading to irreversible paralysis and ultimately death of beetles at various doses (7). Toxicity of insecticides causing higher mortality of adult bruchids in treated pulse seeds after storage period have been reported earlier by several workers (8), (9) in cowpea and (10) in pigeon pea.

Seed damage percentage

In green gram the lowest seed damage by pulse beetle was observed in emamectin benzoate @ 4 ppm (3.67%), which is on par with emamectin benzoate @ 2 ppm (4.00%), followed by spinetoram @ 4 ppm (5.00%), spinetoram @ 2 ppm (5.33%), spinosad @ 4 ppm (5.67%) and spinosad @ 2 ppm (6.00%) after nine months storage period. Seed damage was maximum in control (23.67%) among all treatments at the end of the nine months storage period. (11) also observed the highest seed damage in bengal gram, in deltamethrin treatment which indicated the resistance development in *Callosobruchus chinensis*. Present study also revealed the relatively less effectiveness of deltamethrin seed treatment than other insecticides. Due to the repellent and high mortality of adults, the grub population was reduced, hence the percentage of seed damage was minimal in the emamectin benzoate treated seeds. These findings are similar to the (12) in green gram, (13) in black gram, (14) and (15) in chickpea.

Weight loss (%)

Results indicated that after nine months of storage, emamectin benzoate @ 4 ppm had the lowest seed weight loss (1.10%) and was on par with emamectin benzoate @ 2 ppm (1.20%), which is followed by spinetoram @ 4 ppm (1.65%), spinetoram @ 2 ppm (1.71%), spinosad @ 2 ppm (2.10%), spinosad @ 4 ppm (2.52%), flupyradifurone at 2 ppm (2.59%) and flupyradifurone at 4 ppm (2.60%). The untreated control showed the highest weight loss (10.65%) due to corresponding higher significant percentage of seed damage by pulse beetle at the end of nine months of storage period. These results are in line (9) in cowpea, (10) in pigeon pea, (16) in red gram and (17) in mung bean.

Germination (%)

Even after nine months of storage, all treatments showed higher seed germination than the control. Emamectin

Table 3. Effect of insecticide seed treatment on seed damage percentage and weight loss percentage in green gram cv. DGGV-2 during storage

Treatments	Seed damage percentage				Weight loss percentage			
	1MAS	3 MAS	6 MAS	9 MAS	1MAS	3 MAS	6 MAS	9 MAS
T ₁	0.00 (0.71)*	0.00 (0.71)	0.00 (0.71)	5.33 (2.41)	0.00 (0.71)*	0.00 (0.71)	0.00 (0.71)	1.71 (1.49)
T ₂	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	5.00 (2.35)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	1.65 (1.47)
T ₃	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	7.00 (2.74)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	2.59 (1.76)
T ₄	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	6.33 (2.61)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	2.60 (1.76)
T ₅	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	4.00 (2.12)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	1.20 (1.3)
T ₆	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	3.67 (2.04)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	1.10 (1.27)
T ₇	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	7.67 (2.86)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	3.22 (1.93)
T ₈	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	7.00 (2.74)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	2.94 (1.85)
T ₉	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	6.00 (2.55)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	2.10 (1.61)
T ₁₀	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	5.67 (2.48)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	2.52 (1.74)
T ₁₁	0.00 (0.71)	0.00 (0.71)	6.33 (2.61)	11.00 (3.39)	0.00 (0.71)	0.00 (0.71)	2.72 (1.79)	4.73 (2.29)
T ₁₂	6.00 (2.55)	10.67 (3.34)	16.33 (4.1)	23.67 (4.92)	2.70 (1.79)	4.80 (2.3)	7.35 (2.8)	10.65 (3.34)
S.Em.±	0.007	0.010	0.017	0.029	0.005	0.006	0.011	0.018
CD @ 1%	0.03	0.04	0.07	0.11	0.02	0.02	0.04	0.07

Note: *Figures in parentheses are arc sine transformed values; MAS- Months after storage

Table 4. Effect of insecticides seed treatment on seed germination percentage and seedling vigour index I in green gram cv. DGGV-2 during storage

Treatments	Seed germination percentage				Seedling vigour index I			
	1MAS	3 MAS	6 MAS	9 MAS	1MAS	3 MAS	6 MAS	9 MAS
T ₁	96.33 (79.37)*	95.00 (77.33)	86.00 (68.07)	82.00 (64.92)	4032	3799	3472	3114
T ₂	96.67 (79.97)	95.33 (77.8)	86.67 (68.63)	82.67 (65.43)	4039	3767	3411	3069
T ₃	95.67 (78.14)	93.67 (75.51)	85.00 (67.23)	80.00 (63.44)	4096	3846	3570	3156
T ₄	95.67 (78.07)	94.00 (75.87)	85.67 (67.77)	80.33 (63.68)	4058	3825	3494	3127
T ₅	97.00 (81.63)	95.00 (77.57)	90.00 (71.71)	84.00 (66.48)	4197	4068	3764	3404
T ₆	97.00 (81.63)	95.67 (78.63)	90.33 (72.04)	84.67 (67.01)	4178	4044	3723	3351
T ₇	95.00 (77.4)	92.33 (74.08)	83.00 (65.69)	78.67 (62.52)	4010	3755	3333	3031
T ₈	95.33 (77.8)	93.00 (74.8)	84.00 (66.45)	79.33 (62.98)	3978	3702	3305	2986
T ₉	96.00 (79.21)	94.33 (76.61)	85.33 (67.55)	81.67 (64.69)	4139	3982	3678	3278
T ₁₀	96.33.00 (80.14)	94.67 (77.25)	85.67 (67.86)	82.33 (65.21)	4109	3911	3619	3232
T ₁₁	94.33 (77.29)	91.67 (73.76)	83.67 (66.32)	72.00 (58.09)	3911	3658	3208	2853
T ₁₂	93.00 (74.93)	90.00 (71.71)	81.00 (64.2)	70.00 (56.8)	3863	3572	3119	2747
S.Em.±	2.79	2.17	1.39	1.12	89.72	126.80	68.80	61.57
CD @ 1%	11.02	8.58	5.48	4.41	NS	NS	272.14	243.54

Note: *Figures in parentheses are arc sine transformed values; MAS- Months after storage

benzoate @ 4 ppm of seed had the highest seed germination (84.67%), while the untreated control had the lowest (70.00%) after nine months of storage. The most effective seed treatments for maintaining seed germination were emamectin benzoate @ 4 ppm, which was on par with emamectin benzoate @ 2 ppm (84.00%), spinetoram @ 4 ppm (82.67%), spinosad @ 4 ppm (82.33%), spinetoram @ 2 ppm (82.00%), spinosad @ 2 ppm (81.67%), flupyradifurone @ 4 ppm (80.33%), flupyradifurone @ 2 ppm (80.00%), followed by deltamethrin @ 4 ppm (79.33%) and deltamethrin @ 2 ppm (78.67%) after nine months of storage. Regardless of seed treatment, germination was found to decline with increasing storage time. The reduced germination rate was caused due to direct feeding of developing insects on seed storage materials and damaging seed embryos by consumption of vital components in seeds (18). These results are also in line with (19) in green gram. (20) and (21) studied black gram.

Seedling vigour index I

Seedling vigour index I is also recorded higher in seeds treated with novel insecticide to emamectin benzoate @ 2 ppm and 4 ppm, spinosad @ 2 ppm and 4 ppm, flupyradifurone @ 2 ppm and 4 ppm, spinetoram @ 2 ppm and 4 ppm, deltamethrin @ 2 ppm and 4 ppm per kg of seed in compared to untreated control. The better seed quality parameters were observed with insecticidal seed treatment may be due to lower insect infestation noticed with these treatments. The decline in seedling vigour index I may be attributed due to decline in germination per cent, seedling length and dry matter accumulation in seedlings (22). These results are in correspondence with in chickpea (23), in cowpea (24), in chickpea (25), in black gram and (13) and in green gram (21).

In conclusion, Emamectin benzoate @ 2 ppm and 4 ppm performed better among the other newer insecticides like spinosad, spinetoram and flupyradifurone. @ 2 and 4 ppm at the end of the storage period beside, this chemical stood promising not only in controlling the seed damage and weight loss but also maintaining the qualitative parameters like seed germination and seedling vigour index. This chemical exhibited prolonged sustainable protection from bruchids and can greatly control loss by bruchids during storage and did not show any adverse effect on seed quality of green gram.

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