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Economically management of thrips by insecticides in chilli under field condition

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Abstract
The bioefficacy of six insecticidal sprays against thrips, *Scirtothrips dorsalis* Hood in chilli was evaluated in a field experiment conducted at Main Vegetable Research Station, Anand Agricultural University (AAU), Anand, Gujarat, India during *kharif* 2021. The result revealed that in six tested insecticides, the maximum reduction in thrips population and increasing yield over control was found in the treatment of fipronil 80 WG followed by spinetoram 11.7 SC, cyantraniliprole 10.26 OD and thiamethoxam 25 WG with chilli yield of 118.39, 110.58, 105.72 and 87.72 q/ha, respectively. Looking at the ICBR, the highest (1:28.29) return was obtained with the treatment of fipronil 80 WG followed by thiamethoxam 25 WG (1:19.40) and lambda-cyhalothrin 5 EC (1:17.55). Based on ranking, the treatment of fipronil 80 WG was found significantly effective as well as economic against thrips infesting chilli.

Keywords: Bioefficacy, different insecticides, chilli thrips

Introduction
Chilli, *Capsicum annum* (Linnaeus) is an important solanaceous vegetable crop widely used as a vegetable, spice, condiment, sauce, pickles and medicine. Chilli is integral and the most important ingredient in many different cuisines around the world as it adds pungency, taste, flavour and colour to the dishes. Today, it is unimaginable to think of Indian cuisine without hot spice and chilli. Indian chilli is world famous for two important commercial qualities, it is colour and pungency levels. Major chilli growing countries are India, China, Mexico, Thailand, Ethiopia, Uganda and Pakistan. India is the world's largest producer, consumer and exporter of chilli with a 7.43 lakh ha area. The important chilli growing states are Andhra Pradesh, Maharashtra, Karnataka, Orissa, Gujarat and Tamil Nadu accounting for more than 70 per cent acreage of India (Anonymous, 2021) [1]. Growing chilli faces several major constraints like abiotic and biotic stresses. Among the biotic stresses, pest and disease infestation are also equally responsible for colossal losses. About 51 species of insects and 2 species of mites belonging to 27 families under 9 orders along with snail are known to damage chilli crops both in the nursery and main field (Anon., 2020) [2]. A major threat to chilli cultivation all over the world is its proneness to infestation by pest complexes, especially mites, thrips, fruit borers, whiteflies *etc*. at different stages of crop growth. Among the common insect pests of vegetables, fruits and ornamental crops, the thrips (*Scirtothrips dorsalis*, Thysanoptera: Thripidae) is a serious pest. The adults and nymphs infest tender leaves and derive their nutrients by penetrating the tissues of chilli plants. They lacerate the tender leaf surface resulting in typical leaf curl symptoms and a boat-like appearance, locally called "Kokadava" (Patel *et al*., 2009) [6]. Typical symptoms of thrips damage include silvering of leaf surface, linear thickening of leaf lamina, necrotic spots on leaves and tender fruits, fruit distortion, and early senescence of leaves. Severe infestation causes "chilli leaf curl" also known as "Murda disease". Thrips are also the vector of chilli leaf curl virus disease (Anon., 2020) [2].

At present, many newer synthetic and botanical insecticide molecules are available in the market to manage chilli thrips. The bioefficacy of these molecules needs to be studied for the registration in chilli crop. Based on the wider adaptability by the farmers, six insecticides namely cyantraniliprole, spinetoram, fipronil, emamectin benzoate, thiamethoxam and lambda-cyhalothrin were selected for the present study. Keeping these points in view, detailed investigations were undertaken.

Materials and Method
To evaluate different insecticidal sprays against thrips of chilli, a field experiment was conducted at Main Vegetable Research Scientist, Anand Agricultural University (AAU), Anand, Gujarat, India during *kharif* 2021. It is in Middle Gujarat at 22.035 North Latitude and 72.055 East Longitude and Altitude of 45 m above mean sea level.

Gujarat Vegetable Chilli (GVC) - 111 variety has sown a spacing of 45 cm x 60 cm with the following recommended package of practices except for plant protection. The experiment consists of three replications and six insecticides *i.e.*, cyantraniliprole 10.26 OD, spinetoram

11.7 SC, fipronil 80 WG, Emamectin benzoate 5 SG, thiamethoxam 25 WG, lambda-cyhalothrin 5 EC with one control treatment.

All the insecticides were applied as a foliar spray, with the help of a knapsack sprayer (15-litre capacity). For deciding the quantity of spray fluid required, control plots were sprayed with water. Spray fluid was prepared by mixing a measured quantity of water and insecticides. All necessary care was taken to prevent the drift of insecticides to reach the adjacent plots. When the population of thrips crossed its ETL level (5 thrips/leaf) (Patel and Kumar (2017) [8], the first spray was given on 10th November and the second spray was given at 15 days interval, *i.e.*, on 25th November 2021.

Observations were recorded visually during the early morning from three leaves (*i.e.*, bottom, middle and top) of each of 5 randomly selected plants from a net plot of each treatment. A pre-spray observation was taken and subsequently, the observations were recorded at 3, 7, 10 and 14 days after spraying from each treatment. The data on the thrips population was statistically analyzed for testing the significance of the treatment effect and drawing a valid conclusion using square root transformation, (Steel and Torrie, 1980) [10]. The green chilli fruit yield was recorded picking-wise from each plot. The economics of each insecticide was calculated. Thrips and their damage are shown in (Figure 1).

Result and Discussion

First spray

From each treatment, the number of thrips/3 leaves per plant was recorded and presented in (Table 1). According to the data before spray, all the treatments had uniform populations of thrips that were non-significant, ranging from 15.61 to 17.10 thrips/3 leaves. On the third day after spray, the minimum thrips population were recorded from the treatment of fipronil 80 WG at 0.01 per cent (9.02 thrips/3 leaves) and it was at par with spinetoram 11.7 SC at 0.012 per cent (9.16 thrips/3 leaves), cyantraniliprole 10.26 OD at 0.012 per cent (9.32 thrips/3 leaves) and thiamethoxam 25 WG at 0.01 per cent (9.37 thrips/3 leaves). At 7th DAS, fipronil 80 WG recorded the lowest thrips population (7.35 thrips/3 leaves) and was also at par with the treatment of spinetoram (7.57 thrips/3 leaves), cyantraniliprole (7.74 thrips/3 leaves) and thiamethoxam (7.87 thrips/3 leaves). On the tenth day after spray, treatments of fipronil, spinetoram, cyantraniliprole and thiamethoxam proved to be the most effective treatments and recorded the lowest thrips population (6.71, 6.92, 7.01 and 7.11 thrips/plant, respectively). At 14th DAS, the data on the thrips population revealed that all the insecticidal treatments were found significantly superior to the control.

The data pooled over periods are presented in (Table 1) indicating that all the evaluated insecticides were found significantly superior to the control (16.89 thrips/3 leaves). Among all insecticides, treatment of fipronil recorded the lowest (7.67 thrips/3 leaves) thrips population and it was at par with spinetoram (7.90 thrips/3 leaves), cyantraniliprole (8.01 thrips/3 leaves) and thiamethoxam (8.12 thrips/3 leaves). While treatments of emamectin benzoate (11.22 thrips/3 leaves) and lambda-cyhalothrin (11.36 thrips/3 leaves) were found least effective in reducing thrips population.

Second Spray

From each treatment, the data on the number of thrips per 3 leaves per plant were recorded and presented in (Table 1). Three days after the second spray, the thrips population significantly decreased in all the treated plots over untreated plots. The treatment of fipronil 80 WG at 0.01 per cent maintained its superiority by recording the lowest population (5.09 thrips/3 leaves). Seventh DAS, the treatment of fipronil 80 WG maintained its superiority by recording the lowest population (4.05 thrips/3 leaves) and it was at par with spinetoram (4.56 thrips/3 leaves), cyantraniliprole (4.69 thrips/3 leaves) and thiamethoxam (4.94 thrips/3 leaves). On the tenth day after the second spray, the data revealed that all the treatments were significantly superior to the control. At 14th DAS, treatments of fipronil, spinetoram, cyantraniliprole and thiamethoxam proved to be the most effective treatments and recorded the lowest thrips population (3.55, 4.37, 4.61 and 4.91 thrips/3 leaves, respectively).

The overall order of effectiveness of various treatments in reducing chilli thrips population was fipronil > spinetoram > cyantraniliprole > thiamethoxam > emamectin benzoate > lambda-cyhalothrin > control during *kharif* 2021.

Overall pooled

Thus, looking to the overall effectiveness of various insecticidal spray tested against chilli thrips are presented in (Table 1), indicating that the treatment of fipronil was found significantly most effective treatment recorded the lowest thrips population, which was at par with spinetoram, cyantraniliprole and thiamethoxam.

Fruit yield

The data presented in (Table 2) indicated that all insecticidal sprays gave a significantly higher yield of green chilli fruits as compared to the control. Among the six different insecticides, fipronil recorded the highest yield *i.e.*, 118.39 q/ha of green chilli fruits, which was followed by spinetoram, cyantraniliprole and thiamethoxam (*i.e.*, 110.58, 105.72 and 87.53 q/ha, respectively) significantly the lowest fruit yield was recorded in green chilli control (62.81 q/ha).

An increase in yield over control (Table 2) was in the range of 32.25 to 88.48%. A maximum (88.48%) increases in yield due to the insecticidal application was found in fipronil followed by spinetoram (76.05%), cyantraniliprole (68.31%) and thiamethoxam (39.65%). Emamectin benzoate and lambda-cyhalothrin exhibited 33.78 and 32.25% yield increase over control, respectively.

The overall order of effectiveness of various treatments in terms of fruit yield was $T_3 > T_2 > T_1 > T_5 > T_7$ (Control).

Economics

It is evident from the data that the highest net realization was obtained in the treatment of fipronil (1,38,950 ₹/ha) followed by spinetoram (1,19,425 ₹/ha) and cyantraniliprole (1,07,275 ₹/ha). Whereas minimum net realization was recorded from treatments of thiamethoxam (61,800 ₹/ha), lambda-cyhalothrin (50,650 ₹/ha) and emamectin benzoate (53,050 ₹/ha), respectively (Table 2).

From the above result, it is evident that net realization was comparatively higher in the treatment of fipronil (T_3) followed by spinetoram (T_2).

Incremental cost-benefit ratio (ICBR)

The Incremental cost-benefit ratio (ICBR) for different insecticides was worked out and presented in Table 2. The data on ICBR *i.e.*, gain in rupees per cost of a rupee per treatment indicated that the treatment of fipronil generated the highest ICBR ratio (1:28.29) followed by thiamethoxam (1:19.40), lambda-cyhalothrin (1:17.55) and emamectin benzoate (1:11.88), whereas cyantraniliprole (1:7.90) and spinetoram (1:9.02) gave significantly lower ICBR ration than other insecticidal treatments. the least ICBR was observed with cyantraniliprole followed by spinetoram.

Though treatment of fipronil (T_3) recorded the highest grain yield with the lowest thrips population, the ICBR was 1:28.29, which was due to the lowest price of chemicals.

Thus, the present findings agree with Patel *et al*., (2014) [7] who reported that treatment of cyantraniliprole 10.26 OD was found highly effective in managing the population of thrips and recorded significantly higher yield. Balikai (2018) [3] observed that maximum reduction in the thrips population with the treatment of fipronil 80 WG @ 50 g a.i./ha followed by fipronil 80 WG @ 40 g a.i./ha. Both the treatments were at par and proved significantly superior over the other treatments. The phytotoxic effect on the crop could not be observed during the experiment. Lakshmi *et al*., (2020) [5] reported that the application of fipronil 80 WG @ 50 g a.i./ha was found superior in the suppression of the thrips population. According to Sasmal *et al*., (2020) [9], the significantly lowest thrips counts in the treatment of fipronil 80 WG @ 50 g a.i./ha against thrips on chilli. Ezhilarasan (2021) [4] reported that thiamethoxam 25 WG and spinetoram 11.7 SC were effective in reducing the thrips population. Thus, these results are associated with the present findings.

Table 1: Bioefficacy of insecticides against thrips infesting chilli

Treatments	No. of thrips/3 leaves											
	Before spray	First Spray					Second Spray					Pooled over periods & sprays
		3 DAS	7 DAS	10 DAS	14 DAS	Pooled	3 DAS	7 DAS	10 DAS	14 DAS	Pooled	
Cyantraniliprole 10.26 OD	3.95 (15.61)	3.05 ^{ab} (9.32)	2.78 ^{a} (7.74)	2.65 ^{a} (7.01)	2.86 ^{a} (8.16)	2.83 ^{a} (8.01)	2.38 ^{a} (5.69)	2.17 ^{a} (4.69)	1.94 ^{a} (3.75)	2.15 ^{a} (4.61)	2.15 ^{b} (4.62)	2.49 ^{a} (6.20)
Spinetoram 11.7 SC	4.02 (16.15)	3.03 ^{a} (9.16)	2.75 ^{a} (7.57)	2.63 ^{a} (6.92)	2.84 ^{a} (8.09)	2.81 ^{a} (7.90)	2.33 ^{a} (5.45)	2.13 ^{a} (4.56)	1.89 ^{a} (3.58)	2.09 ^{a} (4.37)	2.11 ^{ab} (4.45)	2.46 ^{a} (6.05)
Fipronil 80 WG	3.98 (15.88)	3.00 ^{a} (9.02)	2.71 ^{a} (7.35)	2.59 ^{a} (6.71)	2.76 ^{a} (7.77)	2.77 ^{a} (7.67)	2.26 ^{a} (5.09)	2.01 ^{a} (4.05)	1.74 ^{a} (3.02)	1.88 ^{a} (3.55)	1.97 ^{a} (3.88)	2.37 ^{a} (5.62)
Emamectin benzoate 5 SG	4.14 (17.10)	3.58 ^{bcd} (12.84)	3.36 ^{b} (11.31)	3.12 ^{b} (9.74)	3.37 ^{b} (11.32)	3.35 ^{b} (11.22)	2.91 ^{b} (8.47)	2.73 ^{b} (7.44)	2.51 ^{b} (6.31)	2.65 ^{bc} (7.03)	2.70 ^{c} (7.29)	3.02 ^{b} (9.12)
Thiamethoxam 25 WG	4.06 (16.50)	3.06 ^{abc} (9.37)	2.81 ^{a} (7.87)	2.67 ^{ab} (7.11)	2.88 ^{ab} (8.30)	2.85 ^{a} (8.12)	2.42 ^{a} (5.87)	2.22 ^{a} (4.94)	2.00 ^{a} (3.99)	2.22 ^{ab} (4.91)	2.21 ^{b} (4.88)	2.53 ^{a} (6.40)
Lambda cyhalothrin 5 EC	3.97 (15.72)	3.60 ^{cd} (12.97)	3.38 ^{b} (11.45)	3.14 ^{b} (9.87)	3.39 ^{b} (11.46)	3.37 ^{b} (11.36)	3.00 ^{b} (9.01)	2.82 ^{b} (7.96)	2.67 ^{b} (7.13)	2.76 ^{c} (7.64)	2.81 ^{c} (7.90)	3.09 ^{b} (9.55)
Control	4.03 (16.28)	4.11 ^{d} (16.91)	4.13 ^{c} (17.03)	4.09 ^{c} (16.70)	4.12 ^{c} (16.94)	4.11 ^{c} (16.89)	4.04 ^{c} (16.32)	4.05 ^{c} (16.43)	4.04 ^{c} (16.32)	4.01 ^{d} (16.10)	4.04 ^{d} (16.32)	4.07 ^{c} (16.56)
S.Em. ± Treatment (T)	0.19	0.16	0.15	0.14	0.15	0.08	0.14	0.13	0.13	0.13	0.06	0.12
Period (P)	-	-	-	-	-	0.06	-	-	-	-	0.05	0.04
Spray (S)	-	-	-	-	-	-	-	-	-	-	-	0.03
T × P	-	-	-	-	-	0.15	-	-	-	-	0.13	0.10
T × S	-	-	-	-	-	-	-	-	-	-	-	0.07
P × S	-	-	-	-	-	-	-	-	-	-	-	0.05
T × P × S	-	-	-	-	-	-	-	-	-	-	-	0.14
C. D. at 5% T	NS	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
C. V. (%)	8.10	8.13	8.15	8.07	8.08	8.31	8.84	8.85	9.16	8.85	8.61	8.48

Note: 1. Figures in parentheses are retransformed values and those outsides are ($\sqrt{x}$) transformed values

2. Treatment mean(s) with the letter(s) in common are not significant by DNMRT at 5% level of significance

Table 2: Economics of insecticides evaluated against thrips in chilli

Tr. No.	Treatments	Quantity of insecticides for two sprays (Litre or kg/ha)	Price of insecticide (₹/litre or kg)	Cost of insecticides (₹/ha)	Labour charge (₹/ha)	Total cost (₹/ha)	Yield (q/ha)	Net gain over control (q/ha)	Increase in yield over control (%)	Realization over control (₹/ha)	ICBR
T_1	Cyantraniliprole 10.26 OD	1.169	9500	11106	2465	13571	105.72	42.91	68.31	107275	1:7.90
T_2	Spinetoram 11.7 SC	1.025	10500	10763	2465	13228	110.58	47.77	76.05	119425	1:9.02
T_3	Fipronil 80 WG	0.125	18750	2344	2465	4809	118.39	55.58	88.48	138950	1:28.29
T_4	Emamectin benzoate 5 SG	0.4	5000	2000	2465	4465	84.03	21.22	33.78	53050	1:11.88
T_5	Thiamethoxam 25 WG	0.4	1800	720	2465	3185	87.53	24.72	39.65	61800	1:19.40
T_6	Lambda cyhalothrin 5 EC	0.6	700	420	2465	2885	83.07	20.26	32.25	50650	1:17.55
T_7	Control	-	-	-	-	-	62.81	-	-	-	-

Note: 1. Labour charges @ Semiskilled labour: ₹ 348.20/- per day x 2 labour = ₹ 696.40/ha, **Farm labour:** ₹ 268/- per day x 2 labour = 536

₹/ha
Labour charge for one spray: ₹ 696.40 + ₹ 536 = ₹ 1232.40/ha, **Total labour charge for two sprays:** ₹ 1232.40 x 2 sprays = ₹ 2464.80/ha
2. Price of chilli = ₹ 2500/quintal (₹ 25/kg)

Table 3: Overall effectiveness of insecticides on chilli (Based on ranking)

Tr. No.	Treatments	Overall Rank				
		Efficacy	Yield (q/ha)	ICBR	Total rank	Rank
T_1	Cyantraniliprole 10.26 OD	3	3	6	12	4
T_2	Spinetoram 11.7 SC	2	2	5	09	3
T_3	Fipronil 80 WG	1	1	1	03	1
T_4	Emamectin benzoate 5 SG	5	5	4	14	5
T_5	Thiamethoxam 25 WG	4	4	2	10	3
T_6	Lambda cyhalothrin 5 EC	6	6	3	15	6
T_7	Control	-	-	-	-	-

Healthy plant **Damage plant** **Damage on chilli fruits**

Fig 1: Chilli thrips & its damage

The overall effectiveness of different insecticides

The effectiveness of various insecticides against chilli thrips, *S. dorsalis* was evaluated by the overall rank method. For this purpose, all treatments were given their rank in descending order of their effectiveness for different character studies.

These ranks of individual characters under study were summed up and ranked (Table 3). The treatment of fipronil was found most effective over the rest of the treatments and occupied the first rank. The order of effectiveness of different insecticidal treatments against chilli thrips, *S. dorsalis* based on rank was found to be $T_3 > T_2 > T_5 > T_1 > T_4 > T_6 > T_7$ (Control).

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