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Research Article

Efficacy of different biopesticides against *Chrysodeixis acuta* (Walker) and *Spodoptera litura* (Fabricius) under laboratory conditions

D. R. BANKAR, S. T. AGHAV, S. B. KHARBADE and VAISHNAVI V. PATIL*

Department of Entomology, Post Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri – 413722, Maharashtra, India

**Corresponding author E-mail:* vaishnavipatil0026@gmail.com

ABSTRACT: The laboratory experiment on the efficacy of different biopesticides against green semilooper, *Chrysodeixis acuta* (Walker) and tobacco leaf eating caterpillar, *S. litura* of soybean was conducted in PG research laboratory, Department of Entomology, Post Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India during *kharif* 2022. Different biopesticides were evaluated against 2nd and 3rd instar larvae of *C. acuta,* and *S. litura*. The larval mortality was recorded at 5, 7 and 10 Days After Treatment (DAT). The experiment included seven treatments, namely *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. Indoxacarb 15.80 % EC @ 0.7 ml/L and *Bt* var. *kurstaki* @ 2.0 g/ ml were used as standard checks and recorded the highest larval mortality over all other treatments. Amongst different biopesticides, *B. bassiana* 1.15 % WP @ 5.0 g/L was found significantly superior against 2nd and 3rd instar larvae of *C. acuta* whereas *M. rileyi* 1.15 % WP @ 5.0 g/L was the significant treatment against 2nd and 3rd instar larvae of *S. litura* under laboratory conditions.

KEYWORDS: Biopesticides, *Chrysodeixis acuta*, soybean, *Spodoptera litura*

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INTRODUCTION

Soybean (*Glycine max*), often referred to as the "wonder crop" of the 21st century, is a crucial oilseed crop globally. Soybean is a key player in India's oilseed and edible oil production, significantly helping to reduce the country's dependence on edible oil imports and supporting various industries by supplying raw materials. In 2022, India achieved a record production of 14.9 million tons of soybeans (IISR, 2023). India ranks fourth in terms of area, with 11.34 million hectares, representing 9.41% of the world's soybean cultivation area, and fifth in production, yielding 11.22 million tonnes (Anonymous, 2022). Madhya Pradesh leads Indian states with the largest area under soybean cultivation, followed by Maharashtra, Rajasthan, Karnataka, Gujarat, and Telangana. Soybean is an important member of the Leguminosae family, known for its high oil content (20%) and protein content (40%), making it a key crop for oil production, nutrition, and livestock feed (Bhamare *et al.,* 2020a).

The soybean crop faces threats from approximately 380 species of insect pests, with about 20 causing significant damage from planting to harvest. Notable pests include The pests like stem fly (*Melanagromyza sojae* Zehnter), green semilooper (*C. acuta* Walker), tobacco caterpillar (*S. litura* Fabricius), girdle beetle (*Obereopsis brevis* Swed), Bihar hairy caterpillar (*Spilarctia oblique* Walker) and whitefly (*Bemisia tabaci* Gennadius) are some of the common insect pests reported to attack the soybean crop (Bhamare *et al.,* 2020c). The green semilooper, *C. acuta,* is responsible for severe yield losses, sometimes up to 50%, by attacking undeveloped pods, flowers and leaves. This pest is found across various crops, including soybean, peanut, cotton and others (Laute *et al.,* 2015). Additionally, *S. litura* Fabricius (Lepidoptera: Noctuidae) has emerged as one of the most serious and destructive defoliating pests of soybean (Bapatla *et al.,* 2018). The larvae of *S. litura* feed on the leaves, leading to complete defoliation. In cases of heavy infestation, this pest can cause severe damage to the entire soybean crop. Additionally, the larvae also damage flowers and pods, resulting in significant yield losses (Bhamare *et al.,* 2020b). To combat these challenges, biocontrol measures, including the use of entomopathogens, are being explored as alternatives to traditional pesticides. Over-reliance on chemical insecticides has caused negative ecological effects, including pest resistance and harm to non-target organisms. In contrast, microbial pesticides offer several benefits, such as safety for natural enemies, targeted action and lower environmental impact. Their application also allows for

quicker field re-entry and is compatible with Integrated Pest Management (IPM) programs. This study aims to evaluate the effectiveness of various biopesticides in controlling major soybean pests, addressing the need for sustainable pest management practices.

MATERIALS AND METHODS

The experiment on the efficacy of different biopesticides against green semilooper *C. acuta* and tobacco leaf eating caterpillar *S. litura* of soybean was carried out in a completely randomised design with three replications under controlled laboratory conditions (Temperature at 25 ± 2°C and RH of 70 ± 10%). The soybean plot for larval rearing was grown by adopting the recommended package of practices as per MPKV, Rahuri (Anonymous, 2025), except plant protection on the research farm of the Department of Entomology, Post Graduate Institute, MPKV, Rahuri during *Kharif* 2022.

Rearing of the initial culture of *C. acuta* and *S. litura*

Initial cultures of *C. acuta* and *S. litura* were raised from egg masses collected from a soybean field at the PG farm of the Department of Entomology, MPKV, Rahuri. The eggs were kept on moist filter paper in petri dishes (9 cm dia.) for hatching. The larvae were reared in the laboratory on soybean leaves. Before feeding, leaves were washed thoroughly with distilled water containing 0.02 per cent Tween-80 and shade dried. Younger larvae were fed on fresh tender leaves, while grown up ones on mature leaves. The full-grown larvae were transferred into glass jars by putting sterile soil at the bottom for pupation. The pupae thus formed were collected and placed in an oviposition cage for adult emergence. The moths emerging from the pupae were transferred into a glass jar lined with butter paper on all sides, and paper pieces of black card were kept in an oviposition cage for egg laying. A cotton swab with a 10 per cent honey solution was served as food to the moths daily during the oviposition period. The eggs laid by moths on the paper pieces of black card sheets were placed on fresh leaves and transferred after hatching of the larvae into the circular petri plates (21 cm dia. x 7 cm ht.), which were used for multiplication of the culture (Talikoti *et al.,* 2009).

Application of biopesticides and method of recording observations

The experiment included seven treatments, *viz., M. rileyi* 1.15% WP @ 5.0 g/L, *M. anisopliae* 1.15% WP @ 5.0 g/L, *B. 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, *B. thuringiensis* var. *kurstaki* @ 2.0 g/L and an untreated control for comparison against 2nd and 3rd instar larvae of *C. acuta* and *S. litura.* The treatments, *viz.,* indoxacarb 15.80% EC @ 0.7 ml/L and *B. thuringiensis* var. *kurstaki* @ 2.0 g/L, were taken as standard checks. Ten larvae of the test insects having uniform age were taken in a glass jar along with soybean leaves as food. Recommended dose of biopesticides was taken and sprayed on 2nd and 3rd instar larvae of *C. acuta* and *S. litura* using a hand atomiser and were allowed to dry for about 15 min. Each larva was transferred into a separate plastic vial (6 x 4 cm) treated with antibiotics to avoid the growth of other micro-organisms. The moist filter paper was placed at the bottom of each vial with treated food. Fresh, untreated soybean leaves were provided to the larvae every 24 h. Each treatment consisted of 10 larvae with three replications. The treated larvae were incubated at room temperature at 25 ± 2°C and RH of 70 ± 10%. The larval mortality was recorded at 5, 7 and 10 DAT.

Statistical analysis

The mortality data were corrected by Abbott's formula (Abbott, 1925) and then by arc sin and square root transformation (Gomez & Gomez, 1984). The experimental data were then subjected to statistical analysis.

RESULTS AND DISCUSSION

Efficacy of biopesticides against the 2nd larval instar of *C. acuta*

The data on the efficacy of different biopesticides against 2nd instar larvae of *C. acuta* are presented in Table 1 and graphically depicted in Figure 1A. From the results, it revealed that larval mortality of *C. acuta* ranged from 2.40 to 100, 10.00 to 30.00 and 16.67 to 46.67 per cent at 5, 7 and 10 DAT, respectively. Indoxacarb 15.80% EC @ 0.7 ml/L and *Bt* var. *kurstaki* @ 2.0 g/ml were used as standard checks and recorded the highest larval mortality over all other treatments.

At 5 DAT, *Bt* var. *kurstaki* @ 2.0 g/L was found significantly superior over other treatments with 20 per cent larval mortality. It was followed by *B. bassiana* 1.15% WP @ 5.0 g/L with 16.67 per cent larval mortality, azadirachtin 10000 ppm @ 2.0 ml/L and *M. anisopliae* 1.15% WP @ 5.0 g/L with 13.33 and 10.00 per cent larval mortality, respectively. The treatment with *M. rileyi* 1.15% WP @ 5.0 g/L was found least effective, with 2.40 per cent larval mortality.

At 7 DAT, *Bt* var. *kurstaki* @ 2.0 g/L was found significantly superior over other treatments with 30.00 per cent larval mortality. The next best treatments were *B. bassiana* 1.15% WP @ 5.0 g/L with 26.67 per cent larval mortality, azadirachtin 10000 ppm @ 2.0 ml/L and *M. anisopliae* 1.15% WP @ 5.0 g/L with 23.33 and 20.00 per cent larval mortality, respectively. The treatment with *M. rileyi* 1.15% WP @ 5.0 g/L was found least effective, with 16.66 per cent larval mortality. A similar trend of efficacy of biopesticides was observed at 10 DAT.

Efficacy of biopesticides against the 3rd larval instar of *C. acuta*

The data pertaining to the efficacy of different biopesticides against 3rd instar larvae of *C. acuta* are presented in Table 1 and graphically illustrated in Figure 1B. From the data, it seems that larval mortality was varied from 2.83 to 100, 10.00 to 30.00 and 16.67 to 46.67 per cent at 5, 7 and 10 DAT, respectively. Indoxacarb 15.80% EC @ 0.7 ml/L and *Bt* var. *kurstaki* @ 2.0 g/ml were used as standard checks and recorded the highest larval mortality over all other treatments.

Amongst the different biopesticides, the treatment T_7 (*Bt* var. *kurstaki* @ 2.0 g/ml) was found to be a significantly superior treatment over all the treatments, with maximum larval mortality of 20.00 per cent at 5 DAT. The treatments T_3 (*B. bassiana* 1.15% WP @ 5.0 g/L), T_5 (Azadirachtin 10000 ppm @ 2.0 ml/L) and T_2 (*M. anisopliae* 1.15% WP @ 2.0 ml/L) were the next best treatments with 16.67, 13.33 and 10.00 per cent larval mortality, respectively. Moreover, the treatment T_1 (*M. rileyi* 1.15% WP @ 5.0 g/L) was proved least effective against larvae of *C. acuta* with 4.33 per cent mortality at 5 DAT.

Amongst the different biopesticides, the treatment T_7 (*Bt* var. *kurstaki* @ 2.0 g/ml) was found to be a significantly superior treatment over all the treatments, with maximum larval mortality of 30.00 per cent at 7 DAT. The treatments T_3 (*B. bassiana* 1.15% WP @ 5.0 g/L), T_5 (Azadirachtin 10000 ppm @ 2.0 ml/L) and T_2 (*M. anisopliae* 1.15% WP @ 2.0 ml/L) were the next best treatments with 26.67, 23.33 and 20.00 per cent larval mortality, respectively. Moreover, the treatment T_1 (*M. rileyi* 1.15% WP @ 5.0 g/L) was proved least effective against larvae of *C. acuta* with 16.66 per cent mortality at 7 DAT.

Amongst the different biopesticides, the treatment T_7 (*Bt* var. *kurstaki* @ 2.0 g/ml) was found to be a significantly superior treatment over all the treatments, with maximum larval mortality of 46.67 per cent at 10 DAT. The treatments T_3 (*B. bassiana* 1.15% WP @ 5.0 g/L), T_5 (Azadirachtin 10000 ppm @ 2.0 ml/L) and T_2 (*M. anisopliae* 1.15% WP @ 2.0 ml/L) were the next best treatments with 40.00, 36.67 and 30.00 per cent larval mortality, respectively. Moreover, the treatment T_1 (*M. rileyi* 1.15% WP @ 5.0 g/L) was proved least effective against larvae of *C. acuta* with 26.67 per cent mortality at 10 DAT.

Results of present findings conform with Ritu *et al.* (2022), who also reported that *B. bassiana* was highly pathogenic to first and second-instar larvae of *T. orichalcea* under laboratory conditions. From the results, it was observed that, second larval instar was more susceptible to *B. bassiana* 1.15% WP @ 5.0 g/L than the third larval instar.

Efficacy of biopesticides against the 2nd larval instar of *S. litura*

The data on the efficacy of different biopesticides against 2nd instar larvae of *S. litura* are presented in Table 2 and graphically depicted in Figure 1C. Results revealed that

Table 1. Effect of different biopesticides against 2nd and 3rd instar larvae of *C. acuta* under laboratory conditions

Tr. No.	Treatment	Dose (g or ml/L)	Larval mortality (%)					
			2nd instar			3rd instar		
			5 DAT**	7 DAT	10 DAT	5 DAT	7 DAT	10 DAT
T_1	*M. rileyi* 1.15 % WP	5.0 g	2.40 (8.91)*	16.66 (24.09)	26.67 (31.09)	4.33 (12.01)	13.33 (21.41)	16.67 (24.09)
T_2	*M. anisopliae* 1.15 % WP	5.0 g	10.00 (18.43)	20.00 (26.57)	30.00 (33.21)	5.56 (13.64)	16.67 (24.10)	20.00 (26.57)
T_3	*B. bassiana* 1.15 % WP	5.0 g	16.67 (24.10)	26.67 (31.09)	40.00 (39.23)	13.33 (21.41)	23.33 (28.88)	40.00 (39.23)
T_4	*Sl*NPV 250 LE	1.0 ml	3.46 (10.72)	10.00 (18.43)	16.67 (24.10)	2.83 (9.68)	10.00 (18.43)	16.67 (24.10)
T_5	Azadirachtin 10000 ppm	2.0 ml	13.33 (21.41)	23.33 (28.88)	36.67 (37.27)	10.00 (18.43)	20.00 (26.57)	30.00 (33.21)
T_6	Indoxacarb 15.80 % EC	0.7 ml	100.00 (90.00)	00.00 (00.00)	00.00 (00.00)	100.00 (90.00)	00.00 (00.00)	00.00 (00.00)
T_7	*B. thuringiensis* var. *kurstaki*	2.0 g	20.00 (26.57)	30.00 (33.21)	46.67 (43.09)	16.67 (24.10)	30.00 (33.21)	46.67 (43.09)
T_8	Untreated control	-	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
SE(m) ±			0.80	0.68	0.62	0.83	1.39	1.27
C.D. at 5%			2.40	2.04	1.86	2.68	4.23	3.77

*Figures in parentheses are arc sin transformed values. **DAT- Days After Treatment

Table 2. Effect of different biopesticides against 2nd and 3rd instar larvae of *S. litura* under laboratory conditions

Tr. No.	Treatment	Dose (g or ml/L)	Larval mortality (%)					
			2nd instar			3rd instar		
			5 DAT**	7 DAT	10 DAT	5 DAT	7 DAT	10 DAT
T_1	*M. rileyi* 1.15 % WP	5.0 g	13.33 (21.41)*	20.00 (26.57)	46.66 (43.08)	13.33 (21.41)	23.33 (28.88)	36.67 (37.27)
T_2	*M. anisopliae* 1.15 % WP	5.0 g	4.33 (12.01)	13.33 (21.41)	40.00 (39.23)	4.33 (12.01)	10.33 (18.75)	16.67 (24.10))
T_3	*B. bassiana* 1.15 % WP	5.0 g	3.46 (10.72)	5.56 (13.64)	20.00 (26.57)	2.83 (9.68)	5.56 (13.64)	13.33 (21.41)
T_4	*Sl*NPV 250 LE	1.0 ml	10.00 (18.43)	16.67 (24.10)	43.33 (41.17)	10.00 (18.43)	20.00 (26.57)	33.33 (35.26)
T_5	Azadirachtin 10000 ppm	2.0 ml	2.83 (9.68)	10.33 (18.75)	30.00 (33.21)	5.56 (13.64)	13.33 (21.41)	20.00 (26.57)
T_6	Indoxacarb 15.80 % EC	0.7 ml	100.00 (90.00)	0.00 (00.00)	0.00 (00.00)	100.00 (90.00)	0.00 (00.00)	0.00 (00.00)
T_7	*B. thuringiensis* var. *kurstaki*	2.0 g	23.33 (28.88)	26.67 (31.09)	50.00 (45.00)	23.33 (28.88)	30.00 (33.21)	46.67 (43.09)
T_8	Untreated control	-	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
SE(m) ±			2.29	1.37	0.61	2.36	1.42	2.39
C.D. at 5%			6.89	4.43	1.91	7.37	4.28	7.33

*Figures in parentheses are arc sin transformed values. **DAT- Days After Treatment

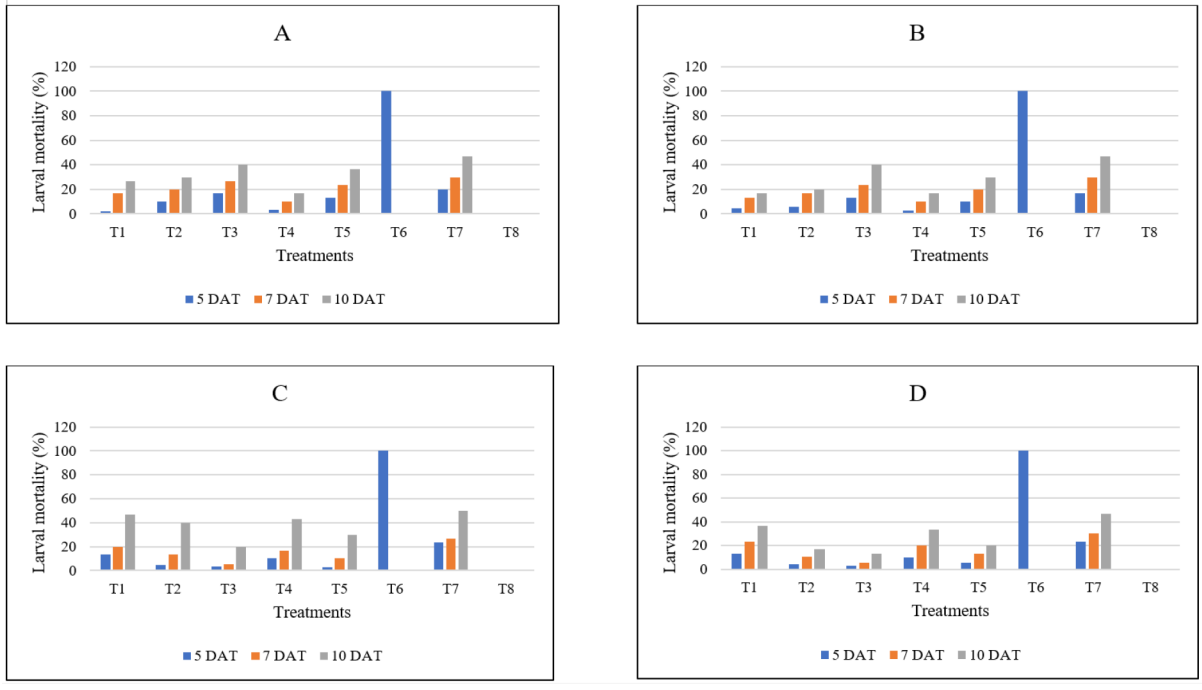


Figure 1. **(A)** Effect of different biopesticides against 2nd larval instar of *C. acuta*, **(B)** Effect of different biopesticides against 3rd larval instar of *C. acuta*, **(C)** Effect of different biopesticides against 2nd larval instar of *S. litura*, **(D)** Effect of different biopesticides against 3rd larval instar of *S. litura*.

larval mortality of *S. litura* ranged from 2.83 to 100, 5.56 to 26.67 and 20.00 to 50.00 per cent at 5, 7 and 10 DAT, respectively. Indoxacarb 15.80% EC @ 0.7 ml/L and *Bt* var. *kurstaki* @ 2.0 g/ml were used as standard checks and recorded the highest larval mortality over all other treatments.

At 5 DAT, *Bt* var. *kurstaki* @ 2.0 g/L was found significantly superior over other treatments, showing the highest larval mortality of 23.33 per cent. The next best treatments were *M. rileyi* 1.15% WP @ 5.0 g/L, *Sl*NPV 250 LE @ 1.0 ml/L, and *M. anisopliae* 1.15% WP @ 5.0 g/L with

13.33, 10.00 and 4.33 per cent larval mortality, respectively. The treatment with azadirachtin 10000 ppm @ 2.0 ml/L was found least effective with 2.83 per cent larval mortality.

At 7 DAT, *Bt* var. *kurstaki* @ 2.0 g/L was found significantly superior over other treatments, showing the highest larval mortality of 26.67 per cent. The next best treatments were *M. rileyi* 1.15% WP @ 5.0 g/L, *Sl*NPV 250 LE @ 1.0 ml/L, and *M. anisopliae* 1.15% WP @ 5.0 g/L with 20.00, 16.67 and 13.33 per cent larval mortality, respectively. The treatment with azadirachtin 10000 ppm @ 2.0 ml/L was found least effective with 10.33 per cent larval mortality. A similar trend of efficacy of biopesticides was observed at 10 DAT.

Efficacy of biopesticides against the 3rd larval instar of *S. litura*

The data pertaining to the efficacy of different biopesticides against 3rd instar larvae of *S. litura* is presented in Table 2 and graphically illustrated in Figure 1D. From the data, it was observed that larval mortality was varied from 2.83 to 100, 5.56 to 30.00 and 13.33 to 46.67 per cent at 5, 7 and 10 DAT, respectively. Indoxacarb 15.80% EC @ 0.7 ml/L and *Bt* var. *kurstaki* @ 2.0 g/ml were used as standard checks and recorded the highest larval mortality over all other treatments.

Amongst the different biopesticides, the treatment T_7 *(Bt* var. *kurstaki* @ 2.0 g/L) was found to be a significantly superior treatment over all the treatments, with maximum larval mortality of 23.33 per cent at 5 DAT. The treatments T_1 (*M. rileyi* 1.15% WP @ 5.0 g/L), T_4 (*Sl*NPV 250 LE @ 1.0 ml/L), and T_5 (Azadirachtin 10000 ppm @ 2.0 ml/L) were the next best ones with 13.33, 10.00 and 5.56 per cent larval mortality, respectively. Moreover, the treatment T_3 (*B. bassiana* 1.15% WP @ 5.0 g/L) was proved least effective against *S. litura* larvae with 2.83 per cent mortality at 5 DAT.

A similar trend of observations was recorded at 7 and 10 DAT. The treatment T_7 *(Bt* var. *kurstaki* @ 2.0 g/L) was found to be a significantly superior treatment over all the treatments, with maximum larval mortality of 30.00 per cent at 7 DAT. The treatments T_1 (*M. rileyi* 1.15% WP @ 5.0 g/L), T_4 (*Sl*NPV 250 LE @ 1.0 ml/L) and T_5 (Azadirachtin 10000 ppm @ 2.0 ml/L) were found next best ones with 23.33, 20.00 and 13.33 per cent larval mortality, respectively. Moreover, the treatment T_3 (*B. bassiana* 1.15% WP @ 5.0 g/L) was proved to be the least effective treatment against *S. litura* larvae with 5.56 per cent mortality at 7 DAT.

Amongst the different biopesticides, the treatment T_7 *(Bt* var. *kurstaki* @ 2.0 g/L) was found to be a significantly superior treatment over all the treatments, with maximum larval mortality of 46.67 per cent at 10 DAT. The treatments T_1 (*M. rileyi* 1.15% WP @ 5.0 g/L), T_4 (*Sl*NPV 250 LE @ 1.0 ml/L) and T_5 (Azadirachtin 10000 ppm @ 2.0 ml/L) were found next best ones with 36.67, 33.33 and 20.00 per cent larval mortality, respectively. Moreover, the treatment T_3 (*B. bassiana* 1.15% WP @ 5.0 g/L) was proved to be the least effective treatment against *S. litura* larvae with 13.33 per cent mortality at 10 DAT.

Results of present findings conform with Patil *et al.* (2014), who also reported that *S. litura* early instar larvae were highly susceptible, and it decreased significantly as the age of the larvae advanced. Patil and Abhilash (2014) reported that the fungus *N. rileyi* proved superior over the untreated control at a lower dosage of mycopathogen. The results of the present findings are in line with Parmar *et al.* (2007) and Surendra (2001), who also reported superiority of *M. rileyi* against *S. litura*.

CONCLUSION

The biopesticide, *B. thuringiensis* var. *kurstaki* @ 2g/ lit was found most effective against *C. acuta* as well as *S. litura* under laboratory conditions. Amongst the rest of the biopesticides, *B. bassiana* 1.15% WP @ 5.0 g/L was found significantly superior against 2nd and 3rd instar larvae of *C. acuta,* while *M. rileyi* 1.15% WP @ 5.0 g/L was found significantly superior against 2nd and 3rd instar larvae of *S. litura* under laboratory conditions.

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