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Field Evaluation of BIPM Module for Insect Pest Management in Green Gram (*Vigna radiata* L.) in Assam

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ABSTRACT

Background: Green gram (*Vigna radiata* L.) is a vital pulse crop in Assam, but its productivity is constrained by insect pests such as whitefly *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae); the leaf roller *Nacoleia vulgalis (Guenée)*(Lepidoptera: Crambidae); the gram pod borer *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae), spotted pod borer, *Maruca vitrata* (Fabricius) (Lepidoptera: Crambidae); the pod bug, *Riptortus pedestris* (Fabricius) (Hemiptera: Alydidae), *Nezara viridula* (Linnaeus) (Hemiptera: Pentatomidae) and the aphid *Aphis craccivora* Koch (Hemiptera: Aphididae). Farmers generally rely on indiscriminate pesticide use, leading to ecological and economic concerns. Bio-Intensive Pest Management (BIPM) offers an eco-friendly alternative by integrating botanicals, biopesticides and cultural practices.

Methods: Field experiments were conducted during 2021-22 to 2023-24 at multiple locations across Assam to evaluate the efficacy of a BIPM module against major insect pests of green gram. The BIPM module comprised: (i) two rows of sesame as a barrier crop, (ii) timely weeding at 30 DAS, (iii) installation of yellow sticky traps (30 cm × 20 cm) @ 30/ha at 30 DAS and (iv) spray of Azadirachtin 300 ppm @ 5 ml/L at vegetative stage; compared with farmers' practice (FP: Weeding + application of chlorantraniliprole 18.5 SC @ 0.3 ml/L). Pest incidence, pod damage, yield and benefit-cost ratio were recorded and statistically analyzed for different years at varied locations.

Result: The BIPM module significantly reduced pest incidence compared to FP. Pooled mean whitefly and leaf roller incidence were 0.84/trifoliate leaf and 1.09%, respectively, under BIPM, against 3.39/trifoliate leaf and 4.48% under FP. Pod borer and pod bug damage were also lower (3.88% and 4.65%) in BIPM plots compared to FP (16.47% and 19.45%). Yield was consistently higher under BIPM (1028.07 kg/ha), representing a 13.39% increase over FP (906.63 kg/ha). Location-wise trials confirmed the superiority of BIPM, with yield advantages ranging from 6.49% to 34.84%. The benefit-cost ratio (1:2.06-1:2.52) was also higher in BIPM plots. Multi-location trials confirmed 6.49-34.84% yield advantage of BIPM across diverse agro-ecological zones of Assam. The findings suggest that the BIPM module provides a sustainable and eco-friendly alternative to pesticide-based practices for effective pest management in green gram, with positive implications for productivity and profitability.

Key words: Bio-intensive IPM, Green gram, Pod borer, Pod bug, Sustainable pest management, Whitefly.

INTRODUCTION

Pulse crops play a pivotal role in sustainable agriculture. They provide highly nutritious food, especially important in vegetarian diets, while also enhancing soil health through nitrogen fixation and water-efficient cultivation. India remains a dominant force in the global pulses sector. As of 2024, the country accounted for approximately 25% of global production, consumed about 27% of global output and imported nearly 14% of the world's pulses. Pulses occupy about 20% of the nation's foodgrain acreage and contribute 7-10% to total foodgrain output. Over the past decade, India's pulse production has increased substantially-from about 17 M tons in 2014 to nearly 27 M tons in 2023-24 (Baxi, 2024; Global Agriculture, 2024). Green gram, *Vigna radiata* (L.) Wilczek, (Fabaceae), is one of the most important pulse crops of India and ranks third after chickpea and pigeon pea. It is to be the hardiest among pulses and is widely cultivated as a short-duration *kharif* crop, often grown as a catch crop between the *rabi* and *kharif* seasons. Pulses are regarded as an important complement to nutrition-rich foods at a low cost, often referred to as the "poor man's meat" (Sireesha and Kumar, 2018). Green gram

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is especially valued for its high nutritive content. Its contain 55-65% carbohydrates, 20-50% protein, 2-4% fat, along with vitamins and minerals, making it an important source of human food and animal feed. Beyond its nutritional importance, the crop also contributes to sustainable agriculture by improving soil fertility through biological nitrogen fixation, enhancing soil structure and replenishing nutrients (Mukherjee and Sen, 2021). After harvesting pods, the green plants are often used as fodder and in some cases, incorporated into the soil as green manure. India is the leading producer of mung bean, contributing nearly 75% of global production. It is cultivated widely across South and Southeast Asia.

During 2023-24 in Assam, the pulse area was 1.48 lakh ha, with a productivity of 801 kg/ha, resulting in a total production of 1.18 lakh tones (Anonymous, 2025). Despite its significance, green gram is attacked by numerous insect pests at various growth stages. In India, nearly 64 insect species have been reported on the crop (Lal, 1985). Major pests include the whitefly *Bemisia tabaci* (Hemiptera: Aleyrodidae), leafhopper *Empoasca kerri* (Hemiptera: Cicadellidae), black aphid *Aphis craccivora* (Hemiptera: Aphididae), cutworm *Agrotis segetum* (Lepidoptera: Noctuidae), stem fly *Ophiomyia phaseoli* (Diptera: Agromyzidae), Bihar hairy caterpillar *Spilarctia obliqua* (Lepidoptera: Erebidae), tobacco caterpillar *Spodoptera litura* (Lepidoptera: Noctuidae), sphinx moth *Agrius convolvuli* (Lepidoptera: Sphingidae), grey weevil *Myllocerus discolor* (Coleoptera: Curculionidae), gram caterpillar *Helicoverpa armigera* (Lepidoptera: Noctuidae), spotted pod borer *Maruca vitrata* (Lepidoptera: Crambidae), blister beetles *Mylabris* spp. (Coleoptera: Meloidae) and the blue butterfly *Lampides boeticus* (Lepidoptera: Lycaenidae) (Jat *et al.*, 2018). Other pests include thrips *Caliothrips indicus* (Thysanoptera: Thripidae), semilooper *Plusia orichalcea* (Lepidoptera: Noctuidae), galerucid beetle *Madurasia obscurella* (Coleoptera: Chrysomelidae), tortricid moth *Cydia ptychora* (Lepidoptera: Tortricidae), stem fly *Melanagromyza phaseoli* (Diptera: Agromyzidae), green bug *Nezara viridula* (Hemiptera: Pentatomidae), pod bugs *Riptortus pedestris* (Hemiptera: Alydidae), *Clavigralla gibbosa* and *C. horrens* (Hemiptera: Coreidae), blue beetle *Raphidopalpa intermedia* (Coleoptera: Chrysomelidae) and several other minor pests (Borah, 1995; Dar *et al.*, 2002; Duraimurugan and Tyagi, 2019). Among these, the legume pod borer, *Maruca vitrata* (Fab.) [Lepidoptera: Pyralidae], is one of the most destructive pests of grain legumes across the tropics and subtropics of Central and South America, Asia and Africa (Agunbiade *et al.*, 2012; Ogah, 2013; Oyewale *et al.*, 2014; Muhammad *et al.*, 2019). Another key pest is the gram pod borer, *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae), which is highly polyphagous and destructive. Known for its high fecundity, migratory behavior, wide adaptability and resistance to many insecticides, it attacks several crops including green gram and chickpea by feeding on leaves and boring into pods. The larvae make holes in pods, feeding on developing seeds with their anterior body inside and the posterior part outside. Once the seeds of a pod are consumed, they move to another. If uncontrolled, infestations can cause severe yield losses (Kumbrekar *et al.*, 2009). Pest infestations in green gram can reduce yields by up to 54.9% (Chhabra and Kooner, 1985). Protection against pod borers alone has been shown to save about 513.67 kg/ha of grain yield, with avoidable yield loss estimated at 36.41%.

To manage these pests, farmers often resort to indiscriminate use of synthetic pesticides. Although effective in the short term, insecticide applications results in ecological imbalances, development of resistance, pesticide residues and destruction of natural enemies. Therefore, there is an urgent need for integrated, eco-friendly and economically viable pest management strategies. Biological and Integrated Pest Management (BIPM), which combines cultural, mechanical, biological and selective chemical measures, offers a sustainable solution. Previous studies have demonstrated the benefits of IPM modules in pulse crops, but their location-specific validation under Assam conditions remains limited. Hence, the present investigation was undertaken during 2021-2024 at multiple locations in Assam to evaluate the effectiveness of a BIPM module in reducing pest incidence and improving the yield and profitability of green gram.

MATERIALS AND METHODS

Field experiments were carried out during the *kharif* seasons of 2021-22, 2022-23 and 2023-24 (Fig 1) at the Tokowbari farm of AAU-ZRS, Shillongani, Nagaon. The trials were further validated through multi-location experiments conducted at Akbarpur, Sribhumi; Gorumuria, North Lakhimpur; Gossaingaon, Kokrajhar; and Buralikson, Golaghat (Table 1). Two treatments were evaluated. The first treatment was the Biological and Integrated Pest Management (BIPM) module, which consisted of the following practices: (i) sowing two lines of sesame as a barrier crop, (ii) timely weeding at 30 days after sowing (DAS), (iii) installation of yellow sticky traps (30 cm × 20 cm) at the rate of 30 traps per hectare at 30 DAS, (iv) spraying Azadirachtin 300 ppm at 5 ml/L during the vegetative stage, (30 day after sowing)and need-based send spraying after 0 days interval. The second treatment followed the farmers' practice (FP), which included timely weeding and

Table 1: GPS locations of experiment site.

Location experimental site	Approximate GPS coordinates (Decimal degrees)
Shillongani, Nagaon	26.3547°N, 92.6303°E
Akbarpur, Sribhumi	24.8200°N, 92.3600°E
Gorumuria, North Lakhimpur	27.2356°N, 94.1426°E
Gossaingaon, Kokrajhar	26.4503°N, 89.9445°E
Buralikson, Golaghat	26.6356°N, 93.9266°E

application of pesticides recommended by AAU, Jorhat, wherein chlorantraniliprole 18.5 SC at 0.3 ml/L was applied as per the farmer's discretion.

Observations were recorded on the following parameters: the whitefly population was assessed as the mean number per trifoliate leaf at 25 and 40 DAS; the incidence leaf roller was calculated as the mean percentage incidence at 25 and 40 DAS; pod borer and pod bug damage were estimated as the mean percentage damage at 45 and 60 DAS; and aphid population was measured as the mean per plant or per 10 cm twig, depending on location-specific conditions. Crop yield was recorded at harvest and expressed in kilograms per hectare.

The data were subjected to statistical analysis and *t*-tests were performed to compare treatments. Significance of differences between treatments was determined at the 5% probability level.

RESULTS AND DISCUSSION

Effect of BIPM module on whitefly and leaf roller incidence

The population of whitefly was significantly reduced in the BIPM module compared to the farmers' practice (FP) during all the three years of study (2021-22 to 2023-24). The pooled mean whitefly incidence under the BIPM module was 0.84 whiteflies per trifoliate leaf, whereas it was 3.39 under FP (Table 2). Similarly, leaf roller incidence remained consistently lower in the BIPM plots (1.09%) compared to FP (4.48%), with all differences being statistically significant at 5% level.

Effect of BIPM module on pod borer and pod bug damage

The incidence of pod borer and pod bug was substantially reduced in BIPM-managed plots compared to FP (Table 3). Pooled analysis showed that pod borer damage under BIPM was 3.88% against 16.47% in FP. Likewise, pod bug damage was 4.65% in BIPM plots, while FP recorded 19.45%. The differences were statistically significant across all years, highlighting the effectiveness of the IPM module in suppressing major pod-feeding insect pests.

Effect of BIPM module on yield performance

Yield performance of green gram improved markedly under the BIPM module (Table 4). During 2021-22, the BIPM plots recorded a yield of 1027 kg/ha, which was 12.17% higher than FP. Similar trends were observed in subsequent years, with yields ranging between 1028.40 and 1028.80 kg/ha. The pooled mean yield under BIPM was 1028.07 kg/ha, representing a 13.39% increase over FP (906.63 kg/ha). The benefit-cost ratio was also favorable in the BIPM plots (1:2.06-1:2.52) compared to FP.

Table 2: Effect of BIPM module on white fly and % leaf roller incidence of green gram (2021-2024).

Treatments	Whitefly (no./trifoliate leaves)*				% Leaf roller incidence*			
	2021-22	2022-23	2023-24	Pooled	2021-22	2022-23	2023-24	Pooled
BIPM module	0.8	0.84	0.88	0.84	1.07	1.04	1.16	1.09
FP	3.4	3.36	3.4	3.39	4.56	4.36	4.52	4.48
"t" value	4.33	4.68	4.91	4.64	1.15	1.19	1.24	1.19
Remarks	S	S	S	S	S	S	S	S

*Mean of 25 DAS and 40 DAS.



Fig 1: A view of field experiment on IPM module at AAU-ZRS, Shillongani.

Effect of BIPM module across different locations of Assam

Multi-location trials confirmed the superiority of the BIPM module over FP in reducing pest incidence and enhancing yield (Table 5). At Shribhumi, BIPM reduced whitefly incidence to 1.03 per trifoliate leaf and leaf roller incidence to 1.43%, compared to 3.68 and 3.99, respectively, under FP. Pod borer and pod bug damage were also lower in BIPM plots (5.19% and 5.78%) than in FP (10.44% and 12.81%).

At North Lakhimpur, aphid populations were substantially lower in BIPM plots (29 per plant) compared to FP (71.4 per plant), while pod bug damage was reduced from 19.45% (FP) to 6.76% (BIPM). In Gossaingaon, pod borer damage decreased from 12.7% (FP) to 4.45% (BIPM), resulting in 34.84% higher yield in BIPM plots. Similarly, in Buralikson, aphid incidence and pod borer damage were minimized under BIPM (9.64/10 cm twig and 0.21%, respectively) compared to FP (29.92/10 cm twig and 0.57%). Overall, across locations, the BIPM module consistently reduced the incidence of key insect pests-whitefly, aphids, pod borers, pod bugs and leaf rollers-and increased yield by 6.49% to 34.84% over FP.

The present study on the eco-friendly BIPM module in green gram clearly demonstrates the potential of integrating biopesticides and botanicals for effective insect pest management under Assam conditions. Similar findings were reported by Geeta *et al.* (2024), who showed that neem oil (5%), *Bacillus thuringiensis* (*Bt*) and *Beauveria bassiana* significantly reduced the larval population of *Helicoverpa armigera* in green gram. Their results indicated that *Bt*-treated plots recorded the lowest larval infestation after the second spray, followed by *B. bassiana* and neem oil, confirming the efficacy of eco-friendly treatments against pod borers.

The seasonal incidence of insect pests recorded in the present trial corroborates earlier observations. Geeta *et al.* (2024) documented peak incidences of whitefly, spotted pod borer and blister beetle during the 35th-36th SMW, which aligns with the pest population buildup noted at mid-crop stages in our study. Similarly, Pawar *et al.* (2023) highlighted significant positive correlations of stem fly incidence with temperature and bright sunshine hours, suggesting that climatic variability partly explains pest fluctuations in mung bean. The persistence of aphids and whiteflies throughout the crop cycle, though with variable intensity, also supports the findings of Pawar *et al.* (2023)

Table 3: Effect of BIPM module on % pod borer damage and % pod bug damage of green gram (2021-2024).

Treatments	% Pod borer damage#				% Pod bug damage#			
	2021-2022	2022-2023	2023-2024	Pooled	2021-2022	2022-2023	2023-2024	Pooled
BIPM module	3.87	3.80	3.96	3.88	4.02	4.84	5.08	4.65
FP	16.28	16.52	16.6	16.47	19.39	19.40	19.56	19.45
"t" value	2.27	2.69	2.95	2.64	1.98	2.08	2.31	2.12
Remarks	S	S	S	S	S	S	S	S

#Mean of 45 DAS and 60 DAS.

Table 4: Effect of BIPM module on yield performance of green gram (2021-2024).

Treatments	Yield (kg/ha)				Increase in yield over FP (%) and B:C			
	2021-2022	2022-2023	2023-2024	Pooled data	2021-2022	2022-2023	2023-2024	Pooled data
BIPM module	1027	1028	1029	1028	12.17 (1:2.06)	13.16 (1:2.11)	13.17 (1:2.52)	13.39 (1:2.23)
FP	902	909	909	907				

Table 5: Effect of BIPM module on insect pests and yield performance of green gram in different locations of Assam.

Location	Treatment	Whitefly (No./trifoliate leaves)*	Aphid (No./plant or twig)	% Pod borer damage	% Pod bug damage	% Leaf roller incidence	Yield (kg/ha)	Increase in yield over FP (%)
Shribhumi	BIPM module	1.03	-	5.19	5.78	1.43	986	12.30%
	FP	3.68	-	10.44	12.81	3.99	878	-
North Lakhimpur	BIPM module	-	29	1.32	6.76	1.45	520	8.30%
	FP	-	71.4	3.46	19.45	8.68	480	-
Gossaingaon	BIPM module	1.3	-	4.45	-	-	329.41	34.84%
	FP	3.7	-	12.7	-	-	244.11	-
Buralikson	BIPM module	0.495	9.64	0.21	-	-	788	6.49%
	FP	0.565	29.92	0.57	-	-	740	-

in Maharashtra. These sucking pests, while less destructive than pod borers, remain critical as virus vectors, indirectly threatening productivity. Chandi (2021) emphasized that vector management must integrate cultural practices, resistant varieties, natural enemies and biopesticides to achieve long-term sustainability.

The ecological benefits of BIPM also extend beyond pest suppression. Mazed *et al.* (2022) highlighted global concerns of insect decline due to intensive agriculture and stressed the importance of conserving pollinators and natural predators for ecosystem stability and food security. Adoption of eco-friendly modules, as validated here, reduces pest pressure, safeguards biodiversity and aligns with global sustainable agriculture goals.

Our findings further confirm the effectiveness of bio-intensive tools such as neem oil, *Bt* and entomopathogenic fungi against *H. armigera* and other key pests. Field evidence also suggests that integrating such approaches into farmer practices mitigates yield losses while preserving environmental health. Supporting this, evaluations of BIPM modules in rice and vegetables have shown their superiority over conventional practices. In rice, BIPM successfully managed stem borer and leaf folder, even under organic black rice systems (Saikia *et al.*, 2016; Borkakati *et al.*, 2024). In tomato, okra and brinjal, BIPM/IPM modules combining cultural practices, biocontrol agents, pheromone traps and botanicals effectively reduced fruit borers, whiteflies and *Leucinodes orbonalis*, thereby improving marketable yield and lowering pesticide dependence (Saikia and Borkakati, 2019; Borkakati and Saikia, 2020; Borkakati *et al.*, 2020). These results collectively highlight the versatility and sustainability of BIPM across diverse cropping systems.

Additional IPM components tested in this study also proved valuable. Seed treatment with thiamethoxam 25 WG effectively controlled thrips in green gram, corroborating Kansagara *et al.* (2018). Seed dressing with *Rhizobium* enhanced yields, as earlier noted by Patil *et al.* (2015). The use of yellow sticky traps for whitefly monitoring matched the reports of Maurya and Tiwari (2018). Similarly, application of 5% NSKE at the flowering stage enhanced insecticidal efficiency, supporting the observations of Gajendran *et al.* (2006) and Singh and Singh (2015). Higher cost-benefit ratios observed in our IPM plots compared to farmers' practices are also consistent with Gajendran *et al.* (2006) in black gram and Khajuria *et al.* (2015), who reported similar results in neem-based IPM modules. Malik *et al.* (2021) likewise confirmed reduced pest incidence, higher yields and improved economic returns in IPM-managed green gram, reinforcing the superiority of integrated approaches. Studies in mung bean (Tamang *et al.,* 2017); cowpea (Anandmurthy *et al.,* 2018) and arahar (Pandey *et al.*, 2024) clearly demonstrate that weather parameters such as temperature, humidity, wind speed and sunshine hours play a decisive role in regulating sucking pest populations and their natural enemies. Future research should therefore, emphasize the development of weather-based pest forecasting models, coupled with eco-friendly management practices, to enable timely interventions. Strengthening natural enemy conservation and refining bio-intensive IPM modules across diverse agro-climatic zones will help reduce yield losses and dependence on chemical pesticides, thereby ensuring sustainable pest management in pulse-based systems.

Overall, the observations of present work establishes that BIPM/IPM practices not only suppress insect pest infestation but also enhance yield, profitability and ecological safety compared to conventional practices. Since the module components are not restricted by soil type or climatic conditions, they can be widely adopted across green gram-growing regions of India. Importantly, by reducing dependence on synthetic insecticides, these eco-friendly modules enhance profitability while contributing to biodiversity conservation and long-term agricultural sustainability.

CONCLUSION

The present study demonstrated that the bio-intensive pest management (BIPM) module, integrating sesame as a barrier crop, timely weeding, yellow sticky traps and azadirachtin spray, was highly effective in reducing the incidence of major insect pests in green gram under Assam conditions. Compared to farmers' practices, BIPM plots consistently recorded lower pest incidence and pod damage, along with higher yields and superior benefit-cost ratios across years and locations. The yield advantage of 6.49-34.84% under BIPM across diverse agro-ecological zones confirms its robustness and adaptability. These findings highlight that BIPM offers a sustainable, eco-friendly and economically viable alternative to chemical-based pest management in green gram, with potential for large-scale adoption to enhance productivity, profitability and environmental safety.

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Disclaimers

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Conflict of interest

The authors declare no conflict of interest.

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