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Effect of botanicals and novel molecules on bruchid infestation and mortality in Mung Bean (*Vigna radiate* L.) storage in ambient conditions

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Abstract
An experiment was conducted at the Department of Seed Science and Technology, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur during 2023–24 and 2024–25. The experiment aimed to evaluate the influence of various botanicals and novel insecticidal molecules on the management of pulse beetle (*Callosobruchus chinensis*) infestation and efficacy of these molecules on mortality of the insects during storage. The experiment was laid out in a Completely Randomized Design (CRD) with twelve treatments and four replications. Treatments included botanicals such as neem kernel powder, neem oil, and EcoNeem Plus, along with novel molecules like broflanilide, dinotefuran, emamectin benzoate, and deltamethrin. Seeds of mung bean variety 'Shweta' were treated, shade-dried, and stored in jute bags under controlled laboratory conditions (20 ± 2 °C and 90 ± 3 % RH). Observations on seed damage, weight loss, and insect mortality were recorded at three-month intervals for up to twelve months. Results revealed that treated seeds maintained significantly higher germination percentage, vigour indices, and seedling growth compared to untreated control. Among the treatments, neem oil and broflanilide proved most effective in maintaining seed quality and minimizing pulse beetle infestation throughout the storage period. Insect mortality increased with storage duration under treated conditions, while untreated seeds showed heavy damage and rapid decline in viability. It was concluded that selected botanicals and novel molecules can effectively preserve mung bean seed quality and reduce storage pest infestation in an eco-friendly and economically feasible manner.

Keywords: Insect infestation, seed damage loss, broflanilide, dinotefuran, germination loss

Introduction
Mung bean (*Vigna radiata* L.) is an important pulse crop valued for its nutritional composition and role in sustainable agriculture. However, during storage, seed quality deteriorates due to moisture changes, seed-borne pests, and biochemical degradation, leading to reduced germination and vigour. The insect pest causing economic losses on pulse are many; some of them are in wide occurrence and some are localized in nature. The annual yield losses has been estimated to about 15% in chickpea, 20% in pigeon pea and 30% in urd and mung bean on an average of 2.5 -3.0 million tonnes of pulses are lost annually due to pest problems. According to an estimate about 60% of the total production is destroyed by insect pests from field to store in which storage insect-pests play an important role. Among various stored insect-pests the pulse beetle (*Callosobruchus chinensis*) is the major insect-pests of pulses causing infestation to pulses both in field as well as in storage. The seed lose their viability as well as nutritive value and so are rendered unfit for human consumption and sowing. The bruchids are most dangerous pest, causing loss of 10-90% (Rathore and Sharma, 2002) [13]. In order to maintain the seed quality during ambient storage which is deteriorated by infestation of bruchids is managed by using seed protectants insecticides and botanicals which arrest the bruchids life cycle during ambient storage. The use of common contact insecticides as seed protectants such as Emamectin benzoate, Spinosad, etc, can maintain the seed germination, viability and vigour (Patil *et al.*, 2006) [9]. The pulse beetle (*Callosobruchus chinensis*) is one of the major storage pests causing

heavy quantitative and qualitative losses. Safe and eco-friendly alternatives such as botanicals and novel insecticidal molecules are increasingly emphasized for protecting seed quality during storage. With the advancement of science, novel molecules are needed to be identified for precise control of bruchids with reduced harming to human health. The present investigation was therefore undertaken to evaluate the effect of different botanicals and novel molecules on the mortality of the insects at various storage periods and their efficacy in preventing seed damage due to insect infestation of mungbean during prolonged storage.

Materials and Methods

The study was conducted during 2023–24 and 2024–25 at the Department of Seed Science and Technology, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (U.P.), India. The experiment comprised of twelve treatments viz., T_1-Neem Seed Kernel Powder @ 5gm/kg, T_2-Neem oil @ 5ml/kg, T_3- Eco Neem plus @ 5ml/kg, T_4-Broflanilide @ 1 ppm (300 SC) 3.33 mg/kg, T_5-Broflanilide @ 2 ppm (300 SC) 6.66 mg/kg, T_6-Broflanilide @ 3 ppm (300 SC) 9.99 mg/kg, T_7-Dinotefuran @ 1ppm (20 SG) 5 mg/kg, T_8-Dinotefuran @ 2ppm (20 SG) 10mg/kg, T_9-Dinotefuran @ 3ppm (20 SG) 20m/kg, T_{10} - Emamectin benzoate @2ppm (5 SG) 40mg, T_{11}-Deltamethrin @ 1ppm (2.8 EC) 0.04 ml/kg, T_{12}-Control. The seeds of mungbean varietiy ‘Shweta’ were disinfested before start the experiment. These seeds were kept at least one week in the laboratory under ambient conditions. One kg of freshly harvested seed with very high percentage of germination and low moisture content (<10%) was taken for each treatment for experiment. For seed treatments with the required quantity of pesticides were diluted in water to make total volume of 5 ml for treating 1 kg of seed for proper coating. After drying in shade, seeds were packed and kept in room under ambient temperature. The data on insect mortality, insect infestation (%), germination loss (%) and seed damage loss (%) at 3, 6, 9 and 12 months was recorded. For insect mortality 100g seeds were taken from each treatment bags tri-monthly and 10 adults of pulse beetle (5 male and 5 female) were released in it and mortality was recorded at 3, 7 and 15 day. The number of dead insects out of ten was recorded as insect mortality at respective day. The data collected during the course of investigation was pooled and subjected to statistical analysis by adopting appropriate method of analysis of variance. The analysis of variance of the data for each parameter was computed using the OPSTAT software.

Results

The results obtained from the pooled data are shown in the table 1 and 2 and graphically depicted in fig 1 and fig 2. The data from the table 1 and fig 1 indicates that there was significant effect of different botanicals and novel insecticides on insect mortality. The data on insect mortality under different treatments at various storage intervals (0, 3, 6, 9, and 12 months) revealed distinct variations in the efficacy of treatments over time. In general, insect mortality increased with time after treatment (from the 3rd to the 15th day), while it gradually decreased with prolonged storage, indicating a progressive decline in the potency of the treatments. Treatment T_9 recorded highest mortality by the ^{15th} day showing consistent and most stable insect mortality at 0, 3, 6 and 12 months which was followed by treatment T_8 and T_6. Apart from this, treatments T_3, T_5 and T_{10} showed moderate stability, while T_1, T_2, T_4 and T_{11} were less effective in the long term. The control (T_{12}) exhibited negligible mortality throughout the storage periods, confirming the treatment effects. Freshly prepared formulations exhibited maximum efficacy, while extended storage led to a gradual loss of activity. Similar observations have been reported in earlier studies on the stability of insecticidal formulations, where prolonged storage reduced the bio-efficacy due to volatilization, oxidation, or chemical degradation of active components. Results reported by Jolly and Ekbote (2005) [4], Jolly *et al.* (2005) [5], Biswas *et al.* (2010) [16], Srinath (2010) [15] and Oyewole and Agwu (2021) [8] confirm the above findings.

The data on table 2 indicated towards the effectiveness of various botanicals and novel insecticides in protecting the grains during prolonged storage under ambient conditions. From the data presented in table 2, it is evident that the insect infestation was effectively checked by the treatments T_4, T_5, and T_6 showing no insect infestation up to 12 months. However, treatments T_8 and T_9 also showed no insect infestation up to 9 months but its efficacy reduced in 12 months. The highest insect infestation was recorded in control which justifies the treatment efficacy. The ability of these insecticidal treatments showed their efficacy in checking the insect infestation during prolonged storage which may be attributed to their toxicity to insect pest. These findings are in accordance to the results reported by Devi and Kalita (2011) [3], Mirmoayedi *et al*. (2011) [6], Raheem and Sridevi (2011) [10], Rajasri and Rao (2012) [11], Mishra *et al.* (2018) [7] and Bhati (2021) [1]. The lowest germination loss after 12 months of storage as compared to initial germination of the seeds was recorded with the treatment T_4 followed by T_9 and T_5 however, initially at 3 months, the lowest germination loss was showed by the treatment T_6 followed by T_9 and T_8. The highest germination loss was recorded with the Control at all storage periods. The lower germination loss may be attributed to the negligible toxicity of these novel molecules on seeds and high activity on insects which rendered them viable and vigourous during the storage up to 12 months. Similar findings have also been reported by Rathod *et al.* (2019) [12], Singh *et al*. (2019) [14] and Bhati *et al.* (2021) [2]. The data regarding seed damage loss presented in the table 2 shows that there was significant effect of various treatments on it. The lowest seeds damage loss was recorded for the treatments T_4, T_5, and T_6 up to 12 months of storage of mungbean seeds. However, treatments T_9 and T_8 also showed no seed damage loss up to 9 months and later at 12 months there was a slight seed damage recorded indicating reduction in the efficacy of these treatments over time during the storage. The highest seed damage loss was recorded in the control during all the storage periods. The reduced seed damage of the seeds during storage by various treatments is mainly due to their effect on mortality of the insect pests which mainly deteriorate and damage the seeds. The findings of this study are in conformity to the results reported by Devi and Kalita (2011), Raheem and Sridevi (2011) [10], Rajasri and Rao (201.2) [11], Mishra *et al*. (2018) [7] and Bhati (2021) [1].

Conclusion

The present study clearly demonstrated that botanicals and novel insecticidal molecules play a crucial role in protecting mung bean seeds from bruchid (Callosobruchus chinensis) infestation during prolonged storage under ambient conditions. The results showed that treatments significantly influenced insect mortality, seed infestation levels, germination loss, and seed damage across different storage intervals. Among all treatments, broflanilide at various concentrations (T_4, T_5, T_6) consistently provided complete protection up to 12 months, maintaining zero insect infestation and negligible seed damage. Neem oil, EcoNeem Plus, and dinotefuran also exhibited considerable efficacy, though their performance gradually declined toward the later storage periods.

Higher insect mortality in treated seeds supported the effectiveness of these protectants, while untreated seeds experienced severe infestation, substantial seed damage, and drastic reductions in germination. The stability of broflanilide-based treatments over time indicates their potential as reliable seed protectants, whereas botanical treatments offer eco-friendly alternatives with moderate yet meaningful protection.

Overall, the study concludes that integrating selected botanicals with novel insecticidal molecules can effectively reduce bruchid infestation and preserve seed quality for up to one year. These treatments present practical, eco-safe, and economically feasible options for farmers and seed storage facilities, contributing to sustainable pulse production and reduced post-harvest losses.

Table 1: Effect of botanicals and novel molecules on insect mortality during storage of mungbean seeds var. 'Shweta' during storage

Treatment	Insect Mortality (Pooled)														
	0 Months			3 Months			6 Months			9 Months			12 Months		
	3rd Day	7th Day	15th Day	3rd Day	7th Day	15th Day	3rd Day	7th Day	15th Day	3rd Day	7th Day	15th Day	3rd Day	7th Day	15th Day
T_1	5.6	7.7	10.0	5.3	8.4	10.0	3.9	6.7	10.0	3.0	5.0	6.3	1.3	3.0	4.8
T_2	4.9	6.6	10.0	6.0	9.0	10.0	5.0	7.2	10.0	3.6	5.3	7.5	2.4	4.0	6.3
T_3	5.9	8.6	10.0	6.6	9.4	10.0	5.7	7.9	10.0	4.2	5.6	8.0	1.7	3.3	6.0
T_4	3.9	6.6	10.0	6.1	7.6	10.0	5.1	6.8	10.0	3.6	4.9	10.0	1.3	3.3	10.0
T_5	4.9	9.2	10.0	7.1	8.3	10.0	5.7	7.7	10.0	4.3	5.6	10.0	2.1	3.7	10.0
T_6	6.9	9.7	10.0	7.4	9.1	10.0	6.6	8.4	10.0	4.6	6.0	10.0	3.7	5.3	10.0
T_7	6.2	10.0	10.0	5.7	7.7	10.0	4.7	6.7	10.0	3.3	4.6	10.0	0.7	2.7	10.0
T_8	7.8	10.0	10.0	7.4	9.3	10.0	7.4	9.0	10.0	5.0	6.6	10.0	1.7	4.0	10.0
T_9	10.0	10.0	10.0	10.0	10.0	10.0	9.2	10.0	10.0	5.2	6.9	10.0	3.4	5.6	10.0
T_{10}	7.9	10.0	10.0	6.3	7.9	9.7	4.3	6.0	8.8	3.6	4.5	8.7	1.3	3.7	6.5
T_{11}	8.6	10.0	10.0	6.7	9.1	10.0	3.7	5.4	6.7	3.3	4.2	8.2	1.0	2.3	5.9
T_{12}	0.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.3	0.8
SE(m)	0.104	0.117	NS	0.078	0.096	0.192	0.092	0.07	0.167	0.037	0.062	0.25	0.025	0.033	0.066
C.D.	0.306	0.343	NS	0.228	0.283	0.565	0.271	0.206	0.489	0.109	0.181	0.734	0.075	0.098	0.194
C.V.	2.98	2.467	NS	2.161	2.085	3.598	3.129	1.778	3.263	1.771	2.163	5.266	2.573	1.68	1.519

Table 2: Effect of botanicals and novel molecules on insect infestation, germination loss and seed damage loss during storage of mungbean seeds var. 'Shweta' during storage

Treatments	Insect Infestation (%)				Germination Loss (%)				Seed Damage Loss (%)			
	3 Months	6 Months	9 Months	12 Months	3 Months	6 Months	9 Months	12 Months	3 Months	6 Months	9 Months	12 Months
T_1	0.00	4.92	26.91	58.76	2.82	7.77	31.99	62.49	0.00	4.92	26.91	58.76
T_2	0.00	0.00	2.79	8.36	6.03	11.92	20.33	30.62	0.00	0.00	2.79	8.36
T_3	0.00	0.00	2.05	5.54	4.93	10.88	15.67	25.83	0.00	0.00	2.05	5.54
T_4	0.00	0.00	0.00	0.00	1.59	4.66	7.00	13.78	0.00	0.00	0.00	0.00
T_5	0.00	0.00	0.00	0.00	1.59	5.36	8.80	15.99	0.00	0.00	0.00	0.00
T_6	0.00	0.00	0.00	0.00	0.00	5.70	9.32	17.28	0.00	0.00	0.00	0.00
T_7	0.00	0.00	2.53	7.11	1.05	6.76	7.98	20.78	0.00	0.00	2.53	7.11
T_8	0.00	0.00	0.00	4.80	0.78	6.39	9.84	17.54	0.00	0.00	0.00	4.80
T_9	0.00	0.00	0.00	4.28	0.53	5.36	8.29	15.21	0.00	0.00	0.00	4.28
T_{10}	0.00	1.15	2.29	3.07	1.31	6.74	10.36	17.93	0.00	1.15	2.29	3.07
T_{11}	0.00	1.56	4.04	10.94	1.32	6.39	10.88	17.41	0.00	1.56	4.04	10.94
T_{12}	0.00	10.10	35.00	70.79	4.47	15.71	38.86	65.99	0.00	10.10	35.00	70.79
SE(m)	NS	0.013	0.082	0.168	0.015	0.065	0.216	0.553	NS	0.013	0.082	0.168
C.D.	NS	0.037	0.235	0.484	0.044	0.188	0.622	1.593	NS	0.037	0.235	0.484
C.V.	NS	1.730	2.593	2.325	1.386	1.678	2.893	4.137	NS	1.730	2.593	2.325

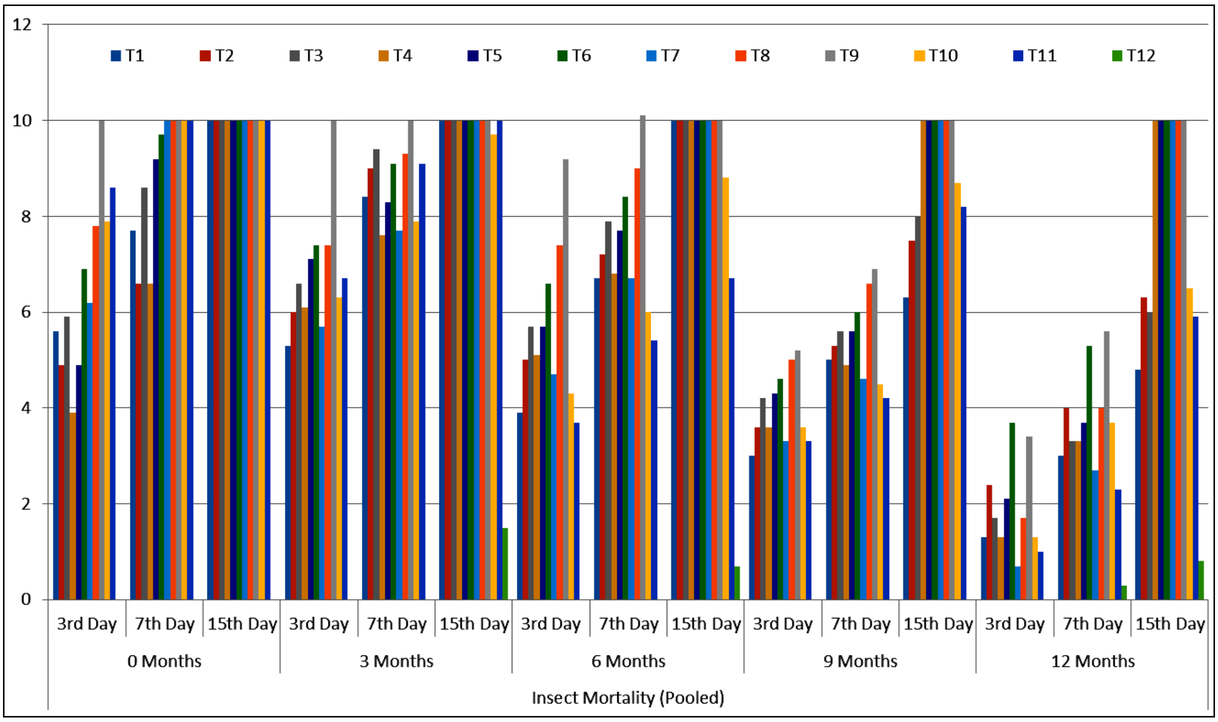

Fig 1: Graphical representation of effect of botanicals and novel molecules on insect mortality during storage of mungbean seeds var. 'Shweta' during storage

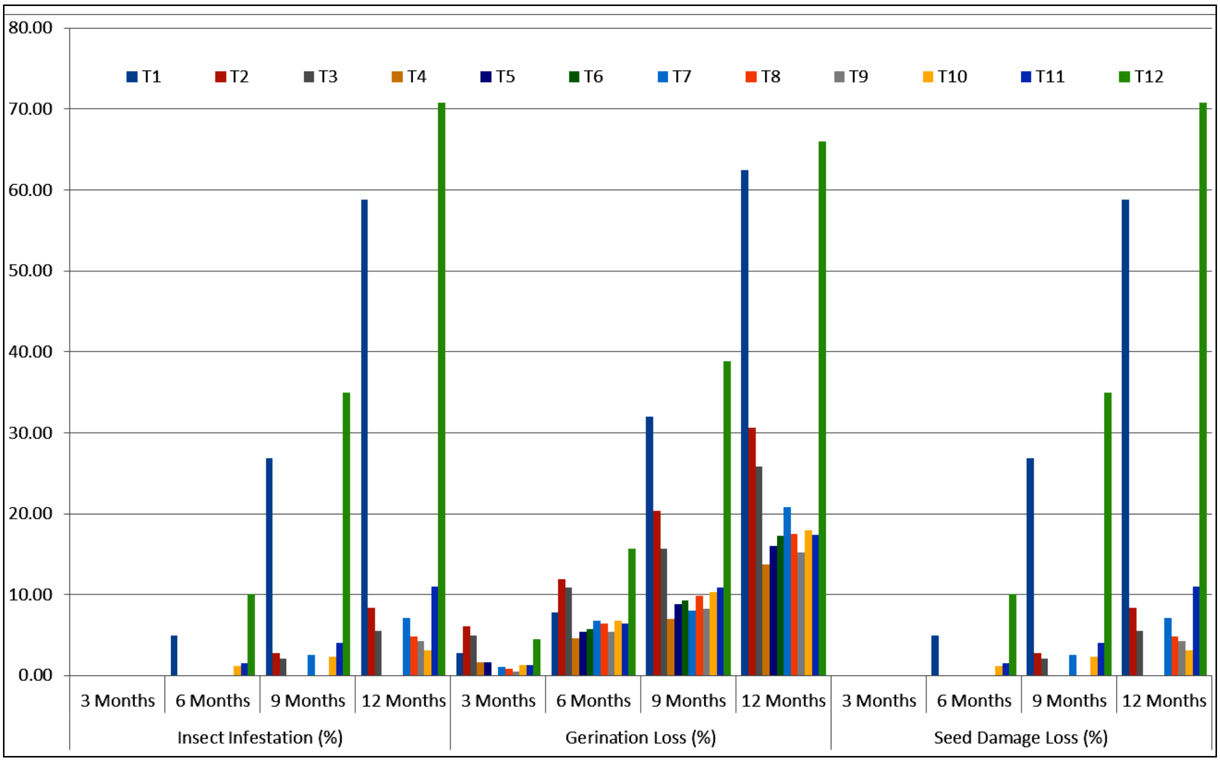

Fig 2: Graphical representation of effect of botanicals and novel molecules on insect infestation, germination loss and seed damage loss during storage of mungbean seeds var. 'Shweta' during storage

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