RESEARCH ARTICLE Legume Research- An International Journal, Volume 49 Issue 2: 320-327 (February 2026)

Comparative Evaluation of Novel Insecticidal Molecules for Control of Pod Bug Infestation in Green Gram

B. Usha Rani[1], K. Suresh[2], Chelvi Ramesh[3]

10.18805/LR-5604

ABSTRACT

Background: Many pulse growers prioritize certified seed production over grain because of its significantly higher market value and better profitability. However, farmers frequently experience poor economic returns due to damage caused by pod-sucking bugs. These insects are major pests of pulse crops, feeding on developing pods and seeds and causing substantial yield and quality losses. As a result, pod-sucking bugs pose not only a pest problem but also a serious economic threat to the seed production system, directly impacting farmers' livelihoods and disrupting the seed supply chain in pulse cultivation.

Methods: To address this challenge, field experiments were conducted to evaluate the efficacy of several newer insecticide molecules against pod-sucking bugs in pulses. The treatments included: Imidacloprid 17.8 SL @ 250 ml/ha, Thiamethoxam 75 WG @ 100 g/ha, Buprofezin 25% SC @ 1000 ml/ha, Thiacloprid 21.7% SC @ 500 ml/ha, Flonicamid 50% WG @ 150 g/ha, Clothianidin 50% WG @ 24 g/ha, Dinotefuran 20% SG @ 150 g/ha, Pymetrozine 50% WG @ 300 g/ha and Dimethoate 35 EC @ 500 ml/ha. Two sprays were made during flowering and pod formation stages in green gram.

Result: Among the treatments tested, Flonicamid 50% WG (150 g/ha) proved to be the most effective. It recorded the lowest pod bug population (2.20 per 3 plants), the highest reduction over control (78.81%) and the minimum pod damage (3.92%) and grain damage (2.03%). Flonicamid also resulted in the highest yield (865.00 kg/ha) and the best benefit–cost ratio (1:2.13). Additionally, this treatment maintained the maximum coccinellid population (9.83 per 10 plants), indicating its compatibility with beneficial insects.

Key words: Grain damage, Newer insecticides, Pod bugs, Pod damage, Population.

INTRODUCTION

Pulses are a vital source of dietary protein, micronutrients and dietary fibre in India, where they are often referred to as the *"poor man's meat"* owing to their affordability and nutritional richness (Joshi and Rao, 2017). Among the major pulse crops, green gram (*Vigna radiata*) and black gram (*Vigna mungo*) are extensively cultivated and consumed, forming an integral component of daily diets in both rural and urban communities. India remains the world's largest producer and consumer of pulses, contributing nearly 25% of global production (FAO, 2020).

Despite their pivotal role in food and nutritional security, pulse cultivation is severely constrained by a wide range of insect pests, including pod borers, aphids, whiteflies, thrips and pod bugs. In recent years, the emergence of new insect pests has posed serious challenges to their cultivation, driven by factors such as changing climatic conditions, shifting pest dynamics and altered cropping patterns. Many pests that were previously considered minor have now evolved into major threats due to favorable ecological conditions and the widespread adoption of intensive farming practices. One such pests in pulses is pod bugs, they are a real threat to quality grain production in pulses. Critical stage for bug damage is pod filling stage. Both nymphs and adults suck sap from pods and make deformed and shriveled leading to reduction in the quality of grains. During pod maturation and harvest stage crops still at risk of deformed and shrivelled seed until pods are dry. Blemished seed is difficult to grade out and results in downgrades in quality. Damaged seed is also prone to weathering. Pod bugs are causing up to 80% yield loss (Ekesi *et al.*, 2002). The pod bug damage in pigeon pea was recorded from 25-40% (Adati *et al.*, 2007). It was once considered to be a minor pest of pigeon pea but, has assumed the status of a major pest. In uncontrolled environment, the percentage number of infected seed to healthy seed in soybean was higher than that in controlled

[1]Department of Agricultural Entomology, Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai-625 104, Tamil Nadu, India.
[2]Krishi Vigyan Kendra, Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai-625 104, Tamil Nadu, India.
[3]Krishi Vigyan Kendra, Regional Research Station, Tamil Nadu Agricultural University, Aruppukottai-626 107, Tamil Nadu, India.

Corresponding Author: K. Suresh, Krishi Vigyan Kendra, Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai-625 104, Tamil Nadu, India.
Email: suresh.k@tnau.ac.in
ORCIDs: 0009-0002-5313-7193, 0000-0003-0311-0283, 0009-0001-4182-559X

How to cite this article: Usha Rani, B., Suresh, K. and Ramessh, C. (2026). Comparative Evaluation of Novel Insecticidal Molecules for Control of Pod Bug Infestation in Green Gram. *Legume Research*. **49(2):** 320-327. doi: 10.18805/LR-5604.

Submitted: 14-11-2025 **Accepted:** 19-01-2026 **Online:** 30-01-2026

environment where insecticides sprayed had taken (Purwantoro *et al.,* 2023)

Many pulse growers prefer to produce seeds specifically for certified seed production rather than for grain, as certified seeds generally fetch a significantly higher market price and offer better returns. However, the presence of pod sucking bugs poses a major obstacle to this goal. Their feeding on developing pods and seeds results in shrivelled, discoloured and malformed seeds with low vigour and poor germination potential. Such damage directly affects the physiological quality of the seed and makes it difficult to meet the stringent standards required for certification. When a large portion of the seed lot fails quality testing due to inferior seed quality, farmers not only lose the premium price they aimed for but may also face complete rejection of their seed lots. Thus, pod sucking bugs are not just a pest problem but a critical economic threat to the seed production system, directly impacting farmers' livelihoods and the overall seed supply chain in pulse cultivation.

To overcome the severe damage caused by pod sucking bugs and ensure the production of high-quality, certifiable seeds, the use of new-generation insecticide molecules offers a highly effective and farmer-friendly solution. The chemical insecticides have found to be effective in controlling the pod pest complex. Many newer molecular insecticides are designed to be more specific to insect pests, reducing harm to beneficial insects and other non-target organisms. These molecules are crucial components of IPM strategies, Using insecticides with different modes of action helps in managing insecticide resistance by preventing pests from developing resistance to a single type of chemical. Hence field experiments were conducted to evaluate the efficacy of different newer molecular insecticides against pod bugs in pulses.

MATERIALS AND METHODS

Two field experiments were conducted, at Regional Research Station Farm, Aruppukottai, Tamil Nadu Agricultural University, Tamil Nadu, India during *Kharif* and *Rabi*, 2023 in a randomized block design with ten treatments, each replicated thrice to evaluate the efficacy of new molecular insecticides against pod bugs in green gram as detailed below (Table 1).

Table 1: List of new molecular insecticides tested in the experiment.

Tr. no.	Treatment details	Dosage
T_1	Imidacloprid 17.8 SL	250 ml/ha
T_2	Thiamethoxam 75 WG	100 g/ha
T_3	Buprofezin 25% SC	1000 ml/ha
T_4	Thiacloprid 21.7% SC	500 ml/ha
T_5	Flonicamid 50% WG	150 g/ha
T_6	Clothianidin 50% WG	24 g/ha
T_7	Dinotefuran 20% SG	150 g/ha
T_8	Pymetrozine 50% WG	300 g/ha
T_9	Dimethoate 35 EC	500 ml/ha
T_{10}	Control	

Two foliar sprays were carried out during the flowering and pod formation stages of the crop. A control plot was maintained without any insecticidal application. The population of different pod bug species was quantitatively assessed using the visual search method on a whole-plant basis from 10 randomly selected plants in each treatment plot.

Observations on pod bug populations were recorded one day prior to spraying and subsequently at 3, 7, 10 and 14 days after each spray (DAS). The efficiency of each treatment was expressed as percent reduction over control, calculated using the following formula:

$$\text{Per cent reduction (\%)} = \frac{\text{Population in the control - Population in the treatment}}{\text{Population in the control}} \times 100$$

Plot wise yield was assessed on hectare basis for statistical explication. Pod damage due to pod bug was calculated at harvest. At 80% maturity the pods were harvested and pooled. 100 pods from each treatment were selected randomly to work out the per cent pod and grain damage. Per cent pod damage and per cent grain damage was calculated by using following formulae (Ganguly *et al.,* 2016).

$$\text{Per cent pod damage} = \frac{\text{Number of damaged pods}}{\text{Total number of pods}} \times 100$$

$$\text{Per cent grain damage} = \frac{\text{Number of damaged grains}}{\text{Total number of grains}} \times 100$$

The data generated from the field experiments, including pod bug population counts, were subjected to square root transformation to stabilize variance and normalize the distribution, while the percentage of pod and grain damage was arc sine transformed to meet the assumptions of analysis of variance (ANOVA). The transformed data were then statistically analyzed and the treatment means were compared using the least significant difference (LSD) test at a 5% level of probability to determine significant differences among treatments. This statistical approach, performed using the SPSS software package, enabled an accurate and reliable assessment and the identification of the most effective treatment against pod sucking bugs in pulses.

RESULTS AND DISCUSSION

The pod bug complex recorded in the study area comprised five economically important hemipteran species, namely *Riptortus pedestris, Riptortus linearis* (Fabricius), *Clavigralla scutellaris* (Westwood), *Clavigralla gibbosa* (Spinola) and *Nezara viridula* (Linnaeus). These species were consistently observed across the cropping season especially during the flowering and pod formation stages.

Table 2: To evaluate the efficacy of new molecular insecticides on the population of podbugs in green gram during *Kharif* 2023 - Field Experiment I.

Tr. no.	Treatment details	Dose	Pre count	Population of pod bugs (No./3 plants)*						Mean	% Reduction over control
				I spray			II spray				
				3 DAS	7 DAS	14 DAS	3 DAS	7 DAS	14 DAS		
T_1	Imidacloprid 17.8 SL	250 ml/ha	10.33	4.33^{bc}	4.67^{bc}	6.33^{bc}	5.00^{f}	5.67^{e}	6.33^{d}	5.39^{e}	41.21
T_2	Thiamethoxam 75 WG	100 g/ha	11.33	2.33^{a}	2.67^{a}	4.33^{a}	3.33^{bc}	4.00^{bc}	5.00^{bc}	3.61^{bc}	60.61
T_3	Buprofezin 25% SC	1000 ml/ha	12.00	3.67^{b}	4.00^{b}	5.67^{b}	4.00^{cde}	4.67^{cde}	5.33^{c}	4.56^{d}	50.30
T_4	Thiacloprid 21.7% SC	500 ml/ha	11.00	1.67^{a}	2.00^{a}	3.67^{a}	3.00^{b}	3.67^{b}	4.67^{b}	3.11^{b}	66.06
T_5	Flonicamid 50% WG	150 g/ha	10.33	2.00^{a}	2.33^{a}	4.00^{a}	2.00^{a}	2.33^{a}	2.00^{a}	2.44^{a}	73.33
T_6	Clothianidin 50% WG	24 g/ha	10.67	2.33^{a}	2.67^{a}	4.33^{a}	3.67^{bcd}	4.33^{bcd}	5.33^{c}	3.78^{c}	58.79
T_7	Dinotefuran 20% SG	150 g/ha	11.00	4.33^{bc}	4.67^{bc}	6.33^{bc}	4.67^{ef}	5.33^{de}	6.33^{d}	5.28^{e}	42.42
T_8	Pymetrozine 50% WG	300 g/ha	11.33	4.00^{b}	4.33^{b}	6.00^{b}	4.33^{def}	5.00^{de}	5.33^{c}	4.83^{de}	47.27
T_9	Dimethoate 35 EC	500 ml/ha	11.67	5.33^{cd}	5.67^{c}	7.33^{c}	6.33^{g}	7.00^{f}	8.33^{e}	6.67^{f}	27.27
T_{10}	Control		11.67	6.00^{d}	7.33^{d}	9.67^{d}	10.00^{h}	10.67^{g}	11.33^{f}	9.17^{g}	0.00
	CD (0.05%)			0.26	0.27	0.209	0.228	0.230	0.11	0.16	

Each value is a mean of three replications.

In a column, means followed by same letter(s) are on par by LSD (p= 0.05).

Population of pod bugs

The pre-count was recorded one day before the first spraying. The data obtained as pre-count indicated that the population of pod bug ranged from 10.33 to 11.67 per cent. There was no any statistical significant different among the treatments.

The observations recorded on 3, 7 and 14 days after first spray in the field experiment I indicated that there was significant difference among the treatments. All the treatments showed significantly lower pod bug population than untreated control. The treatment T_5- Flonicamid 50% WG @ 150 g/ha was recorded minimum pod bug population of 2.00, 2.33 and 4.00 pod bugs/3 plants after 3, 7 and 14 days after first spray, respectively and which was followed by Thiacloprid 21.7% SC (500 ml/ha) (1.67, 2.00 and 3.67 pod bugs/3 plants after 3, 7 and 14 days after first spray). The maximum pod bug population was observed in treatment T_{10}- Untreated control *i.e.* 6.00, 7.33 and 9.67 pod bugs/3 plants after 3, 7 and 14 days after first spray, respectively. After 14 days of first spray, slightly increase in pod bug population was observed.

The data recorded on 3, 7, 10 and 14 days after second spray showed that there was significant difference among the treatments. All the treatments revealed significantly lower pod bug population than untreated control. The treatment T_5- Flonicamid 50% WG @ 150 g/ha was recorded minimum pod bug population of 2.00, 2.33 and 2.00 pod bugs/3 plants after 3, 7 and 14 days after second spray.

While comparing the overall mean population Flonicamid 50% WG @ 150 g/ha recorded the lowest mean pod bug population (2.44/3 plants) and showed the highest reduction over control (73.33%). Thiacloprid 21.7% SC (500 ml/ha) was the next best treatment, with a mean population of 3.11/3 plants and 66.06% reduction. Thiamethoxam 75 WG (100 g/ha) and Clothianidin 50% WG (24 g/ha) also proved effective, with mean populations of 3.61 and 3.78/3 plants, resulting in 60.61% and 58.79% reduction, respectively. Buprofezin 25% SC (1000 ml/ha) showed moderate efficacy with 4.56 pod bugs/3 plants and 50.30% reduction. Treatments such as Imidacloprid 17.8 SL (41.21% reduction), Dinotefuran 20% SG (42.42%) and Pymetrozine 50% WG (47.27%) provided only moderate suppression. Dimethoate 35 EC (500 ml/ha) was the least effective among insecticide treatments, reducing the pod bug population by only 27.27%. In the untreated control the highest mean population (9.17 pod bugs/3 plants) was noticed (Table 2).

The population of pod bugs at 3, 7 and 14 DAS after the first spray in the second field experiment differed significantly among treatments. Flonicamid 50% WG (150 g/ha) recorded the lowest pod bug population (2.00, 2.20 and 2.60/3 plants at 3, 7 and 14 DAS, respectively), significantly lower than the control (10.60, 10.80 and 11.00/ 3 plants). Thiacloprid 21.7% SC (500 ml/ha) was the next best treatment (2.20, 2.60 and 3.10/3 plants), followed by Thiamethoxam 75 WG (100 g/ha) (2.60, 3.00 and 3.80/3 plants). In the second spray also Flonicamid 50% WG (150 g/ha) outperformed all treatments, with populations of only 1.40, 1.70 and 1.83/3 plants at 3, 7 and 14 DAS, compared to 11.20, 11.30 and 11.40/3 plants in control (Table 3).

Pod and grain damage

The minimum pod damage (4.33%) was recorded with Thiamethoxam 75 WG @ 100 g/ha (T_2) and Thiacloprid 21.7% SC @ 500 ml/ha (T_4), which were statistically on par, followed by Flonicamid 50% WG @ 150 g/ha (7.00%). In contrast, Imidacloprid, Buprofezin, Clothianidin, Dinotefuran, Pymetrozine and Dimethoate resulted in relatively higher pod damage, ranging from 7.33% to 9.67%, though still significantly lower than the control (Table 4).

Table 3: To evaluate the efficacy of new molecular insecticides on the population of podbugs in greengram during *Rabi* 2023- Field Experiment II.

Tr. no.	Treatment details	Dose	Pre count	Population of pod bugs (No./3plants)*						Mean	% Reduction over control
				I spray			II spray				
				3 DAS	7 DAS	14 DAS	3 DAS	7 DAS	14 DAS		
T_1	Imidacloprid 17.8 SL	250 ml/ha	9.90	3.30^{e}	3.90^{e}	4.50^{e}	2.20^{e}	2.50^{e}	2.90^{e}	3.22^{e}	72.27
T_2	Thiamethoxam 75 WG	100 g/ha	9.90	2.60^{c}	3.00^{b}	3.80^{c}	1.80^{c}	2.10^{c}	2.50^{c}	2.63^{c}	77.30
T_3	Buprofezin 25% SC	1000 ml/ha	10.20	3.00^{d}	3.40^{c}	4.20^{d}	2.00^{d}	2.30^{d}	2.70^{d}	2.93^{d}	74.71
T_4	Thiacloprid 21.7%SC	500 ml/ha	10.40	2.20^{b}	2.60^{a}	3.10^{b}	1.60^{b}	1.50^{a}	2.00^{b}	2.17^{b}	81.32
T_5	Flonicamid 50 % WG	150 g/ha	10.60	2.00^{a}	2.20^{a}	2.60^{a}	1.40^{a}	1.70^{b}	1.83^{a}	1.96^{a}	83.15
T_6	Clothianidin 50 % WG	24 g/ha	10.80	3.00^{d}	3.40^{c}	4.20^{d}	2.00^{d}	2.30^{d}	2.56^{cd}	2.91^{d}	74.91
T_7	Dinotefuran 20 % SG	150 g/ha	10.20	4.00^{f}	5.23^{f}	5.20^{f}	3.20^{f}	3.50^{f}	3.63^{f}	4.13^{f}	64.43
T_8	Pymetrozine 50 % WG	300 g/ha	9.73	4.20^{g}	5.45^{g}	6.40^{g}	3.40^{g}	3.70^{g}	3.73^{f}	4.48^{g}	61.38
T_9	Dimethoate 35 EC	500 ml/ha	10.20	4.50^{h}	5.75^{h}	6.53^{g}	3.60^{h}	3.63^{g}	4.03^{g}	4.67^{h}	59.71
T_{10}	Control		10.40	10.60^{i}	10.80^{i}	11.0^{h}	11.2^{i}	11.30^{h}	11.40^{h}	11.60^{i}	
	CD (0.05%)			0.036	0.046	0.052	0.037	0.032	0.045	0.0322	

Each value is a mean of three replications.

In a column, means followed by same letter(s) are on par by LSD (p= 0.05).

Table 4: To evaluate the efficacy of new molecular insecticides on the pod bugs and its impact on yield during *Kharif* 2023 - Field Experiment I.

Tr. no.	Treatment details	Dosage	Coccinellid population (Nos/10 plant)	Pod damage (%)	Grain damage (%)	Yield (kg/ha)	CB ratio
T_1	Imidacloprid 17.8 SL	250 ml/ha	6.70	9.67^{c}	7.33^{g}	760.00^{d}	1:1.81
T_2	Thiamethoxam 75 WG	100 g/ha	6.67	4.33^{a}	4.47^{c}	823.33^{c}	1:1.96
T_3	Buprofezin 25% SC	1000 ml/ha	6.80	9.00^{c}	7.47^{gh}	766.67^{d}	1:1.83
T_4	Thiacloprid 21.7% SC	500 ml/ha	7.00	4.33^{b}	3.13^{b}	841.67^{b}	1:2.00
T_5	Flonicamid 50% WG	150 g/ha	7.33	7.00^{a}	2.07^{a}	860.00^{a}	1:2.05
T_6	Clothianidin 50% WG	24 g/ha	6.33	9.67^{c}	6.40^{f}	831.67^{bc}	1:1.98
T_7	Dinotefuran 20% SG	150 g/ha	6.67	9.00^{c}	5.27^{e}	723.33^{e}	1:1.74
T_8	Pymetrozine 50% WG	300 g/ha	6.50	7.33^{b}	4.93^{d}	733.33^{e}	1:1.75
T_9	Dimethoate 35 EC	500 ml/ha	7.00	9.67^{c}	7.67^{h}	723.33^{e}	1:1.76
T_{10}	Control		7.80	13.67^{d}	13.00^{i}	706.67^{f}	1: 1.72
	CD (0.05%)		NS	0.967	0.281	14.20	

Each value is a mean of three replications.

In a column, means followed by same letter(s) are on par by LSD (p= 0.05).

A similar trend was observed in grain damage, where the lowest value (2.07%) was achieved with Flonicamid 50% WG (T_5), which was significantly superior to all other treatments. This was followed by thiacloprid (3.13%) and Thiamethoxam (4.47%), while the untreated control recorded the maximum grain damage (13.00%).

Pod damage was significantly reduced in all treated plots compared to control (12.00%). The lowest pod damage (3.50%) was recorded with Flonicamid 50% WG @ 150 g/ha (T_5), followed by thiacloprid 21.7% SC (5.00%) and Thiamethoxam 75 WG (5.80%), which were statistically on par. The highest pod damage among treated plots was observed with Dinotefuran 20% SG (8.00%), Pymetrozine 50% WG (10.00%) and Dimethoate 35 EC (10.50%), though still significantly lower than control (Table 5).

A similar trend was observed in grain damage, which ranged from 2.00% (T_5: Flonicamid 50% WG) to 9.40% (T_7: Dinotefuran 20% SG), as against 10.80% in the control. Flonicamid treatment was found to be significantly superior, followed by Thiacloprid (3.20%) and Thiamethoxam (4.30%).

Natural enemies

The coccinellid population varied slightly among treatments, ranging from 6.50 to 7.80 (control), with no significant adverse effects observed in treated plots compared to untreated control (Table 4). Similar results were obtained in the field experiment II also. Here the population of coccinellids did not vary significantly across treatments.

Yield

Seed yield was varied significantly among treatments. The highest yield (860.00 kg/ha) was obtained from Flonicamid 50% WG, which was statistically superior, followed by thiacloprid (841.67 kg/ha) and clothianidin (831.67 kg/ha). The untreated control recorded the lowest yield (706.67 kg/ha). Economic analysis further revealed that the maximum cost-benefit ratio (1:2.05) was achieved with Flonicamid 50% WG, this was followed by thiacloprid (1:2.00) and clothianidin (1:1.98). The minimum CBR (1:1.72) was associated with the untreated control (Table 4).

Seed yield was markedly influenced by insecticidal treatments. The maximum yield (870 kg/ha) was recorded with Flonicamid 50% WG, which was significantly superior over all treatments, followed closely by thiacloprid 21.7% SC (860 kg/ha) and clothianidin 50% WG (840 kg/ha). The lowest yield (700 kg/ha) was observed in the untreated control (Table 5). In terms of economic returns, Flonicamid (T_5) achieved the highest benefit-cost ratio (BCR) of 1:2.20, followed by thiacloprid (T_4) (1:2.10) and Thiamethoxam (T_2) (1:1.98).

The pooled data from *kharif* and *rabi* season field experiments revealed significant differences among the insecticidal treatments in reducing pod bug populations, minimizing pod and grain damage and improving yield in green gram (Table 6). However, the population of coccinellids, did not differ significantly across treatments, indicating the relative safety of the tested insecticides to beneficial predators.

Table 5: To evaluate the efficacy of new molecular insecticides on the pod bugs and its impact on yield during *Rabi* 2023 - Field Experiment II.

Tr. no.	Treatment details	Dosage	Coccinellid population (Nos/10plant)	Pod damage (%)	Grain damage (%)	Yield (kg/ha)	BCR
T_1	Imidacloprid 17.8 SL	250 ml/ha	11.00	7.20^{d}	5.80^{e}	770^{cd}	1:1.83
T_2	Thiamethoxam 75 WG	100 g/ha	11.33	5.80^{c}	4.30^{c}	830^{b}	1:1.98
T_3	Buprofezin 25% SC	1000 ml/ha	12.00	6.00^{c}	4.60^{d}	774^{c}	1:1.88
T_4	Thiacloprid 21.7% SC	500 ml/ha	12.33	5.00^{b}	3.20^{b}	860^{ab}	1:2.10
T_5	Flonicamid 50% WG	150 g/ha	12.33	3.50^{a}	2.00^{a}	870^{a}	1:2.20
T_6	Clothianidin 50% WG	24 g/ha	10.67	6.00^{c}	4.80^{d}	840^{ab}	1:1.80
T_7	Dinotefuran 20% SG	150 g/ha	11.00	8.00^{e}	9.40^{g}	730^{e}	1:1.79
T_8	Pymetrozine 50% WG	300 g/ha	11.33	10.00^{f}	8.00^{f}	740^{cde}	1:1.79
T_9	Dimethoate 35 EC	500 ml/ha	11.67	10.50^{g}	9.20^{g}	732de	1:1.78
T_{10}	Control		12.67	12.00^{h}	10.80^{h}	700^{e}	1: 1.68
	SED		NS	0.156	0.142	18.710	
	CD (0.05%)			0.328	0.299	39.309	

Each value is a mean of three replications.

In a column, means followed by same letter(s) are on par by LSD (p= 0.05).

Table 6: To study the impact of newer molecule insecticides on podbugs and its impact on yield (Pooled analysis of *Kharif* and *Rabi* 2023 field experiments).

Tr. no.	Treatment details	Dosage	Population of pod bugs (Nos/3 plants)	Per cent reduction over control	Coccinellid population (Nos/10 plant)	Pod damage (%)	Grain damage (%)	Yield (kg/ha)	B:C ratio
T_1	Imidacloprid 17.8 SL	250 ml/ha	4.30^{e}	58.56	8.85	8.43^{e}	6.57^{f}	765.00^{d}	1:1.82
T_2	Thiamethoxam 75 WG	100 g/ha	3.12^{c}	69.93	9.00	5.07^{b}	4.38^{c}	826.67^{c}	1:1.97
T_3	Buprofezin 25% SC	1000 ml/ha	3.74^{d}	63.94	9.50	7.50^{d}	6.03^{e}	770.34^{d}	1:1.86
T_4	Thiacloprid 21.7% SC	500 ml/ha	2.64^{b}	74.59	9.67	6.00^{c}	3.17^{b}	850.84^{ab}	1:1.205
T_5	Flonicamid 50% WG	150 g/ha	2.20^{a}	78.81	9.83	3.92^{a}	2.03^{a}	865.00^{a}	1:1.213
T_6	Clothianidin 50% WG	24 g/ha	3.34^{c}	67.80	8.50	7.83^{d}	5.60^{d}	835.84^{bc}	1:1.19
T_7	Dinotefuran 20% SG	150 g/ha	4.70^{f}	54.71	8.83	8.50^{e}	7.33^{g}	726.67^{ef}	1:1.77
T_8	Pymetrozine 50% WG	300 g/ha	4.66^{ef}	55.15	9.33	8.67^{e}	6.47^{f}	736.67^{e}	1:1.77
T_9	Dimethoate 35 EC	500 ml/ha	5.67^{g}	45.39	9.50	10.08^{f}	8.43^{h}	727.67^{ef}	1:1.77
T_{10}	Control		10.38^{h}	58.56	10.2	12.83^{g}	11.90^{i}	708.34^{f}	1:1.70
SEd			0.0415		NS	0.224	0.085	10.78	
CD (0.05%)			0.0872			0.469	0.179	22.65	

Each value is a mean of three replications.

In a column, means followed by same letter(s) are on par by LSD (p= 0.05).

All insecticidal treatments significantly reduced the pod bug population compared to the untreated control (10.38 bugs/3 plants). The lowest population (2.20 bugs/3 plants) was recorded in plots treated with Flonicamid 50% WG @ 150 g/ha (T_5), which achieved the highest reduction over control (78.81%), followed by thiacloprid 21.7% SC @ 500 ml/ha (T_4) (2.64 bugs/3 plants; 74.59% reduction). Thiamethoxam 75 WG @ 100 g/ha (T_2) and clothianidin 50% WG @ 24 g/ha (T_6) also recorded low pod bug populations with reductions of 69.93% and 67.80%, respectively. In contrast, dimethoate 35 EC (T_9) was the least effective, recording a reduction of 45.39% over control.

A significant reduction in pod damage was observed across all treated plots compared to the untreated control (12.83%). The lowest pod damage (3.92%) was recorded with Flonicamid (T_5), which was significantly superior to all other treatments. This was followed by thiamethoxam (T_2) (5.07%) and thiacloprid (T_4) (6.00%). Dimethoate (T_9) and pymetrozine (T_8) recorded relatively higher pod damage (10.08% and 8.67%, respectively).

A similar trend was observed for grain damage. flonicamid (T_5) again proved most effective, recording the minimum grain damage of 2.03%, followed by thiacloprid (T_4) (3.17%) and thiamethoxam (T_2) (4.38%). The maximum grain damage (11.90%) was recorded in the untreated control plot.

Significant yield improvements were observed in all insecticidal treatments compared to the control (708.34 kg/ha). The highest grain yield (865.00 kg/ha) was achieved with flonicamid (T_5), which was on par with thiacloprid (T_4) (850.84 kg/ha) and clothianidin (T_6) (835.84 kg/ha). The lowest yield among treatments was observed with Dinotefuran (T_7) (726.67 kg/ha) and Dimethoate (T_9) (727.67 kg/ha).

Economic analysis revealed that Flonicamid (T_5) provided the highest benefit-cost ratio (1:1.213), followed by thiacloprid (T_4) (1:1.205) and thiamethoxam (T_2) (1:1.97). Despite achieving high yields, clothianidin (T_6) recorded a lower B:C ratio (1:1.19) due to higher input costs.

Among the treatments, flonicamid 50% WG @ 150 g/ha was consistently the most effective, recording the lowest pod bug population (2.20/3 plants), maximum reduction over control (78.81%) and the least pod (3.92%) and grain damage (2.03%). This clearly indicates the high efficacy of Flonicamid against sucking pests attacking reproductive plant parts, particularly during the flowering and pod development phases (Soundararajan and Chitra, 2011; Patil *et al*., 2017). Flonicamid is a pyridinecarboxamide insecticide that uniquely disrupts the feeding behaviour of hemipteran pests by affecting chordotonal organs associated with stretch receptor neurons, leading to rapid cessation of feeding and eventual starvation (Morita *et al*., 2007; Saito *et al*., 2013). This anti-feeding property makes Flonicamid highly effective against pod-sucking pests, which rely on continuous sap ingestion for survival. Pezzini and Koch (2015) demonstrated that Flonicamid exhibited high selectivity and potency against the soybean aphid *Aphis glycines*, highlighting its strong anti-feeding properties and minimal impact on non-target organisms. In field studies on Indian bean, Chaudhari *et al.* (2015) reported that plots treated with Flonicamid 50 WG @ 0.015% showed a substantial reduction in the incidence of major sucking pests, including thrips, hoppers and whiteflies, thereby supporting its broad-spectrum activity against hemipterans. Similarly, Anandmurthy *et al.* (2017) observed that Flonicamid 50 WG @ 0.02% significantly reduced whitefly populations in cowpea, achieving a 58.21% reduction over the untreated control.

Further evidence of Flonicamid's efficacy was provided by Swathi (2018), who reported that Flonicamid 50 WG @ 0.0325% was highly effective in suppressing whitefly populations in rice fallow black gram, with a 72.19% reduction over control, accompanied by the lowest disease incidence (17.66%). In another field trial, Kalyan *et al.* (2017) demonstrated that Flonicamid 50 WP @ 100 g a.i. ha^{-1} achieved the maximum reduction (69.72%) in whitefly populations over the untreated control.

These findings consistently support the present results, confirming Flonicamid's effectiveness across diverse host plants and pest species. Its unique mode of action, rapid anti-feeding effect and systemic properties make it an important tool for integrated management of hemipteran pests in pulse-based cropping systems.

The next most effective treatment was Thiacloprid 21.7% SC @ 500 ml/ha, which achieved 74.59% reduction of pod bug populations and recorded only 3.17% grain damage. Thiacloprid, a neonicotinoid insecticide, acts as an agonist at nicotinic acetylcholine receptors (nAChRs) in the insect nervous system, causing overstimulation, paralysis and death (Tomizawa and Casida, 2005). It's systemic and translaminar activity ensures thorough protection of reproductive structures such as flowers and pods, thereby reducing yield losses. Comparable efficacy of thiacloprid against pod-sucking pests has been reported in pigeon pea and cowpea (Ramasubramanian *et al.,* 2014; Sreekanth *et al.,* 2020). Thiacloprid 21.7 SC @ 0.0325% was found to be highly effective against thrips by recording 74.80 per cent reduction in thrips population in black gram (Swathi, 2018). The finding by Sunita Hans, (2024) suggest that Clothianidin, Flonicamid and Diafenthiuron, offered significant benefits in managing insect pests and improving yields of *kharif* pulses. Flonicamid @ 175 and 175 and 200 g/ha, Imidacloprid @ 100 and 125 ml/ha, Thiamethoxam @ 100 and 125 g/ha, Acetamiprid @ 50 and 62.5 g/ha were statistically better in reducing aphid population in Celery (Chandi and Gill, 2019).

Other neonicotinoid insecticides, including thiacloprid, thiamethoxam and clothianidin, also significantly reduced pod bug incidence compared to the untreated control; however, their performance was comparatively lower than that of flonicamid. The observed differences in efficacy may be associated with variations in residual persistence and the potential development of reduced susceptibility of sucking pests to neonicotinoids following repeated

applications (Ahmad *et al.*, 2016; Sahoo and Singh, 2018). In the present study, effective inhibition of feeding activity under Flonicamid treatment played a vital role in safeguarding pods and grains during the most sensitive stages of crop development (Chandrayudu *et al.*, 2015).

The improvement in grain yield observed in Flonicamid-treated plots can be directly linked to effective suppression of pest infestation and reduced pod and grain damage. Protection of reproductive plant parts facilitates uninterrupted assimilate movement towards developing seeds, resulting in improved yield attributes such as higher test weight and better seed quality (Patil *et al.*, 2017; Sreekanth *et al.*, 2020).

Several studies have reported a strong positive association between effective management of sucking pests and enhanced grain yield in pulse crops (Soundararajan and Chitra, 2011; Chandrayudu *et al.*, 2015). In contrast, the lowest grain yield recorded in untreated control plots in the present study can be attributed to severe pest incidence, which adversely affected pod formation and grain filling processes (Ahmad *et al.*, 2016).

The results further indicated that Flonicamid exerted comparatively less adverse impact on natural enemies, particularly coccinellids, when compared to other insecticidal treatments. Conservation of beneficial insects is a crucial aspect of sustainable pest management, as they contribute to natural suppression of pest populations and help prevent pest resurgence (Nauen *et al.*, 2015). Previous studies have reported that Flonicamid exhibits low contact toxicity and a high degree of selectivity towards beneficial arthropods due to its feeding inhibition mode of action (Morita *et al.*, 2007; Sreekanth *et al.*, 2020). Consequently, its compatibility with natural enemies makes Flonicamid a suitable candidate for incorporation into Integrated Pest Management (IPM) strategies in pulse-based cropping systems (Ahmad *et al.*, 2016).

CONCLUSION

Pod sucking bugs are a major challenge not only for grain producers but also for seed producers, as their feeding activity severely affects the quality and viability of seeds. When these pests pierce developing pods and suck the sap from immature seeds, it results in shriveled, underdeveloped and discolored seeds making them unsuitable for commercial seed lots. Such seeds often fail to meet certification standards required for seed production programs. As a result, seed lots are often rejected during quality testing, leading to economic losses and wasted investment in field maintenance, Labour and certification processes. For managing this pest newer insecticide molecules were the prime solution for the farming community. Among the newer insecticide molecules tested Flonicamid 50% WG (150 g/ha) applied during flowering and pod formation stages in green gram, was the most effective treatment, recording the lowest pod bug population (2.20/3 plants), highest reduction over control (78.81%) and minimum pod (3.92%) and grain damage (2.03%). It also recorded the highest yield (865.00 kg/ha) and the best benefit-cost ratio (1:2.13), with maximum coccinellid population (9.83/10 plants).

Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish, or preparation of the manuscript.

Ethics and permissions

Not applicable.

Funding

Not applicable.

REFERENCES

Adati, T., Tamo, M., Yusuf, S.R., Downham, M.C.A., Singh, B.B. and Hammond, W. (2007). Integrated pest management for cowpea-cereal cropping systems in the West African savannah. *Int. J. Trop. Insect Sci.* **27(3-4):** 123-137.

Ahmad, M., Arif, M.I. and Naveed, M. (2016). Dynamics of sucking insect pests in pulse crops and their management. *Journal of Insect Science*. **16:** 1-9.

Anandmurthy, T., Parmar, G.M. and Arvindarajan, G. (2017). Bio-efficacy of new molecules against sucking pests in summer cowpea. *International Journal of Plant Protection*. **10(2):** 236-240.

Chaudhari, A.J., Korat, D.M. and Dabhi, M.R. (2015). Efficacy of newer insecticides against major insect pests of Indian bean, *Lablab purpureus* L. *Karnataka Journal of Agricultural Sciences*. **28(4):** 616-619.

Chandrayudu, E., Srinivasa Rao, V. and Krishna, T.M. (2015). Evaluation of newer insecticides against sucking pests in greengram. *Legume Research*. **38:** 846-850.

Chandi, S.R. and Gill, B.S. (2019). Efficacy of safer insecticides against aphid on celery. *Agricultural Science Digest*. **39(1):** 70-72. doi: 10.18805/ag.D-4854.

Ganguly, S., Srivastava, C.P. and Keval, R. (2016). Field screening of some long duration pigeonpea [*Cajanus cajan* (L.) Millsp.] genotypes against the infestation of pod bug, *Clavigralla gibbosa* (Spinola) and gram pod borer, *Helicoverpa armigera* (Hubner). *Journal of Pure and Applied Microbiology*. **10(3):** 2209-2217.

Ekesi, S., Adamu, R.S. and Maniania, N. K. (2002). Ovicidal activity of entomopathogenic hyphomycetes to the legume pod borer, *Maruca vitrata* and the pod sucking bug, *Clavigralla tomentosicollis*. *Crop Protection*. **21(7):** 589-595.

Joshi, P.K. and Rao, P.P. (2017). Global pulses scenario: Status and outlook. *Indian Journal of Agricultural Sciences*. **87(11):** 1572-1582.

FAO (2020). FAOSTAT: Crops and Livestock Products. Food and Agriculture Organization of the United Nations.

Kalyan, R.K., Saini, D.P., Meena, B.M., Abhishek, P., Pooja, N., Shilpa, V. and Sonika, J. (2017). Evaluation of new molecules against jassids and whiteflies of Bt cotton. *Journal of Entomology and Zoology Studies*. **5(3):** 236-240.

Morita, M., Ueda, T., Yoneda, T., Koyanagi, T. and Haga, T. (2007). Flonicamid, a novel insecticide with a rapid inhibitory effect on aphid feeding. *Pest Management Science*. **63(10):** 969-973.

Nauen, R., Slater, R., Sparks, T.C., Elbert, A. and McCaffery, A. (2015). IRAC: Mode of action classification and insecticide resistance management. *Pesticide Biochemistry and Physiology*. **121**: 122-128.

Patil, S.B., Udikeri, S.S. and Khadi, B.M. (2017). Bio-efficacy of insecticides against sucking pests of greengram. *Journal of Entomology and Zoology Studies*. **5:** 134-138.

Pezzini, D.T. and Koch, R.L. (2015). Compatibility of Flonicamid and a formulated mixture of pyrethrins and azadirachtin with predators for soybean aphid (Hemiptera: Aphididae) management. *Biocontrol Science and Technology*. **25(9**): 1024-1035.

Purwantoro, Sulistyo Apri, Mejaya J. Made, Soehendi Rudy, Trustinah, Suyamto, Nuryati (2023). Resistance level of soybean genotypes against pod sucking bug (*Riptortus linearis* F. Hemiptera: Alydidae). *Legume Research*. **46(6):** 796-800. doi: 10.18805/LRF-731.

Ramasubramanian, T., Sundararajan, K. and Elanchezhyan, K. (2014). Efficacy of neonicotinoids against sucking pests of cowpea. *Legume Research*. **37(5):** 503-507.

Sahoo, T.R. and Singh, S.R. (2018). Yield loss assessment due to sucking pests in pulses. *Indian Journal of Entomology*. **80:** 112-117.

Saito, T., Brown, M.J., Haga, T., Morita, M. and Matsuo, T. (2013). Flonicamid mode of action and its selectivity. *Journal of Pesticide Science*. **38(3):** 174-179.

Soundararajan, R.P. and Chitra, N. (2011). Field evaluation of insecticides against pod bugs in pulses. *Madras Agricultural Journal*. **98:** 123-126.

Sreekanth, P., Reddy, A.V. and Prasad, Y.G. (2020). Field efficacy of neonicotinoids against pod-sucking pests of pigeon pea. *Annals of Plant Protection Sciences*. **28(1):** 82-86.

Sunita Hans, D.A. (2024). Efficacy of some novel insecticides against major pests infesting *kharif* pulses. M.Sc. (Ag.) Thesis submitted Department of Agricultural Entomology, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia. p 103.

Swathi, K. (2018). Study on Seasonal Incidence and Insecticidal Management of Major Insect Pests of Rice Fallow Black gram (*Vigna mungo* L.) in North Coastal Andhra Pradesh. M.Sc. (Ag.) Thesis submitted to Acharya N.G. Ranga Agricultural University, Lam, Guntur, Andhra Pradesh.

Tomizawa, M. and Casida, J.E. (2005). Neonicotinoid insecticide toxicology: Mechanisms of selective action. *Annual Review of Pharmacology and Toxicology*. **45:** 247-268.