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Research Article

Efficacy of different biopesticides against *Chrysodeixis acuta* (Walker) and *Spodoptera litura* (Fabricius) of soybean at field conditions

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ABSTRACT: The field experiment on the efficacy of different biopesticides against green semilooper *Chrysodeixis acuta* (Walker) and tobacco leaf eating caterpillar *Spodoptera litura* of soybean was conducted in PG research farm, Department of Entomology, Post Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India during *kharif* 2022. The treatments are *Metarhizium rileyi* 1.15 % WP @ 5.0 g/L, *Metarhizium anisopliae* 1.15% WP @ 5.0 g/L, *Beauveria bassiana* 1.15% WP @ 5.0 g/L, *Sl*NPV 250 LE @ 1.0 ml/L, Azadirachtin 10000 ppm @ 2.0 ml/L, indoxacarb 15.80% EC @ 0.7 ml/L, *Bacillus thuringiensis* var. *kurstaki* @ 2.0 g/L and untreated control for comparison. Indoxacarb 15.80% EC @ 0.7 ml/L was used as a standard check. Results revealed that *Bacillus thuringiensis* var. *kurstaki* @ 2.0 g/L was found significantly superior over the rest of the treatments, except for indoxacarb (chemical check). *Beauveria bassiana* 1.15% WP @ 5.0 g/L was found to be the next best treatment against *C. acuta,* and it was at par with azadirachtin 10000 ppm @ 2.0 ml/L. However, the treatment with *Metarhizium rileyi* 1.15% WP @ 5.0 g/L was found promising over the rest of the biopesticides, and it was at par with *Sl*NPV 250 LE @ 1.0 ml/L in controlling against *S. litura* in the field. The highest grain yield of soybean was obtained from the treatment with indoxacarb 15.80% EC @ 0.7 ml/L (21.87 q/ha), followed by *Bacillus thuringiensis* var. *kurstaki* @ 2.0 g/L (20.93q/ha). Amongst the remaining biopesticides, the treatment with *Metarhizium rileyi* 1.15% WP @ 5.0 g/L gave the highest grain yield of 19.20 q/ha, and it was at par with *Beauveria bassiana* 1.15% WP @ 5.0 g/L with a yield of 18.90 q/ha. However, the highest Incremental Cost Benefit Ratio (ICBR) was recorded with in treatment with *Metarhizium rileyi* 1.15 WP @ 5.0 g/L (1:12.09), followed by *Beauveria bassiana* 1.15% WP @ 5.0g/L (1:11.56) due to the low cost of biopesticides.

KEYWORDS: Biopesticides, efficacy, field condition, ICBR, soybean

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INTRODUCTION

Soybean (*Glycine max* Linnaeus), often acclaimed as the "wonder crop" of the 21st century, is one of the most important oilseed crops worldwide. In India, it plays a pivotal role in the oilseed and edible oil sector, contributing significantly to reducing the nation's dependence on imported edible oils and providing essential raw materials to various agro-based industries. According to IISR (2023), India recorded a remarkable production of 14.9 million tonnes of soybeans in 2022. The country ranks fourth globally in terms of area, covering 11.34 million hectares, which accounts for about 9.41 per cent of the world's total soybean cultivation area, and fifth in production, with 11.22 million tonnes (Anonymous, 2022). Among Indian states, Madhya Pradesh occupies the largest area under soybean cultivation, followed by Maharashtra, Rajasthan, Karnataka, Gujarat, and Telangana. Belonging to the family Leguminosae, soybean is valued for its rich composition of oil (approximately 20%) and protein (around 40%), making it an indispensable crop for both human nutrition and livestock feed (Bhamare *et al.*, 2020a; Bankar *et al.*, 2025).

However, soybean productivity is often constrained by insect pest infestations, with around 380 pest species reported to attack the crop globally, of which about 20 cause substantial economic damage throughout the crop cycle. Key insect pests include the stem fly (*Melanagromyza sojae* Zehnter), green semilooper (*Chrysodeixis acuta* Walker), tobacco caterpillar (*Spodoptera litura* Fabricius), girdle beetle (*Obereopsis brevis* Swed.), Bihar hairy caterpillar

(*Spilarctia obliqua* Walker) and whitefly (*Bemisia tabaci* Gennadius) (Bhamare *et al.*, 2020c). Among these, *C. acuta* can inflict yield losses of up to 50 per cent by feeding on tender leaves, flowers, and developing pods, and is known to infest several crops such as soybean, groundnut and cotton (Laute *et al.*, 2015). Likewise, *S. litura* has become one of the most destructive defoliators of soybean, with its larvae capable of completely defoliating plants and damaging flowers and pods, leading to considerable yield reductions (Bapatla *et al.*, 2018; Bhamare *et al.*, 2020b; Aghav *et al.*, 2026).

To mitigate these pest problems, sustainable pest management approaches are gaining importance. Over-dependence on chemical insecticides has resulted in several ecological issues, including pest resistance, resurgence and adverse effects on non-target organisms. Consequently, biological control strategies, particularly those employing entomopathogens and other microbial agents, are being explored as effective and eco-friendly alternatives. Microbial biopesticides are known for their host specificity, safety to beneficial organisms, environmental compatibility and suitability for integration into Integrated Pest Management (IPM) programs. Therefore, the present study was undertaken to assess the efficacy of different biopesticides against major insect pests of soybean, with the objective of promoting sustainable and environmentally sound pest management practices.

MATERIALS AND METHODS

The field experiment on the efficacy of different biopesticides against *C. acuta* and *S. litura* of soybean was conducted at PG Research farm, Department of Entomology, MPKV, Rahuri, during *kharif* 2022 to study the field efficacy of different biopesticides against major pests of soybean. The variety KDS 726 (Phule Sangam) was sown at a spacing of 45 cm between rows and 10 cm between plants in 4.05 m x 3.70 m plots. The crop was raised by following all the recommended agronomic practices except insecticide applications (Anonymous, 2025). The experiment was laid out in a Randomised Block Design (RBD) with eight treatments and three replications. Different biopesticides, along with a chemical insecticide as a standard check, were applied at fifteen-day intervals by means of spraying. The experiment included eight treatments, *viz., Metarhizium rileyi* 1.15% WP @ 5.0 g/L, *Metarhizium anisopliae* 1.15% WP @ 5.0 g/L, *Beauveria bassiana* 1.15% WP @ 5.0 g/L, *Sl*NPV 250 LE @ 1.0 ml, Azadirachtin 10000 ppm @ 2.0 ml/L, Indoxacarb 15.80 EC @ 0.7 ml/L, *Bacillus thuringiensis* var. *kurstaki* @ 2.0 g/L and an untreated control for comparison against *C. acuta* and *S. litura.* The treatments, *viz.,* indoxacarb 15.80% EC @ 0.7 ml/L, were taken as a standard chemical check.

Observations to be recorded

Observations on larval population were recorded in a one-meter row of soybean plants at 5 randomly selected spots in each treatment plot, leaving the border rows. Pre-count was taken one day before the first spray, and post-counts at 7 and 14 days after each spray. The post-treatment observations were taken after 14 days was considered as pre- count for the second application. The yield (kg/plot) obtained from individual treatment plots was registered separately for assessing the effect of different treatments on yield. The data on yield (kg/plot) was converted into q/ha. Thus, ICBR was worked out.

Statistical analysis

The experimental data were analysed statistically by applying Randomised Block Design (RBD), and the results obtained from field observations were analysed statistically as per Panse and Sukhatme (1985) for Randomised Block Design (RBD). The significance of treatments was assessed by determining the Critical Difference (C.D.) at a 5 per cent level of significance**.**

RESULTS AND DISCUSSION

Efficacy of different biopesticides against *C. acuta* on soybean after the first spray

Data on the efficacy of different biopesticides against *C. acuta* on soybean after the first and second spray are presented in Table 1 and Figure 1A. Pre-count observations recorded a day before the first spray were non-significant, which indicated that there was uniform incidence of 7.40 to 8.80 larvae/m row length in experimental plots of *C. acuta* on soybean.

At 7 days after the first spray, the larval population of *C. acuta* was varied from 4.20 to 8.00 larvae/m row length. Results showed that treatment with indoxacarb 15.80% EC @ 0.7 ml/L recorded a minimum of 4.20 larvae/ m row length, which was followed by the treatment with *Beauveria bassiana* 1.15 % WP @ 5 g/L and *Bt* var *Kurstaki* @ 2.0 g/L with 4.40 and 4.53 larvae/m row length, respectively, and those were at par with each other. Next best treatment was azadirachtin 10000 ppm @ 2.0 ml/L with 5.47 larvae/m row length. However, the untreated control recorded the maximum number of larval infestation (8.00 larvae / m row length).

Table 1. Field efficacy of different biopesticides against *C. acuta* on soybean after first and second spray

T. No.	Treatment	Dose (g or ml/L)	No. of larvae/m row length							
			First spray			Second spray		Pooled mean of 1st and 2nd spray		
			Pre count	7 DAS**	14 DAS	7 DAS	14 DAS	7 DAS	14 DAS	Mean
T1	*Metarhizium rileyi* 1.15 % WP	5.0 g	7.40 (2.81)*	6.47 (2.64)	7.00 (2.74)	5.13 (2.37)	4.87 (2.31)	5.80 (2.51)	5.93 (2.54)	5.87 (2.52)
T2	*Metarhizium anisopliae* 1.15 % WP	5.0 g	8.80 (3.05)	6.40 (2.63)	6.80 (2.70)	4.93 (2.33)	4.07 (2.14)	5.67 (2.48)	5.43 (2.44)	5.55 (2.46)
T3	*Beauveria bassiana* 1.15 % WP	5.0 g	8.13 (2.94)	4.40 (2.21)	5.13 (2.37)	3.53 (2.01)	1.13 (1.28)	4.00 (2.12)	3.13 (1.91)	3.56 (2.01)
T4	*Sl*NPV 250 LE	1.0 ml	8.20 (2.95)	6.53 (2.65)	6.93 (2.73)	5.47 (2.44)	5.13 (2.37)	6.00 (2.55)	6.03 (2.56)	6.02 (2.55)
T5	Azadirachtin 10000 ppm	2.0 ml	8.40 (2.98)	5.47 (2.44)	5.20 (2.39)	3.60 (2.02)	1.27 (1.33)	4.50 (2.24)	3.23 (1.93)	3.86 (2.08)
T6	Indoxacarb 15.80 % EC	0.7 ml	8.53 (3.01)	4.20 (2.17)	3.87 (2.09)	1.93 (1.58)	0.47 (0.98)	3.06 (1.89)	2.17 (1.63)	2.62 (1.76)
T7	*Bacillus thuringiensis* var. *kurstaki*	2.0 g	7.87 (2.89)	4.53 (2.24)	4.06 (2.13)	2.33 (1.68)	0.60 (1.05)	3.43 (1.98)	2.33 (1.68)	2.88 (1.83)
T8	Untreated control	-	7.80 (2.88)	8.00 (2.91)	9.33 (3.14)	9.86 (3.22)	8.87 (3.06)	8.93 (3.07)	9.10 (3.10)	9.02 (3.08)
SE(m) ±			0.27	0.04	0.06	0.09	0.09	0.06	0.07	0.07
C. D at 5%			N.S.	0.12	0.20	0.27	0.29	0.18	0.22	0.21

*Figures in the parentheses are √(x+0.5) transformations **DAS- Days after spraying

At 14 days after the first spray, standard check Indoxacarb 15.80 % EC @ 0.7 ml/L as well as *Bt* var *kurstaki* @ 2.0 g/L were found most promising treatments with minimum larval population of 3.87 and 4.06 larvae/m row length, respectively. Amongst the remaining biopesticides, the treatment with *B. bassiana* 1.15 % WP @ 5.0 g/L was found promising treatment with 5.13 larvae/m row length, which was followed by the treatment with azadirachtin 10000 ppm @ 2 ml/ L with 5.20 larvae/m row length and was on par with each other. Moreover, the untreated control recorded the highest larval population of 9.33 larvae/ m row length.

Efficacy of different biopesticides against *C. acuta* on soybean after the second spray

At 7 days after the second spray, the larval population of *C. acuta* varied from 1.93 to 9.86 larvae/m row length (Table 1 and Figure 1A). From the results, take the standard check indoxacarb 15. 80 % EC @ 0.7 ml/L was proved to be the most effective treatment with the least larval population of 1.93 larvae/m row length, and it was at par with *Bt* var. *kurstaki* @ 2.0 g/L (2.33 larvae/m row length). However, amongst the remaining biopesticides under study, the treatment with *B. bassiana* 1.15 % WP @ 5.0 g/L was found superior with 3.53 larvae/ m row length, and it was

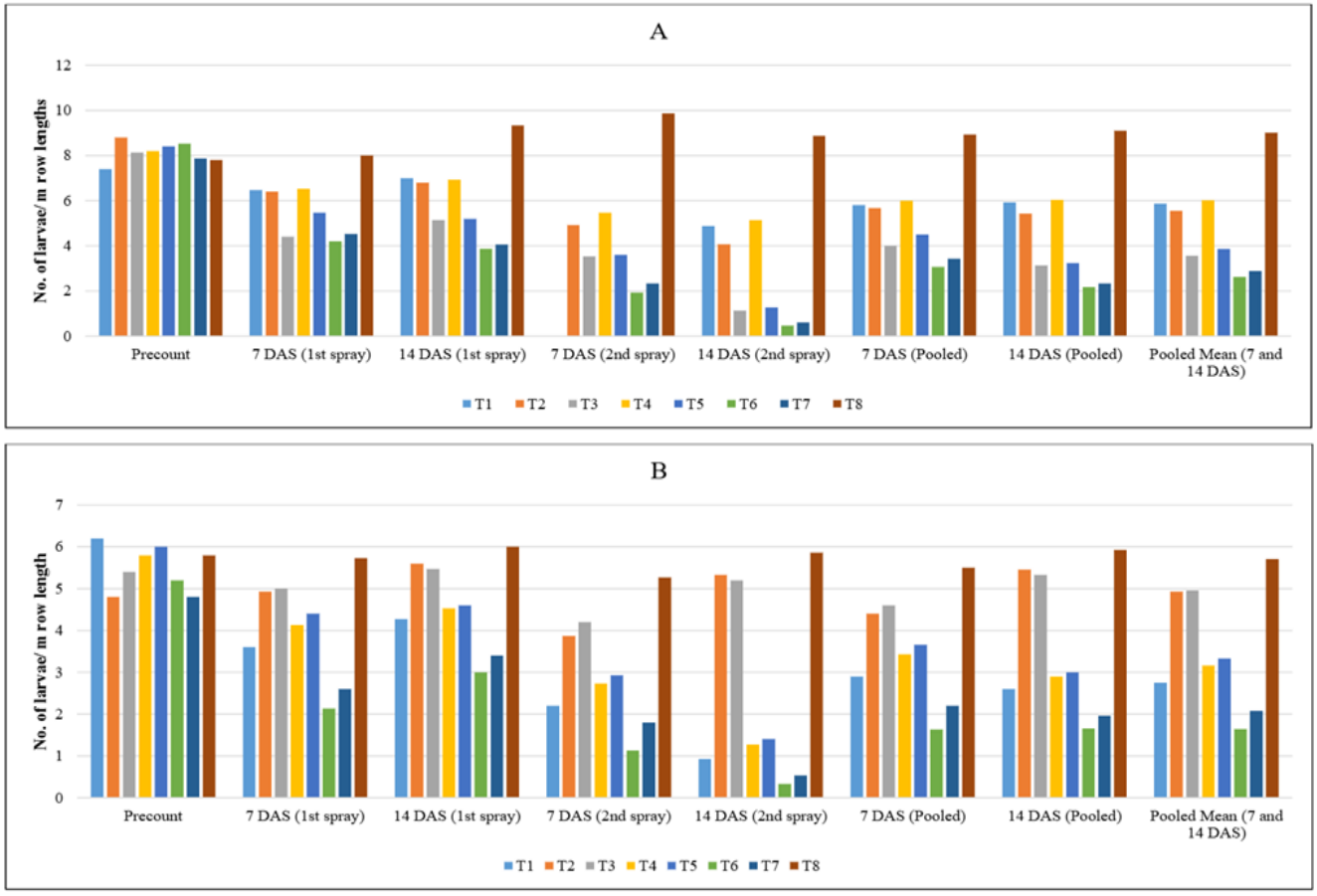


Figure 1. (A). Field efficacy of different biopesticides against *C. acuta* on soybean after first and second spray. **(B).** Field efficacy of different biopesticides against *S. litura* on soybean after first and second spray.

followed by the treatment with azadirachtin 10000 ppm @ 2.0 ml/L with 3.60 larvae/m row length. The untreated control recorded a maximum of 9.86 larvae/m row length.

At 14 days after the second spray, it was observed that the *C. acuta* larval population ranged from 0.47 to 8.87 larvae/m row length. All the treatments were significantly superior to the untreated control, and the chemical insecticide indoxacarb 15.80% EC @ 0.7 ml/L recorded the least larval population of *C. acuta* (0.47 larvae/m row length). It was at par with *Bt* var. *kurstaki* @ 2.0 g/L (0.60 larvae/m row length).

On the other hand, amongst the remaining biopesticides, the treatment *Beauveria bassiana* 1.15% @ 5.0 g/L WP was found most promising one with a minimum of 1.13 larvae/m row length. However, it was followed by the treatment Azadirachtin 10000 ppm @ 2.0 ml/L with 1.27 larvae/m row length, and both treatments were at par with each other. The untreated control recorded the maximum number of larval population (8.87 larvae/m row length).

Pooled mean of the first and second spray

The data on the pooled mean number of *C. acuta* larvae/m row length at 7 days after spray revealed that larval population varied from 3.06 to 8.93 larvae/m row length (Table 1 and Figure 1A). From the results, it was noticed that all the treatments were found significantly superior over the untreated control in reducing *C. acuta* larval population. However, being a chemical insecticide, the treatment with indoxacarb 15.80% EC @ 0.7 ml/L proved most effective with the least larval population of *C. acuta* (3.06 larvae/m row length). It was followed by *Bt* var. *kurstaki* @ 2.0 g/L, with 3.43 larvae/ m row length being on par with indoxacarb 15.80 EC. Amongst the remaining biopesticides, the treatment with *B. bassiana* 1.15 WP @ 5.0 g/L was found

promising treatment with 4.00 larvae/m row length, and it was followed by the treatment with azadirachtin 10000 ppm (4.50 larvae/m row length), which were at par with each other. However, the untreated control recorded the highest mean larval population (8.93 larvae/m row length).

At 14 days after spray, it was observed that the pooled mean larval population of *C. acuta* ranged from 2.17 to 9.10 larvae/m row length. From the results, it revealed that, being a chemical insecticide, the treatment Indoxacarb 15.80 % EC 0.7 ml/L followed by *Btk* var. *kurstaki* @ 2.0 g/L with minimum larval population of 2.17 and 2.33 larvae/ m row length, respectively, and both were at par with each other. Amongst the remaining biopesticides, the treatment *Beauveria bassiana* 1.15 % WP @ 5.0 g/L was found to be the most promising one with 3.13 larvae/m row length, and it was followed by the treatment Azadirachtin 10,000 ppm @ 2.0 ml/L with 3.23 larvae/ m row length, which were on par with each other. However, the untreated control recorded the maximum population of *C. acuta* (9.10 larvae/m row length).

From the data on pooled mean efficacy of different biopesticides against *C. acuta* on soybean at 7 and 14 days after sowing was observed that, being a chemical insecticide indoxacarb 15.80 % EC @ 0.7 ml/L proved most effective treatment with minimum number of *C. acuta* larvae (2.62 larvae/m row length) and it was followed by *Bt* var. *kurstaki* @ 2.0 g/L (2.88 larvae/ m row length) and being on par with each other. However, amongst the remaining biopesticides under study, the treatment with *Beauveria bassiana* 1.15 % WP @ 5.0 g/L was found to be the most promising one with 3.56 larvae/m row length, and it was followed by the treatment with azadirachtin 10000 ppm @ 2.0 ml/L with 3.86 larvae / m row length, which were on par with each other. The untreated control recorded the highest mean larval population (9.02 larvae/m row length).

Results of the present findings are in line with Ahirwar *et al.* (2013), who reported that *B. bassiana* @ 5.0 g/L was most effective against *C. acuta*. Patil *et al.* (2014) reported that *B. bassiana* @ 5×10^9 spores/L was most effective against foliage feeder larval pests. Bochare *et al.* (2018) reported that *B. bassiana* @ 5.0 g/L was most effective in reducing the population of *C. acuta* on soybean.

Efficacy of different biopesticides against *S. litura* on soybean after the first spray

Data on the efficacy of different biopesticides against *S. litura* on soybean after the first and second spray are presented in Table 2 and Figure 1B. The pre-count observations recorded a day before the first spray were non-significant, which indicated that there was uniform incidence of *S. litura* on soybean in the experimental field.

Table 2. Field efficacy of different biopesticides against *S. litura* on soybean after first and second spray

T. No.	Treatment	Dose (g or ml/L)	No. of larvae/m row length							
			First spray			Second spray		Pooled mean of 1st and 2nd spray		
			Pre count	7 DAS**	14 DAS	7 DAS	14 DAS	7 DAS	14 DAS	Mean
T1	*Metarhizium rileyi* 1.15 % WP	5.0 g	6.20 (2.59)*	3.60 (2.02)	4.27 (2.18)	2.20 (1.63)*	0.93 (1.20)	2.90 (1.84)*	2.60 (1.76)	2.75 (1.80)
T2	*Metarhizium anisopliae* 1.15 % WP	5.0 g	4.80 (2.30)	4.93 (2.33)	5.60 (2.47)	3.87 (2.09)	5.33 (2.41)	4.40 (2.21)	5.46 (2.44)	4.93 (2.33)
T3	*Beauveria bassiana* 1.15 % WP	5.0 g	5.40 (2.43)	5.00 (2.34)	5.47 (2.44)	4.20 (2.16)	5.20 (2.39)	4.60 (2.26)	5.33 (2.41)	4.96 (2.34)
T4	*Sl*NPV 250 LE	1.0 ml	5.80 (2.51)	4.13 (2.15)	4.53 (2.24)	2.73 (1.79)	1.27 (1.33)	3.43 (1.98)	2.90 (1.84)	3.16 (1.91)
T5	Azadirachtin 10000 ppm	2.0 ml	6.00 (2.55)	4.40 (2.21)	4.60 (2.26)	2.93 (1.85)	1.40 (1.38)	3.66 (2.04)	3.00 (1.87)	3.33 (1.96)
T6	Indoxacarb 15.80 % EC	0.7 ml	5.20 (2.38)	2.13 (1.62)	3.00 (1.87)	1.13 (1.27)	0.33 (0.91)	1.63 (1.46)	1.66 (1.57)	1.64 (1.46)

Table 2. Continued

T7	*Bacillus thuringiensis* var. *kurstaki*	2.0 g	4.80 (2.30)	2.60 (1.76)	3.40 (1.97)	1.80 (1.51)	0.53 (1.01)	2.20 (1.64)	1.96 (1.57)	2.08 (1.61)
T8	Untreated control	-	5.80 (2.51)	5.73 (2.50)	6.00 (2.55)	5.27 (2.40)	5.86 (2.52)	5.50 (2.45)	5.93 (2.54)	5.71 (2.49)
SE(m) ±			0.34	0.04	0.03	0.10	0.09	0.07	0.06	0.06
C. D at 5%			N.S.	0.13	0.11	0.32	0.28	0.22	0.19	0.20

*Figures in the parentheses are √(x+0.5) transformations **DAS- Days after spraying

At 7 days after the first spray, it seems that the larval population of *S. litura* varied from 2.13 to 5.73 larvae/m row length. From the results, it was noticed that the treatment indoxacarb 15.80% EC @ 0.7 ml/L recorded a minimum of 2.13 larvae/m row length, which was followed by the treatment with *Bt* var *kurstaki* @ 2.0g/L and *Metarhizium rileyi* 1.15% WP with 2.60 and 3.60 larvae/m row length, respectively. Next best treatment was *Sl*NPV 250 LE @ 1.0 ml/L with 4.13 larvae/m row length. However, the untreated control recorded the maximum larval population (5.73 larvae/m row length).

At 14 days after the first spray, the standard check of chemical insecticide indoxacarb 15.80 EC @ 0.7 ml/L was found most promising treatment with a minimum larval population of 3.00 larvae/m row length. It was followed by *Bt* var *kurstaki* @ 2.0g/L with 3.40 larvae/m row length. Amongst remaining biopesticides, the treatment with *Metarhizium rileyi* 1.15% WP @ 5 g/L was found promising treatment with 4.27 larvae/m row length, which was followed by the treatment with *Sl*NPV 250 LE @ 1.0 ml/ L with 4.53 larvae/m row length and were at par with each other. Moreover, the untreated control recorded the highest larval population of *S. litura* (6.00 larvae/m row length).

Efficacy of different biopesticides against *S. litura* on soybean after the second spray

It is seen that *S. litura* larval population varied from 1.13 to 5.27 larvae/m row length at 7 days after the second spray (Table 2 and Figure 1B). The standard check indoxacarb 15. 80 EC @ 0.7 ml/L was proved to be the most effective treatment with the least larval population of 1.13 larvae/m row length, followed by *Bt* var *kurstaki* @ 2.0g/L with 1.80 larvae/m row length, which are on par with each other. However, amongst the remaining biopesticides *Metarhizium rileyi* 1.15% WP @ 5.0 g/L was found superior with 2.20 larvae/m row length, and it was followed by the treatment with *Sl*NPV 250 LE @ 1.0 ml/L with 2.73 larvae/m row length. Whereas the untreated control recorded a maximum of 5.27 larvae/ m row length.

At 14 days after the second spray, it was observed that the *S. litura* larval population ranged from 0.33 to 5.86 larvae/m row length. All the treatments were significantly superior to the untreated control. The standard check indoxacarb 15.80 EC @ 0.7 ml/L recorded the least larval population of *S. litura* 0.33 larvae/m row length, and it was followed by *Bt* var *kurstaki* @ 2.0g/L with 0.53 larvae/m row length being on par with each other. On the other hand, amongst the remaining biopesticides, the treatment *Metarhizium rileyi* 1.15 % WP @ 5.0 g/L was found promising, with a minimum of 0.93 larvae/m row length. However, it was followed by the treatment *Sl*NPV 250 LE @ 1.0 ml/L with 1.27 larvae/ m row length, and those were on par with each other. The untreated control recorded the maximum number of larval population (5.86 larvae/m row length).

Pooled mean of the first and second spray

Data on the pooled mean efficacy of different biopesticides against *S. litura* on soybean are presented in Table 2 and Figure 1B.

The data on the pooled mean number of *S. litura* larvae/m row length at 7 days after spray revealed that larval population varied from 1.63 to 5.50 larvae/m row length. From the results, it was noticed that all the treatments were found significantly superior to the untreated control in reducing larval population. However, being a chemical insecticide, the treatment with indoxacarb 15.80% EC @ 0.7 ml/L proved most effective with the least larval population (1.63 larvae/m row length). It was followed by

Bt var *kurstaki* @ 2.0g/L with 2.20 larvae/m row length, which was at par with indoxacarb. Amongst the remaining biopesticides, the treatment with *Metarhizium rileyi* 1.15% WP @ 5.0 g/L was found to be a promising one with 2.90 larvae/m row length, and it was followed by the treatment with *Sl*NPV 250 LE @ 1.0 ml/L (3.43 larvae/m row length), which were on par with each other. However, the untreated control recorded the highest mean larval population of 5.50 larvae/m row length.

At 14 days after spray, the pooled mean larval population of *S. litura* ranged from 1.66 to 5.93 larvae/m row length. The results revealed that being a chemical insecticide treatment, Indoxacarb 15.80% EC @ 0.7 ml/L, was the most effective treatment with minimum larval population (1.66 larvae/m row length). However, the treatment with *Bt* var *kurstaki* @ 2.0g/L recorded 1.96 larvae/m row length, and it was at par with indoxacarb. Amongst the remaining biopesticides the treatment *Metarhizium rileyi* 1.15% WP @ 5 g/L was found to be the remaining promising treatment with 2.60 larvae/m row length, and it was followed by treatment *Sl*NPV 250 LE @ 1.0 ml/L, with 2.90 larvae/m row length, which were on par with each other. However, the untreated control recorded the maximum number of larvae (5.93 larvae/m row length).

Furthermore, it was observed that chemical check insecticide treatment, indoxacarb 15.80% EC @ 0.7 ml/L found most effective one with a minimum number of *S. litura* population of 1.64 larvae/m row length. It was, however, at par with *Bt* var *kurstaki* @ 2.0g/L which recorded 2.08 larvae/ m row length. Amongst the remaining biopesticides under study, the treatment with *Metarhizium rileyi* 1.15% WP @ 5.0 g/L was found promising, with 2.75 larvae/m row length, and it was followed by the *Sl*NPV 250 LE @ 1.0 ml with 3.16 larvae/m row length. On the other hand, the untreated control registered the maximum mean larval population of *S. litura* (5.71 larvae/ m row length).

Results of the present investigation are in line with Barros *et al.* (2021). Kulkarni and Lingappa (2002) reported the efficacy of *N. rileyi* 5.0 g/L against *S. litura* on soybean. Jadhav *et al.* (2023) reported that microbial agent *N. rileyi* 5.0 g/L significantly recorded the lowest *S. litura* larval population 0.58 larvae/m row length after the second spray and noticed superior over all the treatments.

Effect of different biopesticides on the yield of soybean

The maximum yield (21.87 q/ha) was obtained from the treatment with indoxacarb 15.80 EC @ 0.7 ml/L, which was used as a standard check followed by *Bt* var. *kurstaki* @ 2.0 g/L (20.93 q/ha). Other treatments gave yield as *M. rileyi* @ 1.15 WP @ 5.0 g/L (19.20 q/ha), *B. bassiana* 1.15 WP @ 5.0 g/L (18.90 q/ha), *Sl*NPV 250 LE @ 1.0 ml/L (18.50 q/ha) and azadirachtin 10000 ppm @ 2.0 ml/L (17.80 q/ha). Whereas, *M. anisopliae* 1.15 WP @ 5.0 g/L gave comparatively less yield (14.53 q/ha) (Table 3).

Table 3. Economics of different biopesticides for control of *C. acuta* and *S. litura* on soybean

T. No.	Treatment	Yield (q/ ha)	Increase in yield over control (q/ha)	Additional income over control (Rs./ha)	Cost of plant protection (Rs./ha)	Net profit (Rs./ha)	ICBR
T1	*Metarhizium rileyi* 1.15 % WP	19.20	7.40	34040	2600	31440	1:12.09
T2	*Metarhizium anisopliae* 1.15% WP	14.53	2.73	12558	2600	9958	1:03.83
T3	*Beauveria bassiana* 1.15 % WP	18.90	7.10	32660	2600	30060	1:11.56
T4	*Sl*NPV 250 LE	18.50	6.70	30820	3200	27620	1:08.63
T5	Azadirachtin 10000 ppm	17.80	6.00	27600	5920	21680	1:03.66
T6	Indoxacarb 15.80 % EC	21.87	10.07	46322	3980	42342	1:10.63
T7	*Bt* var. *Kurstaki*	20.93	9.13	41998	5440	36518	1:06.71
T8	Untreated control	11.80	-	-	-	-	-

Incremental cost-benefit ratio of different treatments

As regards the (Table 3), the highest ICBR value of 1:12.09 was recorded in the treatment with *M. rileyi* 1.15 WP @ 5.0 g/L, followed by *B. bassiana* 1.15 WP @ 5.0 g/L (1:11.56) and indoxacarb 15.80 EC @ 0.7 ml/L (1:10.63). Next effective treatments in this respect were *Sl*NPV 250 LE @ 1.0 m/L (1:8.63) and *Bt* var. *kurstaki* @ 2.0 g/L (1:6.71). The lower ICBR values were obtained from the treatment azadirachtin 10000 ppm @ 2.0 ml/L (1:3.66) and *M. anisopliae* 1.15 WP @ 5.0 g/L (1:3.83). Being a chemical insecticide, indoxacarb 15.80 EC @ 0.7 ml/L emerged as most effective against *C. acuta* and *S. litura.* However, amongst the different biopesticides, *M. rileyi* 1.15 WP @ 5.0 g/L proved to be most effective.

CONCLUSION

From the results, it was revealed that *Beauveria bassiana* 1.15% WP @ 5.0 g/L was significantly superior against *C. acuta,* and it was at par with azadirachtin 10000 ppm @ 2.0 ml/L under field conditions. *Metarhizium rileyi* 1.15% WP @ 5.0 g/L was found to be significantly superior against *S. litura,* and it was at par with *Sl*NPV 250 LE @ 1.0 m/L under the field conditions. The highest grain yield was obtained from the treatment with indoxacarb 15.80 EC @ 0.7 ml/L, followed by *Bt* var. *kurstaki* @ 2.0 g/L. Amongst the remaining biopesticides, the treatment with *Metarhizium rileyi* 1.15% WP @ 5.0 g/L recorded the highest grain yield of 19.20 q/ha, and it was at par with *Beauveria bassiana* 1.15% WP @ 5.0 g/L with 18.90 q/ha. The highest ICBR was recorded in treatment with *Metarhizium rileyi* 1.15% WP (1:12.09), followed by *Beauveria bassiana* 1.15% WP (1:11.56) and indoxacarb 15.80 EC (1:10.63).

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REFERENCES

Aghav, S. T., Kharbade, S. B., Kadam, U. K. Sonawane, S. T., Bankar, D. R., Gund, M. S., and Tamnar, S. S. 2026. Influence of abiotic factors on stem fly, (*Melanagromyza sojae* Zehntner) infestation in soybean (*Glycine max* L. Merrill). *Inter J Adv Biochem Res,* **10**(2): 698-701. https://www.doi.org/10.33545/26174693.2026.v10.i2i.7703

Ahirwar, K. C., Marabi, R. S., Bhowmik, and Das. 2013. Evaluation of microbial pesticides against major foliage feeders on soybean, *Glycine max* (L.) Merill. *J Biopest,* **6**(2):144-148. https://doi.org/10.57182/jbiopestic.6.2.144-148

Anonymous, 2022. Soybean outlook - January 2022. Agricultural Market Intelligence Centre, PJTSAU.

Anonymous, 2025. Krishi Darshani, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India. MPKV Extension Publication no 2762, pp. 1-548.

Bankar, D. R., Aghav, S. T., Kharbade, S. B., and Patil, V. V. 2025. Efficacy of different biopesticides against *Chrysodeixis acuta* (Walker) and *Spodoptera litura* (Fabricius) under laboratory conditions. *J Bio Con,* **39**(2), 204-209. https://doi.org/10.18311/jbc/2025/48495

Bapatla, K. G., Patil, R. H., and Yeddula, S. 2018. Impact of leaf damage by defoliators on yield of soybean as a sole crop and as a main crop in intercropping systems. *Inter J Pest Manag*, **64**(1): 51-58. https://doi.org/10.1080/09670874.2017.1297508

Barros, S. K. A., de Almeida, E. G., Ferreira, F. T. R., Barreto, M.R., Lopes, R. B., and Pitta, R. M. 2021. Field efficacy of *Metarhizium rileyi* applications against *Spodoptera frugiperda* (Lepidoptera: Noctuidae) in maize. *Neotrop Entomol*, **50**: 976-988. https://doi.org/10.1007/s13744-021-00903-0 PMid:34590294

Bhamare, V. K., Wahekar, G. R., Bankar, D. R., Thakre, B. A., Hajare, P. B., and Mahajan, R. S. 2020a. Bio-efficacy, persistence and residual toxicity of different insecticides against soybean pod borer *Helicoverpa armigera* (Hubner) infesting soybean. *J Entomol Zool Stud*, **8**(6): 1764-1769. https://doi.org/10.22271/j.ento.2020.v8.i6x.8073

Bhamare, V. K., Wahekar, G. R., Bankar, D. R., Hajare, P. B., Mahajan, R. S., and Thakre, B. A. 2020b. Bio-efficacy, persistence and residual toxicity of different insecticides against soybean leaf eating caterpillar *Spodoptera litura* (Fabricius) infesting soybean. *J Entomol Zool Stud*, SP-**8**(4): 103-107. https://doi.org/10.22271/j.ento.2020.v8.i4c.8153

Bhamare, V. K., Wahekar, G. R., Bankar, D. R., Mahajan, R. S., Hajare, P. B., and Thakre, B. A. 2020c. Bio-

efficacy, persistence and residual toxicity of different insecticides against girdle beetle, *Obereopsis brevis* (Swedenborg) infesting soybean. *J Entomol Zool Stud*, **8**(6): 1782-1787. https://doi.org/10.22271/j.ento.2020.v8.i6x.8079

Bochare, G. D., Undirwade, D. B., Shinde, S. S., and Dhandge, S. R. 2018. Evaluation of microbials and botanicals against defoliators of soybean. *Int J Pure App Biosci,* **6**(5): 62-67.

IISR. 2023. Annual Report 2023. ICAR-Indian Institute of Soybean Research, Indore, M. P. (India). https://doi.org/10.18782/2320-7051.6845

Jadhav, R. S., Mehtre, S. P., and Ghuge, V. R. 2023. Management of major defoliators of soybean using microbial agents. *J Oilseeds Res*, **40**(1): 215-227. https://doi.org/10.56739/jor.v40iSpecialissue.145358

Kulkarni, N. S., and Lingappa, S. 2002. Bioefficacy of entomopathogenic fungus, *Nomuraea rileyi* (Farlow) Samson on *Spodoptera litura* and *Cydia ptychora* in Soybean and on *S. litura* in Potato. *Karnataka J Agric Sci*, **15**(1): 47-55.

Laute, M. S., Patil, N. V., and Barkhade, U. P. 2015. Biology of green semilooper on soybean. *Plant Arch*, **15**(1): 603-606.

Panse, V. G., and Sukhtme, P.V. 1985. Statistical methods for agricultural workers. *Ind Coun Agri Pub*, pp. 87-89.

Patil, R. K., Bhagat, Y. S., Halappa, B., and Bhat, R. S. 2014. Evaluation of entomopathogenic fungus, *Nomuraea rileyi* (Farlow) Samson for the control of groundnut leaf eating caterpillar, *Spodoptera litura* (F.) and its compatibility with synthetic and botanical pesticides. *J Biopest,* **7**(Supp.): 106-115. https://doi.org/10.57182/jbiopestic.7.0.106-115

AUTHOR CONTRIBUTION

D. R. Bankar and S. T. Aghav conceptualised and designed the study, V.V. Patil conducted the study, analysed the data and authored the report under the supervision of S. T. Aghav, S. B. Kharbade and U. K. Kadam. Manuscript was written by D. R. Bankar, S. T. Aghav and V.V. Patil. All authors have read and agreed to the published version of the manuscript.