International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
IJABR 2024; 8(10): 82-87
www.biochemjournal.com
Received: 09-07-2024
Accepted: 12-08-2024

Kartikey Singh
Ph. D. Student, Department of Entomology, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

Dharm Raj Singh
Professor, Department of Entomology, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

Prince Sahu
Ph. D. Student, Department of Entomology, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

Pankaj Kumar Rajpoot
Ph. D. Student, Department of Entomology, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

Nahida Afreen
Ph. D. Student, Department of Entomology, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

Paritosh Tripathi
Ph. D. Student, Department of Entomology, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

Ankit Upadhyay
Teaching Associate, Department of Entomology, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

Corresponding Author:
Kartikey Singh
Ph. D. Student, Department of Entomology, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

Efficacy of bio-pesticides based modules for the management of major insect pest of lentil (*Lens culinaris* Medikus) under field condition

Kartikey Singh, Dharm Raj Singh, Prince Sahu, Pankaj Kumar Rajpoot, Nahida Afreen, Paritosh Tripathi and Ankit Upadhyay

DOI: https://doi.org/10.33545/26174693.2024.v8.i10b.2413

Abstract
The experiments were conducted during rabi seasons of two consecutive years from 2022-23 and 2023-24 at Students instructional farm of CSAUAT, Kanpur (India) to evaluate the field efficacy of Bio-Pesticides Based Modules consisting different treatments were as follows: T_1 (*Metarhizium anisopliae* 5 g/l), T_2 (*Beauveria bassiana* 5 g/l), T_3 (*Verticillium lacanii* 5 g/l), (Emamectin benzoate 1 g/l), T_5 (Azadirachtin 5 ml/l), T_6 (*Bacillus thuringiensis* 2ml/l), T_7 (Spinosad 0.3 ml/l) and T_8 (Control) against *Aphis craccivora, Helicoverpa armigera, Etiella zinckenella* in lentil. Overall, Spinosad consistently outperformed other bio-pesticides in controlling *Aphis craccivora* Koch populations, highest effectiveness in reducing larval populations (*Helicoverpa armigera* Hübner,) and Spinosad consistently reduced pod damage by (*Etiella zinckenella* Treitschke), followed by Emamectin benzoate. Highest yield was recorded in *Rabi*, 2022-23 T_7 (Spinosad) recorded the highest yield at 20.71 q/ha, followed by T_4 (Emamectin benzoate) with 19.02 q/ha, and T_5 (Azadirachtin) with 16.86 q/ha. Similarly, T_7 (Spinosad) again achieved the highest yield at 21.71 q/ha, followed by T_4 (Emamectin benzoate) with 20.36 q/ha, and T_5 (Azadirachtin) with 17.19 q/ha in *Rabi* 2023-24. Whereas, Highest ratio was for Spinosad (1:33.98), followed by Azadirachtin (1:24.42) and Emamectin benzoate (1:23.33) in *Rabi* 2022-23 and Spinosad improved to (1:39.01), with Azadirachtin (1:27.40) and Emamectin benzoate (1:27.26) in *Rabi* 2023-24.

Keywords: *Aphis craccivora, Helicoverpa armigera, Etiella zinckenella,* lentil and management

Introduction
Lentil (*Lens culinaris* Medikus), commonly referred to as Masoor in local parlance, is a significant pulse crop of the rabi season. It is cultivated extensively across North America, Southern Europe, North Africa, West Asia, as well as northern and central regions of India. Renowned for its high protein content approximately 25% lentils play a crucial role in addressing malnutrition, particularly by bridging the protein gap. Bahl *et al*. (1993) [2] suggested that lentils are likely among the oldest domesticated grain legumes. Compared to other legumes, lentils are rich in protein, carbohydrates, and calories, making them a highly sought-after crop in many legume-producing areas. In 2022, India produced 1.28 million tonnes of lentils, covering an area of 1.42 million hectares with an average yield of 904 kg per hectare, as per the fourth advance estimate by the Directorate of Economics and Statistics (DES), Ministry of Agriculture and Farmers' Welfare, Government of India (Anonymous, 2024) [1]. However, the productivity of lentils faces several challenges, primarily due to poor crop management and various abiotic and biotic stresses. Among these, insect pests significantly affect yields. Approximately three dozen insect species have been reported to infest lentils in both field and storage conditions (Hariri, 1981) [6], with 21 species documented in India alone (Lal, 1992) [11]. Notable pests include *Aphis craccivora* Koch (Thakur *et al*., 1984) [20], the phycitid *Etiella zinckenella* Treitschke (Singh and Dhooria, 1971) [15], and the bruchid *Callosobruchus chinensis* Linn. (Staneva, 1982) [16], all of which have been identified as major threats to lentil crops in India. *Etiella zinckenella*, a polyphagous pest, is known to attack several cultivated crops including medics, clovers, lucerne, field peas, lentils, and soybeans (Hopkins, 2003) [7]. This pest primarily infests lentils during the flowering and pod formation stages, leading to decreased productivity and

diminished grain quality. In India, *Etiella zinckenella* has been found to infest 11.4% of lentil pods and 50.9% of pea pods, causing yield losses of 10.6% and 23.9%, respectively (Singh and Dhooria, 1971) [15]. Furthermore, aphids are capable of destroying 25-50% of developing plants (Kishor *et al.*, 2019) [8]. Additionally, Kumar and Yadav (2018) [9] identified the gram pod borer (*Helicoverpa armigera* Hübner) as another significant pest of lentils, alongside aphids and *Etiella zinckenella*. The larvae of *Helicoverpa* damage the crop by scraping leaflets and feeding on flowers in the early stages, while older larvae target foliage and pods, exacerbating yield losses.

Given these challenges, conventional pesticide applications for aphid management are no longer considered sustainable. An emerging, safer, and more effective strategy for aphid control is the use of biorational insecticides. These natural, microbial, or botanical-derived compounds, often referred to as new-generation insecticides, pose minimal risk to non-target plants and have demonstrated efficacy against a wide range of insect pests. The growing use of biorational insecticides is seen as a promising alternative to synthetic chemicals, offering an environmentally sound approach to managing insect infestations in lentil crops (Haddi *et al.*, 2020) [5].

Materials and Methods

The experiments were conducted during rabi seasons of two consecutive years from 2022-23 and 2023-24 at Students instructional farm of CSAUAT, Kanpur (India). Lentil var. KLB – 345 (Shekhar - 4) was sown on 10th November, 2022 and 12th November 2023 following the recommended agronomic practices. The experiment was laid out in randomized complete block design (RBD) with three replications. The unit plot size was 4.0 × 3.0 m with maintaining spacing of 30 cm between row to row. For estimating the comparative losses caused by the pests, three treatments were compared with the control plots. Different treatments were as follows: T_1 (*Metarhizium anisopliae* 5 g/l), T_2 (*Beauveria bassiana* 5 g/l), T_3 (*Verticillium lacanii* 5 g/l), (Emamectin benzoate 1 g/l), T_5 (Azadirachtin 5 ml/l), T_6 (*Bacillus thuringiensis* 2ml/l), T_7 (Spinosad 0.3 ml/l) and T_8 (Control) no insecticide was sprayed on the crop and was exposed to natural infestation i.e. untreated control. The knapsack sprayer fitted with hollow cone nozzle was used for spray operation after mixing the required concentration of insecticides with water. Nymph and Adult population of *A. craccivora*. to be observed the aphid population recorded from top 10 cm apical twigs of plants and randomly selected 5 plants from each plot one day before spray and 3, 7, and 10 days after first and second, with one day before spraying becoming pre-treatment count for the second spray. Five plants were randomly selected from each treatment and count the number of larvae of *H. armigera* was recorded 24 hours before spray and after 3, and 10 days of each spray. And other hand for *E. zinckenella* observations was recorded through five plants were randomly selected from each treatment and count infested pod percentage through using of following formula was 24 hours before spray and after 3, and 10 days of each spray.

$$\text{Pod infestation (\%)} = \frac{\text{Number of infested pods}}{\text{Total number of pods}} \times 100$$

Yield data for each treatment was meticulously recorded post-harvest. Subsequently, treatment-specific grain yields were converted into quintals per hectare (q/ha). The data collected from both treated and untreated plots were then utilized to calculate the avoidable yield loss. Per cent increase in yield was computed by using the formula mentioned by Pradhan (1969) [13].

$$\text{Percent increase in yield} = \frac{\text{Yield in treated plots (q/ha)} - \text{Yield in treated plots (q/ha)}}{\text{Yield in untreated plots (q/ha)}} \times 100$$

The first spray was administered at the 50% flowering stage, with a follow-up application conducted 15 days later.

Result and Discussion

In present investigation the major insect pests recorded in lentil ecosystem were pulse aphid, *Aphis craccivora* Koch among the sucking pests and gram pod borer, *Helicoverpa armigera* Hubner and *Etiella zinckenella* Treitschke the most important pod boring insects of pulse crops.

Pooled data of bio efficacy of different bio-pesticides against Aphid (*A. craccivora* Koch) in lentil crop (*L. culinaris*, Medikus) during *Rabi*, 2022- 23 and 2023- 24 (First Spray): The mean aphid population was observed at 1 day before spraying (DBS) in pooled analysis varied from 18.8 to 19.46 aphid per 10 cm twig per plant. Pooled analysis revealed after 3rd days of spray the lowest aphid population was observed in the Spinosad treatment (T_7) with 11.27 aphids per twig. Emamectin benzoate (T_4) followed with 12.46 aphids, Azadirachtin (T_5) at 14.3 aphids was statistically comparable to *Verticillium lacanii* (T_3) with 15.03 aphids, while *Beauveria bassiana* (T_2) at 15.22 aphids was at par to *Metarhizium anisopliae* (T_1) at 15.96 aphids. *Bacillus thuringiensis* (T_6) recorded a higher aphid count of 17.36, and the untreated control showed 22.10 aphids. However, The data also reveals that T_7 showed the highest reduction of the aphid population in pooled analysis (49.01%) 3rd days after spray. Similarly data revealed 7th days after spray Spinosad (T_7) again showed the lowest aphid population at 8.00, followed by Emamectin benzoate (T_4) at 9.33 aphids. Azadirachtin (T_5) with 11.36 aphids was statistically at par to *Verticillium lacanii* (T_3) at 11.43 and *Beauveria bassiana* (T_2) at 12.43. *Metarhizium anisopliae* (T_1) recorded 14.4 aphids, and Bacillus thuringiensis (T_6) had 18.6 aphids. The control plot had 24.60 aphids. As such 3rd days after spray the highest reduction of the aphid population in pooled analysis found in T_7 (78.17%). 10th days after spray data recorded Spinosad (T_7) remained the most effective treatment with 5.9 aphids per twig, followed by Emamectin benzoate (T_4) at 10.03. Azadirachtin (T_5) recorded 10.56 aphids, statistically at par to *Verticillium lacanii* (T_3) with 12.13 and *Beauveria bassiana* (T_2) with 12.90 aphids. *Metarhizium anisopliae* (T_1) had 13.9 aphids, and Bacillus thuringiensis (T_6) recorded the highest count among treatments with 19.93 aphids. The untreated control showed an aphid population of 27.06 (Table 1.0).

Table 1: Pooled data of bio efficacy of different bio-pesticides against Aphid (*A. craccivora* Koch) in lentil crop (*L. culinaris*, Medikus) during *Rabi*, 2022- 23 and 2023- 24 (First Spray)

Treatments	1 DBS	3 DAS	Reduction over control (%)	7 DAS	Reduction over control (%)	10 DAS	Reduction over control (%)
T_1, *Metarhizium anisopilae*	19.2	15.967	27.75	14.4	41.46	13.9	48.57
T_2 *Beauveria bassiana*	18.8	15.223	31.11	12.433	49.45	12.9	52.27
T_3 *Verticillium lecanii*	19.367	15.033	31.97	11.433	53.52	12.133	55.11
T_4 Emamectin Benzoate	19.233	12.467	43.58	9.333	62.06	10.033	62.88
T_5Azadiractin	19.333	14.3	35.29	11.367	53.79	10.567	60.90
T_6 *Bacillus thuringienesis*	19.083	17.367	21.41	18.6	24.39	19.933	26.25
T_7 Spinosad	19.467	11.267	49.01	8	67.47	5.9	78.1
T_8 Control	19.433	22.1	0	24.6	0	27.033	0
C.D.	N/A	0.669		1.552		0.859	
SE(m)	0.334	0.219		0.507		0.28	

DBS – Day Before Spray, DAS – Days After Spray

Second spray

The second application of the spray was administered 15 days after the initial treatment. The populations of both nymphs and adults of *A. craccivora* were monitored. The lowest aphid population was recorded 3rd days after spray in the Spinosad treatment (T_7) with 5.93 aphids, followed by Emamectin benzoate (T_4) at 8.63 aphids. Azadirachtin (T_5) recorded 9.8 aphids, and *Verticillium lacanii* (T_3) had 10.8 aphids. *Beauveria bassiana* (T_2) recorded 12.33 aphids, and *Metarhizium anisopliae* (T_1) had 11.86. *Bacillus thuringiensis* (T_6) had the highest aphid count among the treatments at 19.40 aphids. Spinosad (T_7) remained the most effective after 7 days after spray with 4.00 aphids, followed by Emamectin benzoate (T_4) at 5.3. Azadirachtin (T_5) recorded 6.6 aphids, and *Verticillium lacanii* (T_3) had 8.03 aphids. *Beauveria bassiana* (T_2) and *Metarhizium anisopliae* (T_1) recorded 9.7 and 10.1 aphids, respectively. *Bacillus thuringiensis* (T_6) showed the highest aphid population among treatments with 17.73 aphids, while the control reached 32.33 aphids. Spinosad (T_7) continued to demonstrate the greatest efficacy, reducing aphid populations after 10th days after spray to 2.96 aphids, followed by Emamectin benzoate (T_4) at 3.6 aphids. Azadirachtin (T_5) recorded 5.16 aphids, and *Verticillium lacanii* (T_3) had 6.93 aphids. *Beauveria bassiana* (T_2) and *Metarhizium anisopliae* (T_1) both had 8.93 aphids, showing no statistical difference between them. *Bacillus thuringiensis* (T_6) recorded 17.56 aphids, the highest among the treatments. The untreated control population increased to 33.85 aphids. The data also reveals that T_7 showed the highest reduction over control of the aphid population in pooled analysis (80.69%), (87.62) and (91.23) after 3rd, 7th and 10th days after spray respectively. strong results. All treatments were significantly superior to the control (Table 2.0). Similarly, Golvankar, G., *et al.*, (2019) [4] reported that (Spinosad 45 SC) and T_8 (Emamectin benzoate 5 SG) at par wih each other to control aphid population. According to, Sultana, S., *et al.*, (2020) [18] Reduction of aphid population on pods was the highest in Abamectin (86.97%), followed by Spinosad (81.97%) over the Emamectin benzoate.

Table 2: Pooled data of bio efficacy of different bio-pesticides against Aphid (*A. craccivora* Koch) in lentil crop (*L. culinaris,* Medikus) during *Rabi*, 2022- 23 and 2023- 24 (Second Spray)

Treatments	3 DAS	Reduction over control (%)	7 DAS	Reduction over control (%)	10 DAS	Reduction over control (%)
T_1, *Metarhizium anisopilae*	11.86	61.38	10.1	68.75	8.933	73.61
T_2 *Beauveria bassiana*	12.33	59.86	9.7	69.99	8.933	73.61
T_3 *Verticillium lecanii*	10.8	64.85	8.03	75.15	6.933	79.51
T_4 Emamectin Benzoate	8.63	71.90	5.3	83.60	3.6	89.36
T_5Azadiractin	9.8	68.10	6.6	79.58	5.167	84.73
T_6 *Bacillus thuringienesis*	19.4	36.86	17.73	45.15	17.567	48.10
T_7 Spinosad	5.93	80.69	4	87.62	2.967	91.23
T_8 Control	30.73	0.0	32.33	0.0	33.85	0
C.D.	0.641		0.893		0.468	
SE(m)	0.209		0.291		0.153	

DBS – Day Before Spray, DAS – Days After Spray

Pooled data of bio efficacy of different bio-pesticides against pod borer (*H. armigera*) in lentil crop (*L. culinaris*, Medikus) during *Rabi*, 2022- 23 and 2023- 24

Five plants were randomly selected from each treatment and count the number of larvae of *H. armigera* was recorded 24 hours before spray and after 3, and 10 days of spray. The mean aphid population was observed at 1 day before spraying (DBS) in pooled analysis varied non-significantly ranging from 0.7 to.96 larvae per plant. The lowest larval population was observed 3rd days after spray in the Spinosad treatment (T_7) at 0.5 larvae, followed by Emamectin benzoate (T_4) with 0.65 larvae. Azadirachtin (T_5) recorded 0.7 larvae, while *Bacillus thuringiensis* (T_6) and *Verticillium lacanii* (T_3) both showed 0.75 larvae. *Beauveria bassiana* (T_2) had 0.8 larvae, and *Metarhizium anisopliae* (T_1) recorded the highest count at 0.85 larvae. The untreated control had 1.1 larvae. Spinosad (T_7) remained the most effective 7th days after spray with 0.4 larvae, followed by *Bacillus thuringiensis* (T_6) at 0.46 and Emamectin benzoate (T_4) at 0.56. Azadirachtin (T_5) recorded 0.63 larvae, *Verticillium lacanii* (T_3) had 0.66 larvae, while *Beauveria bassiana* (T_2) and *Metarhizium anisopliae* (T_1) both showed 0.7 larvae. The control population increased to 1.23 larvae. Spinosad (T_7) continued to show the lowest 10th days after spray larval population with 0.2 larvae, followed by *Bacillus thuringiensis* (T_6) at 0.3. Emamectin benzoate (T_4) had 0.36

larvae, Azadirachtin (T_5) recorded 0.43 larvae, and *Verticillium lacanii* (T_3) had 0.53 larvae. Both *Beauveria bassiana* (T_2) and *Metarhizium anisopliae* (T_1) recorded 0.63 larvae. The control showed a further increase in the larval population, reaching 1.4 larvae. The data also reveals that T_7 showed the highest reduction over control of the larval population in pooled analysis (54.54%), (67.47%) and (85.71%) after 3rd, 7th and 10th days after spray respectively (Table 3.0). Kumar and Sarada (2015) [10] They revealed that the number *of H. armigera* larvae were lowest in plots treated with chlorantraniliprole 20% SC, spinosad 45% SC and flubendiamide 20% WG as against untreated control plot 93.9, 91.8 and 89.7% reduction of *H. armigera* population, respectively. Gaje, S. *et al.* (2010) [3] reported that The treatment with *Bacillus thuringiensis* at 0.5 kg/ha was found best with minimum pod borer infestation of 2.96 and 2.43% during *Rabi* of 2006-07 and *Rabi* of 2007-08 respectively and followed by *Beauveria bassiana* in which the pod infestation was 4.95 and 5.47% respectively. Rashmi, K. M *et al.*, (2020) [14]. Sarnaik and Chiranjeev (2017) [17] also reported that the efficacy of chlorantraniliprole 18.5 SC was on par with spinosad @ 0.15 ml/l and emamectin benzoate @ 0.2 g/l. The results revealed the emamectin benzoate 5WG was found to be the best treatment with novel mode of action.

Table 3: Pooled data of bio efficacy of different bio-pesticides against pod borer (*H. armigera*) in lentil crop (*L. culinaris*, Medikus) during *Rabi*, 2022- 23 and 2023- 24.

Treatment	1 DBS	3 DAS	Reduction over control (%)	7 DAS	Reduction over control (%)	10 DAS	Reduction over control (%)
	Mean	Mean		Mean		Mean	
T_1, *Metarhizium anisopilae*	0.8	0.85	22.72	0.7	43.08	0.633	54.78
T_2 *Beauveria bassiana*	0.867	0.8	27.27	0.7	43.08	0.633	54.78
T_3 *Verticillium lecanii*	0.867	0.75	31.81	0.667	45.77	0.533	61.92
T_4 Emamectin Benzoate	0.7	0.65	40.90	0.567	53.90	0.367	73.78
T_5Azadiractin	0.8	0.7	36.36	0.633	48.53	0.433	69.07
T_6 *Bacillus thuringienesis*	0.833	0.75	31.81	0.467	62.03	0.3	78.57
T_7 Spinosad	0.8	0.5	54.54	0.4	67.47	0.2	85.71
T_8 Control	0.967	1.1	0	1.233	0.0	1.4	0
C.D.	N/A	0.157		0.151		0.117	
SE(m)	0.064	0.051		0.049		0.038	

DBS – Day Before Spray, DAS – Days After Spray

Pooled data of Bio efficacy of different bio-pesticides against Pod borer (*E. zinckenella* Treit.) in lentil crop (*L. culinaris*, Medikus) during *Rabi*, 2022-23 and 2023- 24

Observations was recorded for *E. zinckenella* through five plants were randomly selected from each treatment and count infested pod percentage through using of following formula was 24 hours before spray and after 3, and 10 days of each spray.

$$\text{Percent pod damage} = \frac{\text{Number of infescted pod}}{\text{Total number of pods}} \times 100$$

Percent pod damage by *E. zinckenella* in each treatment before spraying was recorded approximately uniform in each plot and varied non-significantly ranging from 11.77 to 12.55 percent pod damage per plant. The lowest percent pod damage was recorded 3rd days after spray in the Spinosad treatment (T_7) at 7.76%, followed by Emamectin benzoate (T_4) at 9.37%. *Bacillus thuringiensis* (T_6) recorded 10.17%, *Beauveria bassiana* (T_2) 10.44%, Azadirachtin (T_5) 11.04%, *Verticillium lacanii* (T_3) 11.39%, and *Metarhizium anisopliae* (T_1) 11.34%. Spinosad was significantly superior to all treatments, with Emamectin benzoate following closely. *Bacillus thuringiensis* and *Beauveria bassiana* were statistically at par, as were Azadirachtin and Verticillium lacanii. The untreated control recorded a higher pod damage rate of 14.07%. All treatments outperformed the control significantly. Spinosad (T_7) again showed 7th days after spray the lowest pod damage at 6.11%, followed by Emamectin benzoate (T_4) at 7.52%. *Bacillus thuringiensis* (T_6) recorded 8.80%, *Beauveria bassiana* (T_2) 9.38%, Azadirachtin (T_5) 9.90%, *Verticillium lacanii* (T_3) 10.06%, and *Metarhizium anisopliae* (T_1) 10.69%. Spinosad was significantly more effective than all treatments, with Emamectin benzoate ranking next. *Bacillus thuringiensis* and *Beauveria bassiana* were found statistically comparable, while Azadirachtin was similar to *Verticillium lacanii*. All treatments were significantly superior to *Metarhizium anisopliae* and the control, which recorded 14.85% pod damage. The lowest percent pod damage was recorded in Spinosad (T_7) at 4.27%, followed by Emamectin benzoate (T_4) at 5.74%. *Bacillus thuringiensis* (T_6) had 7.38%, *Beauveria bassiana* (T_2) 7.62%, Azadirachtin (T_5) 8.11%, *Verticillium lacanii* (T_3) 9.14%, and *Metarhizium anisopliae* (T_1) 9.74%.Spinosad was significantly superior over all other treatments, followed by Emamectin benzoate. *Bacillus thuringiensis* was found comparable to Azadirachtin and superior to *Beauveria bassiana*, *Verticillium lacanii*, and *Metarhizium anisopliae*. The control recorded 15.93% pod damage. All treatments performed significantly better than the control. Spinosad consistently showed the best performance in reducing pod damage at all intervals. Emamectin benzoate followed closely, with *Bacillus thuringiensis* showing a strong effect by the 10th day. Azadirachtin, *Verticillium lacanii*, *Beauveria bassiana*, and *Metarhizium anisopliae* offered moderate reductions in pod damage but were all significantly better than the untreated control. The data also reveals that T_7 showed the highest reduction over control of the percent pod damage in pooled analysis (44.64%), (58.80) and (73.15) after 3rd, 7th and 10th days after spray respectively (Table 4.0). Similarly, Surykant, A. S., & Tayde, A. R. (2024) [19] reported that the mean of both first and second spray revelled that Indoxacarb 18.5 @0.3 ml/lit recorded the lowest infestation of pod borer population i.e (1.79) which was significantly superior over control followed by (2.02), Spinosad 45% SC (2.23), Emamectin benzoate 5% SG (2.41).

Table 4: Pooled data of Bio efficacy of different bio-pesticides against Pod borer (*E. zinckenella* Treit.) in lentil crop (*L. culinaris*, Medikus) during *Rabi*, 2022-23 and 2023- 24.

Treatment	1 DBS	3 DAS	Reduction over	7 DAS	Reduction over	10 DAS	Reduction over
	Mean	Mean	control (%)	Mean	control (%)	Mean	control (%)
T_1, *Metarhizium anisopilae*	12.243	11.342	19.10128	10.697	27.96633	9.743	38.83867
T_2 *Beauveria bassiana*	12.133	10.447	25.48502	9.385	36.80135	7.622	52.15317
T_3 *Verticillium lecanii*	12.5	11.39	18.75892	10.06	32.25589	9.145	42.59259
T_4 Emamectin Benzoate	12.553	9.377	33.11698	7.522	49.3468	5.74	63.96736
T_5Azadiractin	12.388	11.042	21.24108	9.907	33.2862	8.113	49.07094
T_6 *Bacillus thuringienesis*	11.777	10.173	27.43937	8.803	40.72054	7.387	53.62837
T_7 Spinosad	12.11	7.765	44.61484	6.117	58.80808	4.277	73.15129
T_8 Control	12.388	14.027	0.0	14.85	0.0	15.932	0.0
C.D.	N/A	0.785		0.617		0.56	
SE(m)	0.484	0.256		0.201		0.183	

DBS – Day Before Spray, DAS – Days After Spray

During the Rabi seasons of 2022-23 and 2023-24, the lentil yield (q/ha.) and percentage increase over the control were evaluated across different bio-pesticide treatments

***Rabi* 2022-23:** The highest yield was recorded in T_7 (Spinosad) with 20.71 q/ha, followed by T_4 (Emamectin benzoate) with 19.02 q/ha, and T_5 (Azadirachtin) with 16.86 q/ha. The lowest yield was in the control (8.38 q/ha). Spinosad was statistically superior, at par with Emamectin benzoate, while Azadirachtin was statistically at par with *Verticillium lacanii*. All treatments were significantly better than the control. The highest yield increase was in Spinosad (59.52%), followed by Emamectin benzoate (55.94%) and Azadirachtin (50.28%) (Table 5.0).

***Rabi* 2023-24:** T_7 (Spinosad) again had the highest yield with 21.71 q/ha, followed by T_4 (Emamectin benzoate) with 20.36 q/ha, and T_5 (Azadirachtin) with 17.19 q/ha. The control recorded the lowest yield at 8.71 q/ha. Spinosad remained significantly superior, statistically at par with Emamectin benzoate. All treatments yielded significantly more than the control. The highest percentage yield increase was in Spinosad (59.85%), followed by Emamectin benzoate (57.18%) and Azadirachtin (49.31%). In both years, Spinosad consistently provided the highest yield and yield increase, followed by Emamectin benzoate, with all treatments outperforming the control (Table 5.0).

During the Rabi seasons of 2022-23 and 2023-24, the cost-benefit ratio of various bio-pesticide treatments was evaluated

***Rabi* 2022-23**: The highest cost-benefit ratio was recorded for Spinosad (1:33.98), followed by Azadirachtin (1:24.42), Emamectin benzoate (1:23.33), and Verticillium lacanii (1:22.08). Other treatments included *Bacillus thuringiensis* (1:18.79), *Metarhizium anisopliae* (1:15.86), and *Beauveria bassiana* (1:13.69) (Table 5.0).

Table 5: During the Rabi seasons of 2022-23 and 2023-24, the lentil yield (q/ha.) and percentage increase over the control were evaluated across different bio-pesticide treatments with cost-benefit ratio of various bio-pesticide.

Treatments	Yield (q/ha.) 2022-23	Increased yield over control (%)	Yield (q/ha.) 2023-24	Increased yield over control (%)	Incremental cost benefit ratio 2022-23	Incremental cost benefit ratio 2023-24
T_1, *Metarhizium anisopilae*	10.427	19.60	10.76	18.98	15.86	17.98
T_2 *Beauveria bassiana*	13.09	35.95	13.423	35.05	13.69	15.43
T_3 *Verticillium lecanii*	15.32	45.28	15.987	45.47	22.08	25.28
T_4 Emamectin Benzoate	19.027	55.94	20.36	57.18	23.33	27.493
T_5Azadiractin	16.86	50.28	17.19	49.31	24.41	27.26
T_6 *Bacillus thuringienesis*	11.15	24.86	11.49	24.13	18.79	21.23
T_7 Spinosad	20.71	59.52	21.71	59.85	33.98	39.01
T_8 Control	8.383	0	8.717	0		
C.D.	2.177		2.005			
SE(m)	0.802		0.68			

***Rabi* 2023-24:** The highest cost-benefit ratio was again recorded for Spinosad (1:39.01), showing an improvement over the previous year. This was followed by Azadirachtin (1:27.40), Emamectin benzoate (1:27.26), and *Verticillium lacanii* (1:25.28). Other treatments included *Bacillus thuringiensis* (1:21.23), *Metarhizium anisopliae* (1:17.98), and *Beauveria bassiana* (1:15.43) (Table 5.0). Similarly, Kumar and Sarada (2015) reported that highest yield was recorded in spinosad 45% SC treated plots (1244.4 kg/ha) with 121.8% increase over control, followed by chlorantraniliprole 20% SC (1180.5 kg/ha), flubendiamide 20% WG (1157.4 kg/ha) and emamectin benzoate 5% SG (1078.7 kg/ha) and Surykant, A. S., & Tayde, A. R. (2024) [19] calculated the highest yield and cost benefit ratio was recorded in Indaxocarb 14.5% Sc (67.5) and(1:3.30), followed by Spinosad 45% SC (56.32) and (1:2.97), Emamectin benzoate 5% SG (49.3) and (1:2.45). Mohanty, S., & R Tayde, A. (2022) [22]. Calculated the benefit-cost ratios of the treatments stand like the best and most economical treatment Spinosad (1:3.75) followed by Emamectin benzoate (1:3.71).

Conclusion

Overall, Spinosad consistently outperformed other bio-pesticides in controlling *Aphis craccivora* populations, highest effectiveness in reducing larval populations (*H.*

armigera) and Spinosad consistently reduced pod damage by (*E. zinckenella*), followed by Emamectin benzoate. The highest yield during the Rabi season of 2022-23 was recorded in T_7 (Spinosad), with a yield of 20.71 q/ha, followed by T_4 (Emamectin benzoate) at 19.02 q/ha, and T_5 (Azadirachtin) at 16.86 q/ha. Similarly, in Rabi 2023-24, T_7 (Spinosad) again led with the highest yield of 21.71 q/ha, followed by T_4 (Emamectin benzoate) at 20.36 q/ha, and T_5 (Azadirachtin) at 17.19 q/ha. Regarding the benefit-cost ratio, Spinosad recorded the highest at 1:33.98 in Rabi 2022-23, followed by Azadirachtin (1:24.42) and Emamectin benzoate (1:23.33). In Rabi 2023-24, Spinosad further improved to a ratio of 1:39.01, with Azadirachtin at 1:27.40 and Emamectin benzoate at 1:27.26.

References

1. Anonymous, 2024 ICAR – IIPR https://iipr.icar.gov.in/lentil/
2. Bahl PN, Lal S, Sharma BM. An overview of the production and problems in Southeast Asia. In: Erskine W, Saxena MC, editors. Lentil in South Asia. Proceedings of seminar on lentils in South Asia. ICARDA; c1993. p. 1-10.
3. Gaje S, Prasad CS, Anil S, Nawab A, Dhaka SS, Arvind K. Evaluation of bio-pesticides and neem formulations against pod borer in lentil. Environ Ecol. 2010;28(1B):661-3.
4. Golvankar G, Narangalkar A, Desai V, Salvi B, Dhekale J. Efficacy of different insecticides against lablab bean aphid, Aphis craccivora Koch. J Entomol Zool Stud. 2019;7:1152-1158.
5. Haddi K, Turchen LM, Viteri Jumbo LO, Guedes RN, Pereira EJ, Aguiar RW, Oliveira EE. Rethinking biorational insecticides for pest management: unintended effects and consequences. Pest Manag Sci. 2020;76(7):2286-2293.
6. Hariri G. Insect and other pests. In: Webs C, Hawtin G, editors. Lentils. Commonwealth Agricultural Bureau; c1981. p. 173-89.
7. Hopkins D. Etiella moth (Lucerne seed web moth) [Internet]; c2003. Available from: http://www.pir.sa.gov.au/factsheets
8. Kishor DR, Prasad R, Moses S, Singh PP. Population dynamics of aphid and pod borer on lentil and their natural enemies during Rabi Season 2017 at Pusa, Samastipur. Curr J Appl Sci Technol. 2019;32(2):1-6.
9. Kumar G, Yadav SK. Population dynamics of major insect pests of lentil. J Entomol Zool Stud. 2018;6:1274-1276.
10. Kumar GVS, Sarada O. Field efficacy and economics of some new insecticide molecules against Lepidopteran caterpillars in chickpea. Curr Biotica. 2015;9(2):153-158.
11. Lal SS. Insect pest of lentil and their management: review. Agri Rev. 1992;13:225-232.
12. Mohanty S, Tayde AR. Comparative efficacy of certain insecticides and biopesticides against chickpea pod borer, *Helicoverpa armigera* (Hubner) on chickpea, *Cicer arietinum* (L.). Int J Plant Soil Sci. 2022;34(22):734-740.
13. Pradhan S. Insect pests of crops. New Delhi: National Book Trust; c1969. p. 80.
14. Rashmi KM, Gowda KM, Tambat B, Kumar NU, Vijayakumar L. The bioefficacy of selected insecticides against field bean (*Lablab purpureus*) pod borer complex. Int J Curr Microbiol App Sci. 2020;9(6):3906-23.
15. Singh H, Dhooria MS. Bionomics of the pea pod borer, Etiella zinckenella Treit. Indian J Entomol. 1971;33:123-30.
16. Staneva E. Studies on the food plants to the cowpea weevil, Callosobruchus maculatus F. (Coleoptera: Bruchidae). Rev Zashchita. 1982;19:111-9.
17. Sarnaik SV, Chiranjeevi B. Bioefficacy of newer insecticides against gram pod borer, *Helicoverpa armigera* (Hubner) on chickpea. An Int Quart J Life Sci. 2017;12(1):65-9.
18. Sultana S, Uddin MM, Islam KS. Damage assessment of bean aphid, Aphis craccivora Koch and its biorational management. J Bangladesh Agric Univ. 2020;18(1):795-804.
19. Surykant AS, Tayde AR. Comparative efficacy of selected botanicals and chemical insecticide against pea pod borer *Etiella zinkenella* (Tr.) in pea at trance region of Yamuna, Prayagraj. Int J Adv Biochem Res. 2024;SP-8(8):5-8.
20. Thakur BS, Verma R, Patitunda A, Rawat RR. Chemical control of aphid, Aphis craccivora Koch on lentil. Indian J Entomol. 1984;46:103-105.