

Bio-efficacy of selected botanicals, biopesticides and newer insecticides against black thrips under field condition

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Abstract

A field trial conducted at the Regional Horticulture Research and Extension Center, Bengaluru (2023-2024), evaluated the efficacy of botanicals, biopesticides and insecticides against *Thrips parvispinus* in chilli. The experiment used a randomized block design with ten treatments replicated three times. Treatments included Azadirachtin (1 ml L⁻¹), *Lecanicillium lecanii* (5 g L⁻¹), *Beauveria bassiana* (5 g L⁻¹), *Metarhizium anisopliae* (5 g L⁻¹), Diafenthiuron (1.25 g L⁻¹), Cyantraniliprole (1.8 ml L⁻¹), Spinetoram (0.2 ml L⁻¹), Broflanilide (0.2 ml L⁻¹), Thiamethoxam (0.2 g L⁻¹) and an untreated control. Four sprays were applied at seven-day intervals and thrips populations were recorded by tapping the growing tips and flowers of 10 randomly selected plants onto a white paper board and recorded the black thrips population. Leaf curl symptoms were assessed on 10 plants per treatment using a 0–4 visual rating scale. Results showed Broflanilide (0.2 ml L⁻¹) as the most effective treatment, reducing thrips by 74.02 per cent and achieving the lowest percentage leaf curl index (39.65%). *Beauveria bassiana* (5 g L⁻¹) and Cyantraniliprole (1.8 ml L⁻¹) also showed strong control, reducing thrips by 59.83 per cent and 54.85 per cent, respectively. The untreated control had the highest infestation (3.01 thrips per plant, 96.66% PLI). Broflanilide, *Beauveria bassiana* and Cyantraniliprole emerged as promising candidates for integrated pest management in chilli.

Keywords: *Thrips parvispinus*, chilli, biopesticides, botanicals, insecticides, broflanilide, *beauveria bassiana*, cyantraniliprole, pest management, leaf curl index

Introduction

Chilli (*Capsicum annum* L.) is one of the most important commercial spice and vegetable crops in India, widely recognized as a universal spice and often referred to as the “wonder spice.” India is the largest producer, consumer and exporter of dry chilli, with an estimated cultivation area of 852,000 hectares, producing 1,578,000 metric tons (MT) with a productivity of 1.90 MT per hectare during 2021-22 (Anon., 2023a). However, chilli cultivation faces several biotic challenges, particularly from insect pests. Over 35 species of insects and mites have been reported as pests of chilli, among which thrips and mites are considered major constraints in its successful production.

Scirtothrips dorsalis (Hood) has long been recognized as a key thrips species affecting chilli crops. However, in recent years, an invasive thrips species, *Thrips parvispinus* (Karny), has emerged as a serious threat, causing extensive damage to leaves, flowers and fruits. Initially reported in India on papaya from Bangalore, Karnataka (Tyagi *et al.*, 2015) [11], this species later led to severe outbreaks on chilli crops in the southern states of Andhra Pradesh, Karnataka and Telangana, with reported damage levels ranging from 50 to 80% (Anon., 2022). *Thrips parvispinus* is a polyphagous pest, attacking a wide range of horticultural crops, including chilli, papaya, coffee, sweet pepper, green beans, eggplant and cucurbits (Moritz *et al.*, 2013) [5]. The feeding activity of nymphs and adults results in deep punctures, leaf scratches and brownish streaks on flower petals, leading to drying, flower drop and reduced fruit set, which can ultimately result in yield losses exceeding 85 per cent (Prasannakumar *et al.*, 2021) [9].

Effective management of *T. parvispinus* on chilli requires integrated pest management (IPM) strategies, with insecticidal applications playing a crucial role in controlling infestations. Due to its short developmental cycle and ability to complete multiple generations within a single cropping season, repeated insecticide applications are often necessary. However, being a relatively new pest in India, information regarding the efficacy of insecticides against *T. parvispinus* remains limited. Therefore, the present study was conducted to evaluate the effectiveness of various insecticides and biorational approaches against *T. parvispinus* on chilli. The findings of this study will provide valuable insights for selecting appropriate control measures to mitigate the impact of this invasive pest and ensure sustainable chilli production.

Materials and Methods

A field trial was conducted during December, 2023-2024 at Regional Horticulture Research and Extension Center, Bengaluru to evaluate the efficacy of botanicals, biopesticides and newer insecticides against black thrips (Plate 1). The experiment was laid out in a randomized block design with ten treatments replicated three times. Rudra variety was selected. About 25 days old seedlings were transplanted by adopting spacing of 90 × 60 cm between rows and among plants, respectively with the plot size of 4.5 × 3.6 m. The regular agronomic operations were followed equally for all treatments, which are prescribed by the University of Horticultural Sciences, Bagalkot. A total four sprays were given at seven days' interval starting from 25 days after transplantation by using knapsack sprayer. The treatment details are mentioned in the Table 1.

Pre-treatment observations on number of thrips (nymphs and adults) were made a day before treatment imposition and post treatment counts were made at one, three, five and seven days after each spray. Thrips count was recorded on

ten randomly selected plants in each replication by tapping tender shoots on white paper board and LCI was recorded and PLI was calculated after each spray.

Table 1: Details of treatments imposed for managing black thrips under field conditions

Treatment	Details	Dose (g, ml L ⁻¹)
T ₁	Azadirachtin 10,000 ppm	1.00 ml
T ₂	<i>Lecanicillium lecanii</i> (1×10 ⁸ CFU g ⁻¹)	5.00 g
T ₃	<i>Beauveria bassiana</i> (1×10 ⁸ CFU g ⁻¹)	5.00 g
T ₄	<i>Metarhizium anisopliae</i> (1×10 ⁸ CFU g ⁻¹)	5.00 g
T ₅	Diafenthiuron 50 WP	1.25 g
T ₆	Cyantraniliprole 10.26 OD	1.8 ml
T ₇	Spinetoram 11.7 SC	0.2 ml
T ₈	Broflanilide 20 SC	0.2 ml
T ₉	Thiamethoxam 25 WG	0.20 g
T ₁₀	Untreated control	-

The number of thrips was recorded from 10 randomly selected plants in each replication at 1, 3, 5 and 7th day after each spray. Since the thrips are mostly congregated towards terminal parts of plants; the observations were recorded by tapping the terminal shoots against white paper board and fallen thrips were counted visually and the upward curling symptoms caused by thrips on leaves was recorded based on visual rating scale. Based on the leaf curl symptoms, the per cent leaf curl index (PLI) was calculated. Sprays were given at weekly interval, first spray starting from 25 days after transplantation as the level of thrips infestation crossed economic threshold level.

Results and Discussion

A field experiment was conducted during 2023-2024 to evaluate the efficacy of different botanicals, biopesticides and newer insecticides against black thrips in chilli, with the aim of identifying promising components for developing effective pest management strategies. The results from the study are presented below.

The results indicated that all insecticidal treatments were significantly more effective in reducing the black thrips population compared to the untreated control. Among the chemical insecticides, Broflanilide at 0.2 ml L⁻¹ and Cyantraniliprole at 1.8 ml L⁻¹ recorded the lowest number of black thrips per plant, showing superior efficacy. In the category of botanical insecticides, Azadirachtin at 1 ml L⁻¹ also demonstrated a notable reduction in thrips population. Similarly, among the bio-pesticides, *Beauveria bassiana* at 5 g L⁻¹ effectively minimized thrips numbers. The pre-treatment population of black thrips across all plots ranged from 1.11 to 3.46 per plant, with no significant differences observed between the plots at this stage. This consistency in initial thrips numbers suggests that the post treatment reductions were primarily due to the effectiveness of the treatments rather than any pre-existing differences between the plots. Additionally, the varying performance of treatments across different groups emphasizes the importance of selecting the appropriate insecticide based on the specific pest management needs.

The bio-efficacy study on the use of botanicals, biopesticides and newer insecticides against *T. parvispinus* (black thrips) in chilli fields during the 2023-2024 season, measured across multiple sprays, revealed important trends regarding the effectiveness of the treatments. The results varied significantly across the different sprays, with some treatments consistently out performing others (Table 2).

At first spray, Broflanilide at 0.2 ml L⁻¹ exhibited the lowest population of black thrips, with a recorded mean of 0.84 thrips per plant, making it statistically the most effective treatment at this stage. The treatment reduced the black thrips population considerably compared to the untreated control, which recorded 2.48 thrips per plant, the highest population among all treatments. *B. bassiana* at 5 g L⁻¹ also performed well, recording 1.18 thrips per plant, and stood out as a superior biopesticides in this trial. On the other hand, treatments like *M. anisopliae* at 5 g L⁻¹ and Azadirachtin 1 ml L⁻¹ recorded relatively higher thrips populations of 2.54 and 2.37 thrips per plant, respectively and were statistically different from the top-performing treatments (Table 2).

At the second spray, Broflanilide at 0.2 ml L⁻¹ once again achieved the lowest population, reducing the black thrips population to 0.62 thrips per plant, significantly outperforming all other treatments. Cyantraniliprole at 1.8 ml L⁻¹ was the next best treatment, recording 1.01 thrips per plant, followed by *B. bassiana* at 5 g L⁻¹ at 0.97 thrips per plant, both of which showed strong efficacy in controlling black thrips. The untreated control group saw a significant spike in the thrips population, with 3.27 thrips per plant, marking the highest population recorded across all treatments at this stage. This comparison highlights the necessity of continued pest management, especially with effective treatments like Broflanilide at 0.2 ml L⁻¹ and *B. bassiana* at 5 g L⁻¹ (Table 2).

During the third spray, Broflanilide at 0.2 ml L⁻¹ maintained its position as the most effective treatment, with a thrips population of 1.25 thrips per plant, which was the lowest among all treatments. *B. bassiana* at 5 g L⁻¹ continued to show promise with a recorded population of 1.53 thrips per plant while, Cyantraniliprole at 1.8 ml L⁻¹ also demonstrated effective control with 1.58 thrips per plant. The untreated control registered 2.94 thrips per plant, showing a significantly higher population compared to the treated plots. Azadirachtin 1 ml L⁻¹ and *M. anisopliae* at 5 g L⁻¹ recorded higher populations of 2.39 and 2.60 thrips per plant, respectively, proving to be less effective than the other treatments in reducing thrips at this stage (Table 2).

After the fourth spray, Broflanilide at 0.2 ml L⁻¹ continued to be the out performer, recording the lowest population of black thrips at 0.44 thrips per plant, which was statistically different from all other treatments. *B. bassiana* at 5 g L⁻¹ noticed an increase in thrips population to 2.59 thrips per

plant, although it still provided effective control compared to the untreated control, which recorded 3.36 thrips per plant, the highest population observed. Cyantraniliprole at 1.8 ml L⁻¹ and Spinetoram at 0.2 ml L⁻¹ maintained moderate effectiveness, with populations of 1.65 and 1.72 thrips per plant, respectively, showing they could still contribute to an effective pest management program (Table 2).

When the results from all four sprays were pooled, Broflanilide at 0.2 ml L⁻¹ had the lowest pooled mean population of black thrips at 0.79 thrips per plant, with a 74.02 per cent reduction in thrips population compared to the control, making it the best treatment overall for managing black thrips in chili crops. *B. bassiana* at 5 g L⁻¹ followed with a pooled mean of 1.57 thrips per plant and a 59.83 per cent reduction over control, establishing it as a strong biopesticide alternative. Cyantraniliprole at 1.8 ml L⁻¹ (1.36 thrips per plant) and Spinetoram at 0.2 ml L⁻¹ (1.61

thrips per plant) also proved effective, with reductions of 54.85 per cent and 46.80 per cent, respectively. On the other hand, the untreated control had a pooled mean of 3.01 thrips per plant, clearly demonstrating the need for treatment interventions to control thrips populations. *M. anisopliae* at 5 g L⁻¹ and Azadirachtin 1 ml L⁻¹ were less effective, with pooled means of 2.52 and 2.23 thrips per plant, respectively (Table 2).

Overall, the results highlight that Broflanilide at 0.2 ml L⁻¹ was consistently the best treatment across all sprays, achieving the lowest thrips populations and the highest per cent reduction over the untreated control. Other treatments like *B. bassiana* 5 g L⁻¹ and Cyantraniliprole at 1.8 ml L⁻¹ were also effective, particularly when considering their biopesticide and chemical nature, respectively. These findings suggest that combining these treatments could offer effective strategies for managing black thrips populations in chilli fields (Table 2).

Table 2: Bio-efficacy of botanicals, biopesticides and newer insecticides against Black thrips, *Thrips parvispinus* on chilli at different spray under field conditions during 2023-2024

Sl. No	Treatment Details	Dose (g, ml L ⁻¹)	Mean no. of thrips plant ⁻¹ at different sprays				Pooled mean	Per cent reduction over control
			I spray	II spray	III spray	IV spray		
1	Azadirachtin 10,000 ppm	1.00 ml	2.37 (1.44) ^{ef}	2.17 (1.48) ^g	2.39 (1.52) ^{ef}	2.00 (1.41) ^{cd}	2.23	31.12
2	<i>Lecanicillium lecanii</i> (1×10 ⁸ CFU g ⁻¹)	5.00 g	2.16 (1.41) ^{ef}	1.97 (1.42) ^f	2.07 (1.43) ^{de}	1.98 (1.42) ^{de}	2.05	32.11
3	<i>Beauveria bassiana</i> (1×10 ⁸ CFU g ⁻¹)	5.00 g	1.18 (1.03) ^b	0.97 (1.00) ^b	1.53 (1.18) ^b	2.59 (1.13) ^b	1.57	59.83
4	<i>Metarhizium anisopliae</i> (1×10 ⁸ CFU g ⁻¹)	5.00 g	2.54 (1.50) ^{fg}	2.34 (1.54) ^h	2.60 (1.58) ^f	2.59 (1.57) ^{de}	2.52	16.51
5	Diafenthiuron 50 WP	1.25 g	1.63 (1.30) ^{de}	1.38 (1.19) ^d	1.85 (1.31) ^{cd}	1.83 (1.36) ^{cd}	1.67	44.48
6	Cyantraniliprole 10.26 OD	1.08 ml	1.21 (1.12) ^{bc}	1.01 (1.02) ^b	1.58 (1.20) ^{bc}	1.65 (1.29) ^{bc}	1.36	54.85
7	Spinetoram 11.7 SC	0.02 ml	1.51 (1.24) ^{cd}	1.31 (1.16) ^c	1.88 (1.32) ^{cd}	1.72 (1.33) ^{bc}	1.61	46.80
8	Broflanilide 20 SC	0.02 ml	0.84 (0.93) ^a	0.62 (0.81) ^a	1.25 (1.04) ^a	0.44 (0.72) ^a	0.79	74.02
9	Thiamethoxam 25 WG	0.20 g	1.84 (1.33) ^{de}	1.64 (1.29) ^e	2.02 (1.39) ^d	1.85 (1.37) ^{cd}	1.84	39.08
10	Untreated control	-	2.48 (1.51) ^g	3.27 (1.81) ⁱ	2.94 (1.72) ^g	3.36 (1.78) ^e	3.01	
SEM (±)			0.14	0.07	0.13	0.18		
CD at 5%			0.41	0.02	0.37	0.52		

Figures in the parenthesis indicates square root $\sqrt{x+0.5}$ transformed values

Figures in each column by same alphabet (s) are not significantly different (CD at 5%) DAS – Days after Spray

The field study on the bio-efficacy of botanicals, biopesticides and newer insecticides against Black thrips (*T. parvispinus*) evaluated the per cent leaf curl index (PLI) over four sprays during 2023-2024. The results provided insights into the performance of different treatments in managing leaf curl symptoms caused by thrips infestations (Table 3).

After the first spray, Broflanilide at 0.2 ml L⁻¹ remained the best performing treatment, reducing the PLI to 25.33 per cent, which was significantly lower than the untreated control, which maintained a PLI of 49.33 per cent. *B. bassiana* 5 g L⁻¹ also showed excellent control with a PLI of 24.00 per cent, statistically different from many other treatments, suggesting that early applications of these biopesticides can effectively reduce initial infestation levels (Table 3).

Following the second spray, the untreated control showed an alarming increase in PLI to 62.66 per cent, indicating

worsening conditions without intervention. Conversely, Broflanilide at 0.2 ml L⁻¹ and *B. bassiana* at 5 g L⁻¹ maintained their effectiveness, with PLIs of 40.66 per cent each. Spinetoram at 0.2 ml L⁻¹ also provided good control, reducing PLI to 47.33 per cent and demonstrated statistically significant results when compared to untreated plants (Table 3).

By the third spray, the untreated control continued to rise, reaching 54.66 per cent PLI, showing that the pest pressure had not been alleviated. Broflanilide at 0.2 ml L⁻¹ continued to perform well, reducing the PLI to 42.66 per cent, which was among the lowest recorded. Cyantraniliprole at 1.8 ml L⁻¹ reduced PLI to 51.33 per cent, remaining statistically different from other treatments and indicating sustained control over time. *B. bassiana* at 5 g L⁻¹ kept its PLI at 46.66 per cent, showing consistency in thrips management (Table 3).

At the fourth spray, the untreated control reached the highest PLI of 96.66 per cent, confirming the severe

infestation in untreated plots. In contrast, Broflanilide at 0.2 ml L⁻¹ achieved the lowest PLI at 50.00 per cent, demonstrating its long-term efficacy in managing the leaf curl symptoms. *B. bassiana* at 5 g L⁻¹ and Spinetoram at 0.2 ml L⁻¹ followed with PLIs of 66.66 per cent and 71.33 per cent respectively, still offering good control over the untreated plants. Cyantraniliprole at 1.8 ml L⁻¹ also continued to provide effective management, reducing PLI to 68.00 per cent (Table 3).

When the data from all four sprays were pooled, Broflanilide at 0.2 ml L⁻¹ had the lowest overall PLI with a pooled mean of 39.65 per cent and the highest percent reduction over control at 39.72 per cent, making it the most effective treatment in reducing black thrips related leaf curl symptoms. *B. bassiana* at 5 g L⁻¹ also performed well, with a pooled mean of 44.49 per cent while, Cyantraniliprole at 1.8 ml L⁻¹ exhibited a pooled mean of 46.33 per cent, both being effective options. On the other hand, Azadirachtin at 1 ml L⁻¹ and *M. anisopliae* at 5 g L⁻¹ were less effective, with higher PLIs, indicating their potential for use in integrated pest management strategies rather than as standalone treatments (Table 3).

The statistical differences among treatments were significant, with Broflanilide 0.2 ml L⁻¹ standing out as the best treatment, showing the most substantial reductions in PLI throughout the study. *B. bassiana* at 5 g L⁻¹ and Cyantraniliprole at 1.8 ml L⁻¹ were also strong performers, providing excellent control with consistent reduction across all sprays. Meanwhile, Azadirachtin at 1 ml L⁻¹ and *M. anisopliae* 5 g L⁻¹ showed moderate control but may require integration with other control measures for optimal results. In contrast, the untreated control experienced a consistent increase in PLI, peaking at 96.66 per cent, highlighting the importance of proper management practices to prevent severe crop damage (Table 3).

Broflanilide 0.2 ml L⁻¹ emerged as the most effective treatment against Black thrips-induced leaf curl, followed closely by *B. bassiana* and Cyantraniliprole at 1.8 ml L⁻¹. These results suggest that incorporating these products into a pest management program can significantly reduce black thrips populations and associated damage, offering chilli growers effective tools for sustainable pest control (Table 3).

Table 3: Bio-efficacy of botanicals, biopesticides and newer insecticides against Black thrips, *Thrips parvispinus* PLI on chilli at different spray under field conditions during 2023-2024

Sl. No	Treatment Details	Dose (g, ml L ⁻¹)	Per cent Leaf curl index at different sprays				Pooled mean	Per cent reduction over control	Yield (T ha ⁻¹)
			I spray	II spray	III spray	IV spray			
1	Azadirachtin 10,000 ppm	1.00 ml	38.00 (6.64) ^{de}	52.00 (7.20) ^{cd}	74.66 (8.63) ^{ef}	88.66 (9.40) ^{de}	63.33	3.78	09.33
2	<i>Lecanicillium lecanii</i> (1×10 ⁸ CFU g ⁻¹)	5.00 g	35.33 (5.93) ^{bcd}	46.66 (6.87) ^{bc}	68.66 (8.28) ^e	87.33 (9.34) ^d	59.49	9.61	10.54
3	<i>Beauveria bassiana</i> (1×10 ⁸ CFU g ⁻¹)	5.00 g	24.00 (4.88) ^a	40.66 (6.37) ^a	46.66 (6.82) ^{ab}	66.66 (8.15) ^b	44.49	32.40	16.21
4	<i>Metarhizium anisopliae</i> (1×10 ⁸ CFU g ⁻¹)	5.00 g	38.66 (6.21) ^{cd}	44.00 (7.43) ^d	80.00 (8.78) ^f	93.33 (9.65) ^{ef}	63.99	2.78	09.13
5	Diafenthiuron 50 WP	1.25 g	36.00 (5.99) ^{cd}	42.66 (6.62) ^{ab}	58.66 (7.39) ^{cd}	78.00 (8.82) ^c	53.83	18.21	15.08
6	Cyantraniliprole 10.26 OD	1.08 ml	28.00 (5.27) ^{ab}	38.00 (6.52) ^{ab}	51.33 (7.16) ^{bc}	68.00 (8.23) ^b	46.33	29.61	15.51
7	Spinetoram 11.7 SC	0.02 ml	33.33 (5.77) ^{bc}	47.33 (6.52) ^{ab}	54.00 (7.34) ^{cd}	71.33 (8.44) ^b	51.49	21.77	15.41
8	Broflanilidae 20 SC	0.02 ml	25.33 (5.01) ^a	40.66 (6.37) ^a	42.66 (6.52) ^a	50.00 (7.06) ^a	39.65	39.72	19.42
9	Thiamethoxam 25 WG	0.20 g	39.33 (6.25) ^{cd}	55.33 (6.82) ^{abc}	77.33 (7.65) ^d	78.00 (8.82) ^c	62.49	5.05	13.64
10	Untreated control	-	49.33 (7.02) ^e	62.66 (7.91) ^e	54.66 (8.94) ^f	96.66 (9.83) ^f	65.82		06.77
SEM (±)			3.03	2.08	2.15	1.71			
CD at 5%			9.02	6.18	6.39	5.10			

Figures in the parenthesis indicates square root $\sqrt{x+0.5}$ transformed values

Figures in each column by same alphabet (s) are not significantly different (CD at 5%) DAS – Days after Spray

The reduction in the black thrips infestation and PLI incidence after four sprays of different treatments on chilli has indicated that for managing thrips populations and their associated leaf curl symptoms, as measured by the per cent leaf curl index (PLI) across four spray applications (Fig. 1 and 2). Broflanilidae at 0.2 ml L⁻¹ emerged as the most effective control method across both thrips populations and leaf curl symptoms, measured by the per cent leaf curl index (PLI). In the first spray, Broflanilidae recorded the lowest thrips population at 0.84 per plant, significantly outperforming the untreated control's 2.48 thrips per plant and achieving a PLI of 25.33 per cent, compared to 49.33 per cent for the untreated control. *B. bassiana* at 5 g L⁻¹ also showed notable efficacy, with 1.18 thrips per plant and a PLI of 24.00 per cent, highlighting the importance of

biopesticide applications. However, the untreated control's PLI surged to 62.66 per cent by the second spray, underscoring the need for timely pest management interventions.

Broflanilidae and *B. bassiana* maintained their effectiveness during this period, each achieving a PLI of 40.66 per cent. In subsequent sprays, Broflanilidae continued to excel, reducing thrips to 1.25 per plant and achieving a PLI of 42.66 per cent in the third spray. By the fourth spray, it reached a thrips count of 0.44 and a PLI of 50.00 per cent, significantly outpacing other treatments. Pooled data showed Broflanilidae averaged 0.79 thrips per plant, with a 74.02 per cent reduction over control, while the average PLI was 39.65 per cent, representing a 39.72 per cent reduction. *B. bassiana* and Cyantraniliprole also demonstrated

effective control, reinforcing the potential of integrated pest management strategies in chilli cultivation. Thus, demonstrating their effectiveness within their respective categories. However, both of them were statistically more effective in reducing thrips populations and the incidence of PLI in chilli crop under field conditions.

Broflanilide 20 SC, a novel insecticide introduced in 2020, has demonstrated exceptional control over *Thrips parvispinus* (black thrips) in chilli crops. As a GABA-gated chloride channel blocker, it disrupts neurotransmission in insects, causing rapid paralysis (Katsuta *et al.*, 2019) [4]. Originally targeting soil pests, Broflanilide application at 0.2 ml L⁻¹ effectively reduced thrips populations by up to 74 per cent over untreated controls in the 2023-2024 bio-efficacy study. Its efficacy extends to minimizing leaf curl symptoms, promoting healthier yields. With its unique mode of action and consistent performance, Broflanilide stands out as a primary choice for black thrips management, especially within integrated pest management strategies.

Nakao and Banba (2016) [7] revealed Broflanilide, as a meta-diamide compound [3-benzamido-N-(4-(perfluoropropan-2-yl) phenyl) benzamide], metabolized into desmethyl-Broflanilide, which acts as a non-competitive antagonist of resistant-to-dieldrin (RDL) γ -aminobutyric acid (GABA) receptors. Unlike conventional non-competitive antagonists like Fipronil, desmethyl-broflanilide binds to a distinct site near G336 in the M3 region of the Drosophila RDL GABA receptor. Though this binding site partially overlaps with that of macrocyclic lactones, desmethyl-broflanilide operates through a different mode of action. This review also explores the unique selectivity mechanisms of meta-diamides, positioning broflanilide as a promising insecticide, particularly effective against pests resistant to cyclodienes and fipronil.

Similar findings by Saware and Tayde (2024), where the precount populations were recorded one day before spraying, while the post-treatment observations were recorded 3, 7 and 14 days after each spraying. The mean of two sprays revealed that Broflanilide 20 SC (0.49 thrips count per three leaves) proved to be the most effective treatment, followed by Imidacloprid 17.8 SC (0.77 thrips per three leaves), Spinosad 45 SC (0.92 thrips per three leaves), Fipronil 5 SC (1.21 thrips per three leaves), Acetamiprid 20 SP (1.60 thrips count per three leaves), *Beauveria Bassiana* 2 \times 10⁸ CFU ml⁻¹ (2.11 thrips count per three leaves) and neem oil 1500 ppm (2.36 thrips per three leaves). The crop yield ranged between Broflanilide (128 q ha⁻¹) and neem oil (48) as compared to the untreated control (28 q ha⁻¹). CBR ranged from Broflanilide (1:8.16) to neem oil (1:2.44) as compared to the untreated control (1.1.04).

Beauveria bassiana (UHS Bagalkot END1 strain), an entomopathogenic fungus applied at 5 g L⁻¹, is a potent biopesticide against pests such as aphids, whiteflies, thrips

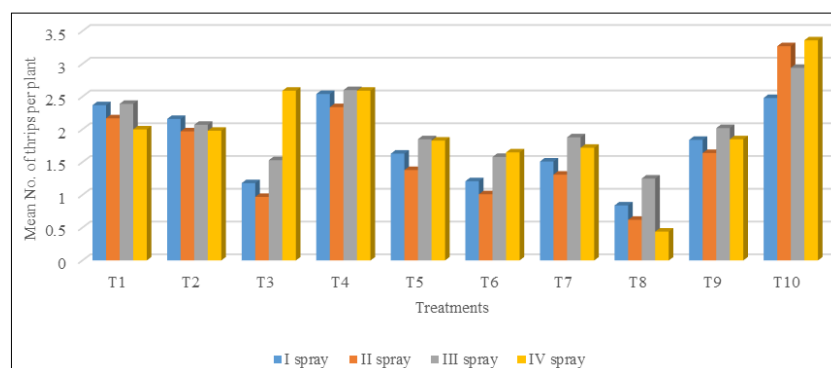
and caterpillars. Functioning through spore penetration of the insect cuticle, it causes paralysis and eventual death. First discovered in the early 20th century and commercialized in the 1990s, *B. bassiana* offers an eco-friendly, biological approach to pest control. In the 2023-2024 bio-efficacy study, this strain notably reduced thrips populations and leaf curl symptoms, complementing chemical controls like Broflanilide effectively within an integrated pest management strategy to enhance chilli crop health and yield.

The 100 per cent colonization of cabbage plant by indigenous *B. bassiana* UHSB-END 1 AT 30 dpi in combination of treatment and showed a maximum efficacy in managing the population of major insects of cabbage. Introducing this indigenous isolate will hope in managing the both key insects (*P. xylostella* and *M. persicae*) in cabbage agroecosystem without disturbing the environment and further helps in production of cabbage with minimum pesticide residue for consumers (Yogananda *et al.*, 2023) [12].

Similar findings where by Praveen *et al.* (2020) conducted two field experiments on chilli indicated that the *B. bassiana* 112 oil-based formulation applied with a Controlled Droplet Applicator (CDA) sprayer produced the highest reduction of 54.12 per cent and 48.82 per cent thrips, respectively. For tomato thrips, the field trials indicated that *B. bassiana* 112 oil formulation applied with CDA sprayer was significantly higher than the other treatments with 55.07 per cent and 52.36 per cent reduction, respectively.

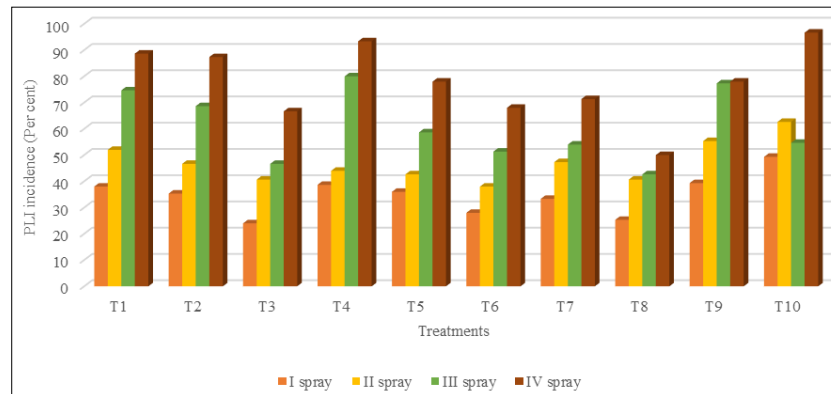
Cyantraniliprole 10.26 OD, a diamide insecticide applied at 1.8 ml L⁻¹, effectively controls lepidopteran larvae and sucking pests like thrips by disrupting calcium ion channels in their muscle cells, leading to paralysis (Ataide *et al.*, 2024) [1]. In the 2023-2024 bio-efficacy study on chilli crops, Cyantraniliprole demonstrated strong thrips control, second only to Broflanilide and *Beauveria bassiana*, achieving a 54.85 per cent reduction in thrips over untreated control. Its targeted, efficient action supports integrated pest management by offering reliable pest suppression alongside Broflanilide and *B. bassiana* for sustainable chilli crop protection.

Similar findings where by Muralimohan *et al.* (2023) [6] found the bio-efficacy of new generation molecules and biorational against *T. parvispinus*. The results suggested that new molecules *viz.*, Broflanilide 30 SC (18.60g a.i ha⁻¹) and Fluxametamide 10 EC (40 g a.i ha⁻¹) were found highly effective in reducing the thrips population on chilli crop, followed by Spinetoram 11.7 SC (60g a.i ha⁻¹) and Tolfenpyrad 15 EC (150 g a.i ha⁻¹). Other insecticides *viz.*, Spinosad 45 SC (73 g a.i ha⁻¹), Cyantraniliprole 10.26 OD (60 g a.i ha⁻¹) and Thiamethoxam 25 WG (37.50 g a.i ha⁻¹) were found moderately effective on this species.



T1- Azadirachtin 10,000 ppm T2- *Lecanicillium lecanii* (1×10^8 CFU g^{-1}) T3- *Beauveria bassiana* (1×10^8 CFU g^{-1}) T4- *Metarhizium anisopliae* (1×10^8 CFU g^{-1}) T5- Diafenthiuron 50 WP T6- Cyantraniliprole 10.26 OD
T7- Spinetoram 11.7 SC T8- Broflanilidae 20 SC T9- Thiamethoxam 25 WG and T10- Untreated control

Fig 1: Efficacy of botanicals, biopesticides and newer insecticides against black thrips infestation on chilli



T1- Azadirachtin 10,000 ppm T2- *Lecanicillium lecanii* (1×10^8 CFU g^{-1}) T3- *Beauveria bassiana* (1×10^8 CFU g^{-1}) T4- *Metarhizium anisopliae* (1×10^8 CFU g^{-1}) T5- Diafenthiuron 50 WP T6- Cyantraniliprole 10.26 OD
T7- Spinetoram 11.7 SC T8- Broflanilidae 20 SC T9- Thiamethoxam 25 WG and T10- Untreated control

Fig 2: Efficacy of botanicals, biopesticides and newer insecticides against Leaf curl disease incidence on chilli

Conclusion

Among the different insecticides evaluated, Broflanilide 20 SC at 0.2 ml L^{-1} consistently emerged as the most effective treatment, achieving the lowest thrips populations and PLI. Cyantraniliprole 10.26 OD at 1.8 ml L^{-1} and Spinetoram 11.7 SC at 0.2 ml L^{-1} also provided substantial control, indicating other chemical alternatives. Among biopesticides, *Beauveria bassiana* (1×10^8 CFU g^{-1}) at 5 g L^{-1} found to be highly effective, with significant reduction in both thrips population as well as PLI. Among botanicals, Azadirachtin 10,000 ppm at 1 ml L^{-1} showed moderate efficacy and may require integration with other treatments.

Broflanilide 20 SC @ 0.2 ml L^{-1} and *Beauveria bassiana* @ 5 g L^{-1} (1×10^8 CFU g^{-1}) found to be the most effective treatments, in reducing thrips populations and PLI incidence.

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