International Journal of Environment and Climate Change

Volume 14, Issue 11, Page 44-51, 2024; Article no.IJECC.121310
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Field Demonstration of Indigenous Strains *Bacillus thuringiensis* and *Beauveria bassiana* for Sustainable Management of *Spodoptera litura* in Groundnut

M. Pradeep [a*], G. Narayana Swamy [b], P. Pedda Nagi Reddy [c] and G.L. Siva Jyothi [d++]

[a] Department of Plant Pathology, S.V. Agricultural College, Tirupati, Acharya N.G. Ranga Agricultural University, Lam, Guntur, India.
[b] Department of Horticulture, SMGR Agriculture College, Udayagiri, Acharya N.G. Ranga Agricultural University, Lam, Guntur, India.
[c] Department of Horticulture, S.V. Agricultural College, Tirupati, Acharya N.G. Ranga Agricultural University, Lam, Guntur, India.
[d] Krishi Vigyan Kendra, Nellore, Acharya N.G. Ranga Agricultural University, Lam, Guntur, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/ijecc/2024/v14i114526

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/121310

Original Research Article

Received: 13/08/2024
Accepted: 15/10/2024
Published: 21/10/2024

[++] Programme Coordinator;
**Corresponding author: E-mail: m.pradeep@angrau.ac.in;*

Cite as: *Pradeep, M., G. Narayana Swamy, P. Pedda Nagi Reddy, and G.L. Siva Jyothi. 2024. "Field Demonstration of Indigenous Strains Bacillus Thuringiensis and Beauveria Bassiana for Sustainable Management of Spodoptera Litura in Groundnut". International Journal of Environment and Climate Change 14 (11):44-51. https://doi.org/10.9734/ijecc/2024/v14i114526.*

ABSTRACT

This study by Krishi Vigyan Kendra, Nellore, evaluates the efficacy of biopesticides *Bacillus thuringiensis* (Bt) and *Beauveria bassiana* formulations against *S. litura* compared to conventional insecticides over two growing seasons (2018-19 and 2019-20). Twenty Front Line Demonstrations (FLDs) involving 20 farmers were conducted, with treatments applied when leaf damage exceeded 25%. Results indicated significant reductions in leaf damage (8.40% for biopesticides vs. 8.89% for insecticides) and larval populations. Specifically, larval counts decreased substantially after treatment, with average counts at 50 DAS dropping from 21.29 (FP) to 3.37 (Demo) in 2018-19 and from 22.15 (FP) to 3.53 (Demo) in 2019-20. Economic analysis revealed comparable net returns and benefit-cost ratios for both treatments (1.92 and 1.93 for biopesticides and insecticides, respectively). These findings support the economic viability of adopting biopesticide, promoting sustainable agricultural practices and profitability in groundnut cultivation.

Keywords: Bacillus thuringiensis; Beauveria bassiana; Spodoptera litura; ground nut.

1. INTRODUCTION

Groundnut, also known as peanut, is a vital legume crop in India, contributing significantly to the nation's food security, edible oil production, and agricultural economy. Groundnut oil constitutes nearly 50% of the total oilseed production in India, fulfilling a vital dietary need and ensuring food security, especially for plant-based protein sources. States like Gujarat and Andhra Pradesh see a substantial contribution, with groundnut accounting for 4-6% of the total value of agricultural commodities.

Groundnut cultivation in India faces a significant threat from a multitude of insect pests. Over 115 insect species have been reported to attack groundnut crops, with some causing substantial yield reductions. According to (Dutta, 2006), these insect pests and diseases inflict annual losses of Rs. 238 crores on the crop. *Spodoptera litura* is a highly adaptable and destructive insect pest, targeting over 100 plant species, including groundnuts [2]. Its presence is prevalent across diverse agroecological zones of India, making it a nationwide concern. The adult moth lays eggs on the underside of leaves. Upon hatching, the larvae become the primary threat. These caterpillars are voracious feeders, consuming leaves, flowers, and pods, leading to significant yield losses. Studies report yield losses ranging from 25.8% to a staggering 100%, depending on the infestation level and the stage of the groundnut crop (Srivatsava, 2018). Early defoliation by *S. litura* larvae can significantly hamper plant growth, pod development, and ultimately, groundnut yield. Due to insecticide resistance, favorable weather conditions, cyclonic weather, and heavy rainfall after a long dry spell, outbreaks of this pest occur (Thanki, 2003). Farmers are forced to resort to frequent insecticide applications to control *S. litura* populations. This not only increases production costs but also raises concerns about environmental safety and potential development of insecticide resistance in the pest population (De la Rosa De la Rosa and Maheshala, 2023).

The widespread devastation caused by *S. litura* necessitates the development and implementation of sustainable management strategies. This study primarily aimed at field level demonstrations to showcase that Biopesticides have greater potential as alternatives to insecticides for sustainable management of diseases.

2. MATERIALS AND METHODS

Krishi Vigyan Kendra, Nellore, conducted a demonstration of indigenous strains of *Bacillus thuringenesis (Bt)* (Water dispensible garanule (WDG) formulation containing *10^7CFU/g-)* and *Beauveria bassiana* (WDG-10^8 Conidia/g) (Formulations of biopesticides received from Regional Agricultural Research Station, Acharya N.G. Ranga Agricultural University, Tirupati) against *S. litura* on Groundnut in farmer's fields, aiming to disseminate improved agricultural technology of biopesticide management to the farming community. Over the period from 2018-19 to 2019-20, twenty Front Line Demonstrations (FLDs) were organized in TP Gudur mandal of Nellore district, involving 20 farmers in the *rabi* season. Each field demonstration of a famrer considered as one replication for each season. The demonstration area was selected in above selected places because intensive cultivation practices of groundnut crop with non-judicious application of insecticides in sandy coastal tracts. Each demonstration covered an area of one hectare, with 0.50 hectares allocated for each treatment viz., biopesticide application and farmers' practices on TAG-24 variety of Groundnut. Prior to the FLDs, farmers were carefully selected, and training was provided, covering various cultivation aspects as suggested Acharya NG Ranga Agricultural University, Andhra Pradesh. Farmers Practice: Spraying of chemicals (Novaluron (5.25%)+ Indoxicarb(4.5%) SC@ 0.175% or Chlorantraniliprole 20% SC (0.03%) after the damage according to each situation at farmer's field. Demonstration: When the defoliation crosses 20-25% application of Bt strains 2 gm/l and *Beauveria bassiana* 5 gm/l was applied in separate treatment. Data was collected 10 days after application. Farmers practice and demonstrations were considered as two treatments and each farmer location as replication. The spraying was carried out by each farmer with their respective equipment during evening hours. Data outputs from both demonstration and farmers' practices were collected and analyzed. Leaf area damage was calculated based on visual observation of five plants in ten location of each treatment plot. Percent leaf damage was calculated based on leaf area lost due to spdoptera damage. The larval count for each treatment was also calculated at ten locations in each plot. At each location, no. of larvae was counted per meter row of groundnut plants. The cost of cultivation, gross returns, net income, and benefit-cost ratio were also calculated following the methodology outlined by (Samui, 2000).

3. RESULTS

This study evaluated the efficacy of biocontrol agents (Demo treatment) versus conventional insecticides (Farmers Practice) in managing *Spodoptera litura* populations on groundnut crops over two growing seasons (2018-19 and 2019-20). The experiment assessed leaf damage percentages at critical stages of pest occurrence on groundnut and compared larval counts before and after treatments application.

3.1 Leaf Damage Assessment

Leaf damage percentages were calculated at 30DAS and 40 DAS for application of treatments to check whether leaf damage reached above threshold levels (>25%) (Threshold levels for *S. litura* was taken from National Institute of Plant Health Management, Hyderabad) or not. The pooled average leaf damage percentage was below threshold levels at 30 DAS of observation in both treatment plots. The subsequent observation at 40 DAS exhibited that leaf damage was reached above threshold levels (>25%) and eventually treatments were imposed. The effect of treatments in terms of leaf damage at 60 DAS *i.e.*, after 20 Days of treatment imposition was calculated which showed significant reduction both in FP (8.89%, Pooled average of 2018-19 & 2019-20) and Demonstrations (8.40%, Pooled average of 2018-19 & 2019-20). Significant reduction of leaf damage area was more than 90% in both treatments across two seasons (ANOVA, $p < 0.05$). This indicates that both FP and Demo treatments successfully mitigated leaf damage caused by *S. litura* larvae. Significant differences in leaf damage were observed between the years 2018-19 and 2019-20 (ANOVA, $p < 0.05$) (Table 1). This variation likely stemmed from environmental factors or differing management practices during each growing season. There was no significant difference in leaf damage between FP (insecticides) and Demo (biopesticides) treatments (ANOVA, $p = 0.672$).

3.2 Larval Count Analysis

The live count of larval stages was taken at different intervals to observe the effect of treatments on larval mortality. A high population of larvae per meter row length of groundnut crop was observed on 40 DAS in both the years for FP (pooled avg 21.72) and Demo (pooled avg 21.72). Later, the larval count was substantially decreased to 3.45 for FP and 8.72 for Demo at 50 DAS when pooled with two years of data. At 60DAS, a similar trend of decrease in larval trend was observed for FP (1.74) and Demo (4.11). Statistically, for the year 2018-19, at 50 DAS and 60 DAS, both FP and Demo treatments led to significant decreases in larval counts compared to 40 DAS (ANOVA, $p < 0.01$) (Table 2). This demonstrates the efficacy of both insecticides and bioagents in reducing Spodoptera larvae populations. Variance tests revealed significant differences in larval counts between FP and Demo treatments across 50 DAS and 60 DAS ($p < 0.001$). This highlights the variability in treatment effectiveness against *S. litura* larvae during the 2018-19 growing season.

Table 1. Leaf damage assessment by *Spodoptera litura* on groundnut

Year	Treatments	No. of Plants per sq mt	Leaf damage%			% reduction from previous observation
			30 DAS	40 DAS	60 DAS	
2018-19	**FP**	53.27	18.21	28.74	8.49	91.51
	Demo	55.63	17.54	32.19	8.95	91.05
2019-20	**FP**	52.18	14.66	33.42	9.29	90.71
	Demo	51.64	13.34	34.85	7.85	92.15
Pooled Avergae	**FP**	52.73	16.44	31.08	8.89	
	Demo	53.64	15.44	33.52	8.40	
				F- value	**P value**	
Between Years (2018-19 vs. 2019-20)				**513.1**	**<0.05**	
Between Treatments (FP vs. Demo)				**0.182**	**0.672**	
Before vs. After Treatment (40 DAS vs. 65 DAS)				**513.1**	**<0.05**	

Table 2. Larval count at different stages of groundnut crop for farmers practice vs demonstrations

	2018-19							**2019-20**					
	40 DAS (Before treatment)		**50 DAS (After treatment)**		**60 DAS**			**40 DAS (Before treatment)**		**50 DAS (After treatment)**		**60 DAS**	
	FP	**Demo**	**FP**	**Demo**	**FP**	**Demo**		**FP**	**Demo**	**FP**	**Demo**	**FP**	**Demo**
1	20.14	25.5	1.2	8.81	2.35	5.72	1	22.34	20.2	2.83	10.78	0.68	4.49
2	24.57	24.08	6.31	7.64	1.93	3.45	2	20.15	25.87	3.07	7.55	1.27	3.84
3	23.81	20.31	1.14	8.52	2.07	4.73	3	20.21	26.63	4	8.82	1.42	6.65
4	21.59	24.75	4.96	10.19	1.48	3.57	4	25.97	21.23	5.51	8.33	1.82	2.16
5	19.33	19.34	3.77	8.87	0.75	5.03	5	20.15	24.26	3.21	7.7	2.49	5.93
6	21.46	22.39	3.54	9.54	1.44	3.17	6	19.25	22.46	3.38	12.39	2.33	4.36
7	22.54	26.81	5.45	6.8	2.94	1.71	7	24.79	23.68	4.96	10.5	1.41	2.65
8	21.17	23.89	2.24	6.03	1.3	4.15	8	19.9	25.86	2.78	9.26	1.51	2.58
9	18.49	26.99	1.28	8.36	1.15	1.35	9	23.42	26.29	2.95	9.39	2.62	5.75
10	19.83	20.53	3.82	8.56	2.67	5.82	10	25.33	24.36	2.64	6.51	1.24	5.2
Average	**21.29**	**23.45**	**3.37**	**8.33**	**1.80**	**3.87**	**5.5**	**22.15**	**24.08**	**3.53**	**9.12**	**1.69**	**4.36**
					F-value	**P-value**						**F-value**	**P-value**
Comparison for 40 DAS vs 50 DAS:					**13.52**	**<0.05**	**Comparison for 40 DAS vs 50 DAS:**					**10.58**	**<0.05**
Comparison for 50 DAS vs 60 DAS:					**159.1**	**<0.05**	**Comparison for 50 DAS vs 60 DAS:**					**250.6**	**<0.05**
Comparison of FP and Demo across 50 DAS and 60 DAS:					**0.35**	**<0.05**	**Comparison of FP and Demo across 50 DAS and 60 DAS:**					**0.18**	**<0.05**

Table 3. Economic analysis of experimentation

Year	Gross cost (Rs/ha)		Gross return (Rs/ha)		Net return (Rs/ha)		B:C ratio	
	Demo	Farmers Practice	Demo	Farmers Practice	Demo	Farmers Practice	Demo	Farmers Practice
2018-19	104075	110945	204952	215050	100877	1,04,105	1.92	1.93
2019-20	107775	110275	246981	254184	139206	143909	2.30	2.29

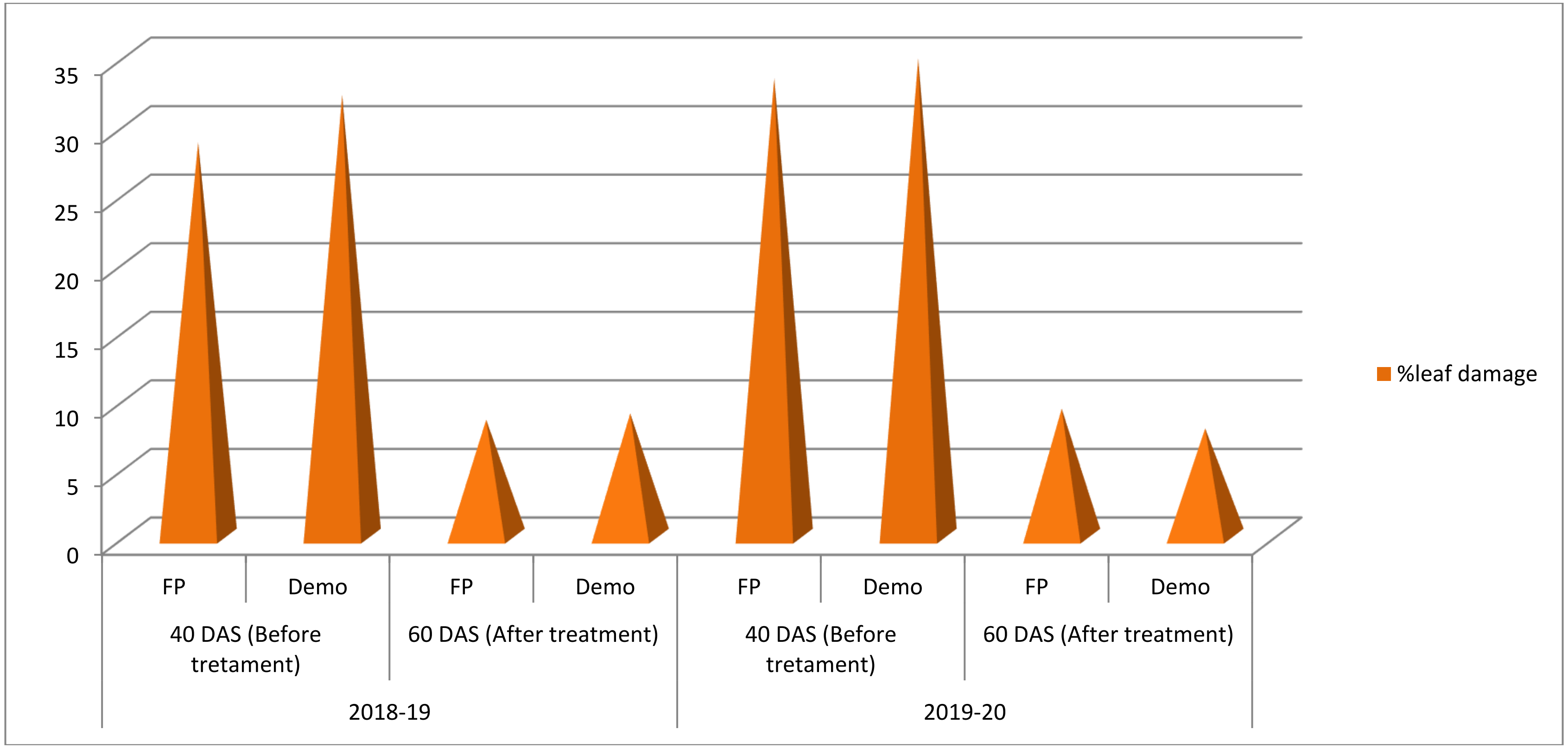
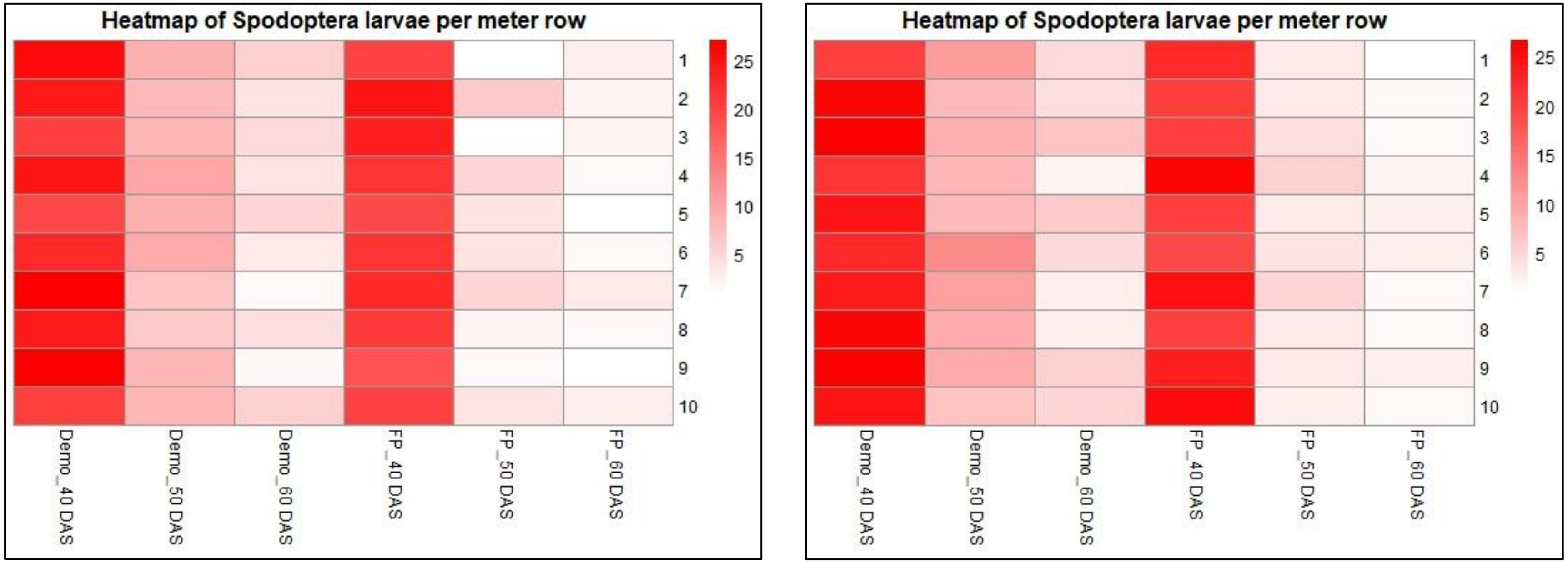


Fig. 1. Leaf damage% by *Spodoptera lithura* on groundnut at two different stages



A) 2018-19 **B) 2019-20**

Fig. 2. Heat map showing larval population at different stages of crop growth after biopesticide and inseticides application

Similar to 2018-19, significant decreases in larval counts were observed at 50 DAS and 60 DAS compared to 40 DAS for both FP and Demo treatments (ANOVA, $p < 0.001$). Both treatments effectively reduced larval populations. Variance tests also indicated significant differences in larval counts between FP and Demo treatments across 50 DAS and 60 DAS ($p < 0.001$). This reaffirms varying treatment impacts on *S. litura* larvae during the 2019-20 growing season.

Both FP (insecticides) and Demo (bioagents) treatments showed comparable effectiveness in reducing *Spodoptera litura* populations across both studied years as significant reductions in leaf damage and live larval counts were consistently observed after treatment applications. Thus, the use of biopesticides viz., *Bacillus thuringenesis* and *Beauveria bassiana* presents a promising alternative to conventional insecticides, addressing concerns related to environmental safety and potential insecticide resistance development.

The financial analysis demonstrates that the Demo treatments using biocontrol agents were economically competitive with Farmers' Practice involving insecticide usage across both years. Despite variations in gross costs and returns, the net returns and BC ratios were comparable between Demo (1.92 in 2018-19 & 2.30 in 2019-20) and Farmers' Practice (1.93 in 2018-19 & 2.29 in 2019-20) (Table 3). These findings support the economic viability of adopting biocontrol agents and sustainable agricultural practices in groundnut cultivation.

4. DISCUSSION

The overreliance on synthetic chemical insecticides has led to numerous problems, including the development of insecticide resistance, biodiversity, environmental pollution, secondary pest outbreaks, and human health hazards. Additionally, it has led to toxicity affecting non-target organisms.

Bacillus thuringiensis (Bt) is a bacterium that produces insecticidal proteins effective against various lepidopteran pests, including *Spodoptera litura*, Bt's mode of action involves the ingestion of its crystalline proteins, which are activated in the alkaline environment of the insect gut. Once activated, these proteins bind to specific receptors in the gut lining, leading to cell lysis, disruption of gut function, and ultimately the death of the insect. Studies have demonstrated the effectiveness of Bt against *S. litura*, showing significant mortality rates. A study by (Ali, 2016) highlighted that different strains of Bt exhibited varying levels of efficacy against *S. litura*, with some strains causing over 90% mortality in larval populations within a few days of exposure.

Beauveria bassiana is a fungus known for its entomopathogenic properties, effectively targeting various insect pests, including *Spodoptera litura*. Spores of *B. bassiana* attach to the cuticle of *S. litura* larvae. Once attached, the spores germinate, penetrating the insect's exoskeleton leading to tissue colonization. The fungus secretes enzymes that break down host tissues and nutrients, allowing it to grow and weaken the host's immune response, ultimately leading to death (Faria, 2007).

Pot culture studies and field trials by Vimala et al. (Vimala, 2021) revealed that efficacy of Bt-127 WDG formulation was on par with the commercial Btk formulation against 7 and 9 days old larvae of Spodoptera. Bt-127 WDG formulation was promising against early as well as older instar larvae based on dead larval counts in pot culture experiments. (Dodiya and Barad, 2022) studied eight tested biopesticides, among which SlNPV 250 LE, *B. bassiana* 1% WP and aqueous bidi tobacco dust extract 2% found most effective and recorded minimum larval population of *S. litura* as well as per cent damaged groundnut plant. In a study concluded by Kumar and Kaur (2017), Directorate of Oilseed Research developed strains of *B. bassiana* at 200 mg/l and Bt-5 at 2.5 g/l are effective for early season suppression of *Helicoverpa armigera* on sunflower and are safe for natural enemies. Our results also showed that these biopesticides can be valuable alternative for chemical insecticides based on controlling larval populations of *S. lithura* in demonstrations (bio pesticides used) at same level as that insecticides and also economical and proved to be beneficial to environment by other studies.

5. CONCLUSION

In conclusion, this study underscores the effectiveness of both FP and Demo treatments in mitigating *Spodoptera litura* infestations on groundnut crops. The results highlight the feasibility of integrating biocontrol agents with traditional pest management practices to achieve sustainable pest control and enhance crop yield security in groundnut cultivation.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

Ali, A., et al. (2016). Efficacy of *Bacillus thuringiensis* against *Spodoptera litura*: A review. *Journal of Pest Science, 89*(2), 357-368.

De la Rosa, W., et al. (2016). Effect of *Beauveria bassiana* on *Spodoptera litura*: Infection dynamics and pathogenicity. *Biocontrol Science and Technology, 26*(9), 1307-1320.

Dodiya, R. D., & Barad, A. H. (2022). Effectiveness of biopesticides against *Spodoptera litura* infesting groundnut under field conditions. *Pharma Innovation Journal, 11*(8S), 1601-1605. https://doi.org/10.22271/tpi.2022.v11.i8Su.15037

Dutta, D., & Bandopadhyay, P. (2006). Production potential of intercropping of groundnut (Arachis hypogea) with pigeonpea (Cajanus cajan) and maize under various proportions in rainfed. *Indian Journal of Agronomy, 51*(2), 103-106.

Faria, M. R., & Wraight, S. P. (2007). Biological control of insect pests using *Beauveria bassiana*: A review. *Biological Control, 43*(2), 100-117.

Kumar, S., & Kaur, J. (2017). Efficacy of *Beauveria bassiana* and *Bacillus thuringiensis* as ecosafe alternatives to chemical insecticides against sunflower capitulum borer, *Helicoverpa armigera* (Hübner). *Journal of Entomology and Zoology Studies, 5*(2), 185-188.

Maheshala, N. V., Kurella, A., Jena, R., Gangaiah, H., & Thankappan, R. (2023). IPM in groundnut: Current scenario. In *Integrated Pest Management in Diverse Cropping Systems* (1st ed., p. 45). Apple Academic Press. https://doi.org/10.1201/9781003304524

Samui, S. K., Mitra, S., Roy, D. K., Mandal, A. K., & Saha, D. (2000). Evaluation of FLD on groundnut. *Journal of the Indian Society of Coastal Agricultural Research, 18*(2), 180-183.

Srivatsava, K., Sharma, D., Anal, A., Sharma, A., & Sonika. (2018). Integrated management of *Spodoptera litura*: A review. *International Journal of Life-Science Scientific Research, 4*. https://doi.org/10.21276/ijlssr.2018.4.1.4

Thanki, K. V., Patel, G. P., & Patel, J. R. (2003). Population dynamics of *Spodoptera litura* on castor, *Ricinus communis*. *Indian Journal of Entomology, 65*(3), 347-350.

Vimala Devi, P. S., Duraimurugan, P., Chandrika, K. S. V. P., & Vineela, V. (2021). Development of a water dispersible granule (WDG) formulation of *Bacillus thuringiensis* for the management of *S. litura* (F.). *Biocontrol Science and Technology, 31*(5), 1-15.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/121310