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Optimization of biofumigant doses for the management of pulse beetle (*Callosobruchus chinensis*) in green gram (*Vigna radiata* L.)

Varshitha K*, Sangeeta I macha, Shakuntala N M, Doddagoudar S R, Sushila Nadagouda
Department of Seed Science and Technology, University of Agricultural Sciences, Raichur, Karnataka, India

Abstract
A laboratory experiment was conducted during 2024-25 at the Department of Seed Science and Technology, College of Agriculture, UAS, Raichur, to standardize the optimum doses of biofumigants in green gram (*Vigna radiata* L.). The experiment was laid out in a completely randomized design with nine treatments and three replications. Biofumigant tablets (10 g each) were prepared using shade-dried powders of lantana and sweet flag at varying concentrations, while tablets without biofumigants served as control. After three days of exposure, lantana at 90% (D_5) recorded the highest insect mortality (60.00 %), and after seven days achieved complete mortality (100 %), followed by sweet flag 90 % (D_9) with 96.67 %. After one month of storage, lantana at 90 % (D_5) also showed the lowest seed weight loss (3.22 %) and seed infestation (6.58 %), whereas the untreated control (D_1) recorded the highest seed weight loss (33.25 %) and seed infestation (41.92 %). The results revealed that lantana tablets at 90 % concentration were most effective in inducing complete insect mortality and minimizing seed damage. Hence, fumigation with lantana tablets effectively preserved seed quality by reducing insect infestation and can serve as a safe and eco-friendly alternative to chemical fumigation.

Keywords: Insect mortality, green gram, Lantana, seed weight loss, seed infestation and Sweet Flag

Introduction

Green gram (*Vigna radiata* (L.) Wilczek) is an important leguminous crop of the family Fabaceae, widely cultivated in India and other South Asian countries. It is a short-durated and self-pollinated crop that fits well into various cropping systems and provides quick returns to farmers. The seeds are highly nutritious, containing about 29 % protein, 63 % carbohydrates and 16 % fiber, making it an essential source of dietary protein for millions of people (Anon., 2024). Besides its nutritional and economic importance, the crop enriches soil fertility through biological nitrogen fixation and provides valuable fodder residues after harvest, enhancing its role in sustainable agriculture. However, seed quality deterioration during storage is a major problem that reduces germination, vigour and market value. Storage pests such as bruchids (*Callosobruchus* spp.) cause heavy damage, and although chemical fumigants like aluminium phosphide are effective, their excessive use has raised concerns over resistance, environmental safety and human health (Donahaye, 2000). To overcome these limitations, the use of plant-based biofumigants offers an eco-friendly and sustainable alternative. Biofumigants release volatile allelochemicals that suppress pest activity without affecting seed viability (Rajashekar *et al*., 2012). Therefore, the present study was undertaken to standardize the optimum doses of botanical biofumigants against pulse beetle (*Callosobruchus chinensis* L.) in green gram (*Vigna radiata* L.) during storage.

Materials and Methods

The laboratory experiment on "Studies on effect of biofumigants on seed longevity in green gram (*Vigna radiata* L.)" was carried out during 2024–25 in the Department of Seed Science and Technology, College of Agriculture, University of Agricultural Sciences, Raichur, Karnataka, India. The experimental site is located in the North-Eastern Dry Zone (Zone-2) of Karnataka at 16°15′ N latitude and 77°20′ E longitude with an altitude of 389 m above mean sea level. The region experiences a semi-arid climate with moderate rainfall and high summer temperatures. Weather data on temperature, humidity and rainfall during the study period were recorded at the Meteorological Observatory, Main Agricultural Research Station, Raichur.

The study comprised nine treatments involving two biofumigants-lantana (*Lantana camara* L.) and sweet flag (*Acorus calamus* L.) arranged in a Completely Randomized Design (CRD) with three replications. The treatments were as follows:

D_1: Tablets without biofumigants (Control) (one tablet/ 100 g of seeds)
D_2: Biofumigation with lantana tablets at 60% (one tablet/ 100 g of seeds)
D_3: Biofumigation with lantana tablets at 70% (one tablet/ 100 g of seeds)
D_4: Biofumigation with lantana tablets at 80% (one tablet/ 100 g of seeds)
D_5: Biofumigation with lantana tablets at 90% (one tablet/ 100 g of seeds)
D_6: Biofumigation with sweet flag tablets at 60% (one tablet/ 100 g of seeds)
D_7: Biofumigation with sweet flag tablet at 70% (one tablet/ 100 g of seeds)
D_8: Biofumigation with sweet flag tablets at 80% (one tablet/ 100 g of seeds)
D_9: Biofumigation with sweet flag tablets at 90% (one tablet/ 100 g of seeds)

Insect Culture

The pulse beetle (*Callosobruchus chinensis*) infested seeds were obtained from the Seed Unit and mass cultured on green gram in 1 kg plastic jars at the Department of Entomology. The jars were covered with muslin cloth and secured with rubber bands. Every two generations, half of

the infested seeds were replaced with fresh uninfested seeds to maintain a continuous culture. Freshly emerged adults were used for the experiments.

Preparation of Biofumigant Tablets

Leaves of lantana and rhizomes of sweet flag were shade-dried for 45 days, ground into fine powder, and mixed with kitchen ash (carrier) and rice gruel in ratios of 60:35:5, 70:25:5, 80:15:5 and 90:5:5 (Kathirvelu *et al.*, 2019) [6]. A thick paste was prepared, molded manually into 10 g tablets and shade-dried. Control tablets were prepared using only carrier (9.5 g) and rice gruel (0.5 g).

Seed Fumigation Procedure

For each treatment, 100 g of clean green gram seeds were placed in airtight plastic containers. One 10 g biofumigant tablet was fixed to the lid and five pairs of newly emerged beetles were released. Each treatment was replicated thrice. Insect mortality was recorded up to seven days after fumigation and seed weight loss was assessed after one month. A control with carrier alone was also maintained.

Observations recorded

Physiological parameters

Insect Mortality (%)

Insect mortality was determined as the percentage of dead beetles after fumigation, following the method of Sun and Shepaud (1947) [11]:

$$\text{Insect mortality (\%)} = \frac{\text{Total number of dead insects}}{\text{Total number of insects released}} \times 100$$

Seed Weight Loss (%)

Seed weight loss due to insect feeding was estimated as per Harris and Lindblad (1978):

$$\text{Per cent seed weight loss} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100$$

Seed Infestation (%)

Seed infestation by *C. chinensis* was computed using the formula:

$$\text{Per cent seed infestation} = \frac{\text{Number of infested seeds}}{\text{Total number of seeds}} \times 100$$

Statistical analysis

Data were statistically analyzed using the method of Panse and Sukhatme (1985) [8]. The critical difference (CD) was computed at 1 % level of probability wherever the "F" test was significant.

Results and Discussion

Insect Mortality (%)

Insect mortality of pulse beetle differed significantly with biofumigant dosage and exposure period (Table 1). At 3 DAE, mean mortality was 45.93 %, with lantana tablets at 90 % (D_5) recording the highest (60.00 %), followed by sweet flag 90 % (D_9) (53.33 %), while the control (D_1) showed no mortality (0.00 %). At 7 DAE, mortality increased markedly (mean 73.70 %), with D5 achieving complete mortality (100 %) and D_9 showing 96.67 %. Mortality increased with concentration and duration, indicating a strong dose- and time-dependent response. The superior effect of lantana is attributed to coumaran, a bioactive compound causing neurotoxicity in insects (Rajashekar *et al*., 2013; 2014) [9, 10]

Seed Weight Loss and Seed Infestation (%)

Per cent seed weight loss and infestation after one month of storage are presented in Table 2. The mean seed weight loss and infestation were 9.76 % and 14.93 %, respectively, which were significantly lower than the untreated control (33.25 % and 41.92 %). Lantana tablets at 90 % (D_5) recorded the lowest seed weight loss (3.22 %) and infestation (6.58%), followed by sweet flag 90% (D_9) (4.18 % and 7.86 %), showing comparable efficacy. The reduced damage in lantana-treated seeds is attributed to coumaran and volatile compounds that interfere with feeding and reproduction of pulse beetles (Nandi *et al*., 2008; Ileke and Oni, 2011; Rajashekar *et al*., 2013) [3, 7, 9].

Overall, lantana 90% (D_5) proved most effective in achieving complete mortality and minimizing seed damage, followed by sweet flag 90% (D_9), indicating the potential of botanical biofumigants as eco-friendly alternatives for protecting stored green gram seeds.

Table 1: Effect of biofumigants on insect mortality (%) by pulse beetle (*Callosobruchus chinensis* L.) in green gram

Biofumigants	Insect mortality (%)		
	3 DAE	5 DAE	7 DAE
D_1 - Tablets without biofumigants (control)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
D_2 - Biofumigation with lantana tablets at 60 %	50.00 (44.99)	53.33 (46.92)	66.67 (54.78)
D_3 - Biofumigation with lantana tablets at 70 %	56.67 (48.84)	60.00 (50.85)	83.33 (66.14)
D_4 - Biofumigation with lantana tablets at 80 %	53.33 (46.92)	66.67 (54.78)	96.67 (83.84)
D_5 - Biofumigation with lantana tablets at 90 %	60.00 (50.76)	83.33 (66.14)	100.00 (89.99)
D_6 - Biofumigation with sweet flag rhizome tablets at 60 %	43.33 (41.15)	40.00 (39.23)	53.33 (46.92)
D_7 - Biofumigation with sweet flag rhizome tablets at 70 %	46.67 (43.07)	53.33 (46.92)	80.00 (63.43)
D_8 - Biofumigation with sweet flag rhizome tablets at 80 %	50.00 (44.99)	56.67 (48.84)	86.67 (68.85)
D_9 - Biofumigation with sweet flag rhizome tablets at 90 %	53.33 (46.92)	73.33 (59.00)	96.67 (83.84)
Mean	45.93 (40.85)	54.07 (45.85)	73.70 (61.98)
S. Em±	2.13	2.08	3.30
CD @ 1 %	6.36	6.23	9.88

*Figures in the parenthesis indicate the angular transferred values

Table 2: Effect of biofumigants on per cent seed weight loss and seed infestation by pulse beetle (*Callosobruchus chinensis* L.) in green gram

Biofumigants	Per cent seed weight loss	Per cent seed infestation
D_1 - Tablets without biofumigants (control)	33.25 (35.21)	41.92 (40.34)
D_2 - Biofumigation with lantana tablets at 60 %	9.33 (17.78)	15.55 (23.22)
D_3 - Biofumigation with lantana tablets at 70 %	7.38 (15.76)	12.55 (20.74)
D_4 - Biofumigation with lantana tablets at 80 %	5.33 (13.35)	9.47 (17.92)
D_5 - Biofumigation with lantana tablets at 90 %	3.22 (10.34)	6.58 (14.86)
D_6 - Biofumigation with sweet flag rhizome tablets at 60 %	10.33 (18.75)	16.41 (23.89)
D_7 - Biofumigation with sweet flag rhizome tablets at 70 %	8.50 (16.95)	13.37 (21.44)
D_8 - Biofumigation with sweet flag rhizome tablets at 80 %	6.33 (14.57)	10.67 (19.06)
D_9 - Biofumigation with sweet flag rhizome tablets at 90 %	4.18 (11.80)	7.86 (16.28)
Mean	9.76 (18.20)	14.93 (22.73)
S. Em±	1.36	1.58
CD @ 1 %	4.06	4.73

*Figures in the parenthesis indicate the angular transferred values

Conclusion

The findings of the present study indicated that, significantly maximum mortality of pulse beetle was recorded in seeds fumigated with lantana tablets at 90 % (D_5) (one tablet of 10 g weight/ 100 g of seeds). The lantana leaves contain the bioactive molecule coumaran, which was toxic to *Callosobruchus chinensis* (pulse beetle) when exposed for seven days, thereby reducing seed infestation and seed weight loss and proving to be an effective and eco-friendly alternative to chemical fumigation.

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