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Bioefficacy and phytotoxicity evaluation of insecticides against insect pests of chilli under field conditions in Haryana

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ABSTRACT: The study was aimed to evaluate the bioefficacy and phytotoxicity of insecticides against thrips (*Scirtothrips dorsalis*), fruit borer (*Helicoverpa armigera*) and tobacco caterpillar (*Spodoptera litura*) on chilli crop. Among the treatments, Cyantraniliprole 10.26% OD @ 750 and 600 ml/ha resulted in the low populations of thrips 1.60 and 1.93/plant at 3 days after first spray (DAFS), which declined to 0.27 and 0.47/plant, respectively by 14 days after second spray (DASS), respectively. Similarly, the low larval population of fruit borer and tobacco caterpillar 1.07 and 1.20/plant and 0.87 and 1.13/plant, respectively were recorded at 3 DAFS, which reduced to 0.13 and 0.20/plant, and 0.33 and 0.47/plant, respectively by 14 DASS. Cyantraniliprole 10.26% OD @ 750 and 600 ml/ha also showed low fruit infestation and high yield as compared to other treatments. Lambda cyhalothrin 4.9% CS @ 500 ml/ha, emamectin benzoate 5% SG @ 200 g/ha, lufenuron 5.4% EC @ 600 ml/ha and cyantraniliprole 10.26% OD @ 450 ml/ha were relatively less effective. The products were eco-friendly, since no phytotoxicity to chilli crop and no adverse impact on prevailing natural enemies, spiders and coccinellid in crop ecosystem was observed.

Keywords: Bioefficacy, chilli, thrips, fruit borer, tobacco caterpillar

INTRODUCTION

The chilli (*Capsicum annuum* L.) is one of the most valuable vegetable and spice crops. Its specific characteristics of pungency, aroma, colour, flavour and nutritive enrich make it to hold a critical part of ingredients used in the preparation of various food cuisines worldwide and preferred equally by rich as well as poor families. The major constraints in profitable production of chilli are diseases and insect pests, which attack the crop at vegetative as well as reproductive growth phases. The major insect pests hampering the crop growth at vegetative phase are sucking insect pests like leaf hoppers, whitefly, thrips, aphids and red spider mites which feed on the cell sap resulting in crinkling and curling of the leaves. At reproductive phase of the crop, direct damage to the chilli fruits is caused by fruit borer (*Helicoverpa armigera*) and tobacco caterpillar (*Spodoptera litura*) by initially feeding on leaves and later boring in to fruiting bodies thereby declining the quality fruit yield. Thrips (*Scirtothrips dorsalis*) not only damage the crop, also serve as one of the vectors of transmitting viral diseases. The chilli fruit production is significantly affected by sap-sucking pests and fruit borers, leading to considerable monetary losses to growers. Effective pest management strategies implication in time is therefore, becomes crucial for optimal crop production. The excessive and indiscriminate use of conventional and synthetic pyrethroid insecticides often, leads to the development of undesirable problems like suppression of natural enemies, loss of bioeffectiveness, development of pest resurgence and resistance, and even failure of pest control (Nagia *et al*., 1990, Goel *et al*., 1992, Ukey and Sarode, 2001, Kumar *et al*., 2006, Latha and Hunumanthraya, 2018). Thus, it becomes necessary to evaluate new molecules for the effective control of pests with no phytotoxicity to crops and no harm to consumer and environment. Keeping such issues in view, a field trial was conducted to evaluate bioefficacy, phytotoxicity and safety to natural enemies of insecticides Cyantraniliprole 10.26% OD, Lufenuron 5.4% EC, Lambda cyhalothrin 4.9% CS and Emamectin benzoate 5% SG on chilli crop against thrips, fruit borer and tobacco caterpillar pests.

MATERIALS AND METHODS

A field experiment was conducted at the IPFT Experimental Research Farm, Gurugram, Haryana (Latitude 28^{o} 50' 53.34" N, Longitude 77^{o} 09'34.11" E and 217 masl) during *kharif* 2022-23 to evaluate the bioefficacy and phytotoxicity of insecticides against the insect pests of chilli crop. The chilli crop var. Sakata 653 was planted in randomized block design (RBD) plots of 5 m x 4 m size and at a spacing of 30 cm x 50 cm. All the recommended agronomic practices for the

crop like irrigation, weeding, nutrient management, etc. were followed at regular intervals. With the initiation of incidence of pests on the crop, spray schedule was planned and application of treatments was done twice at 15 days interval. The treatments Cyantraniliprole 10.26% OD @ 450, 600, 750 and 1200 ml/ha, Lufenuron 5.4% EC @ 600 ml/ha, Lambda cyhalothrin 4.9% CS @ 500 ml/ha and Emamectin benzoate 5% SG @ 200 g/ha were applied using knapsack sprayer fitted with hollow cone nozzle and using 500 l/ha spray volume. The observations for the population of pests were made before first spray and further at 3, 7 and 14 days after each spray. To record the observations on thrips population, randomly selected three upper tender leaves per plant and ten plants per replicated plot were observed. However, for the larval population of fruit borer and tobacco caterpillar recording ten random plants per replicated plot were observed. The per cent fruit infestation by fruit borer and tobacco caterpillar was recorded before first spray and further at 10 days after first spray (DAFS) and at 10 and 20 days after second spray (DASS) by observing 50 random fruits per plot, and based on the data per cent fruit infestation was calculated.

The observations were also recorded visually for the phytotoxicity symptoms *viz*. Leaf injury on tips/ surface, Wilting, Vein clearing, Necrosis, Chlorosis, Stunting, Epinasty and Hyponasty after 3, 7, 10 and 14 days of each spray following 0-10 phytotoxicity rating scale (where 0=0%, 1=1-10%, 2=11-20%, 3=21-30%, 4=31-40%, 5=41-50%, 6=51-60%, 7=61-70%, 8=71-80%, 9=81-90%, 10=91-100%). To assess the impact of applied treatments on natural enemies, the population of spiders and coccinellids were recorded before first spray and at 3 and 7 days after each spray on randomly selected ten plants per plot. The crop yield was recorded at each harvest and cumulative yield expressed in terms of q/ha. The experimental data were analyzed statistically after subjecting to angular/ square root transformation as per the requirement.

RESULTS AND DISCUSSION

Control of thrips (*S. dorsalis*)

The population of thrips recorded at each time interval has been presented in Table 1. It was recorded that before first spray the population of thrips was ranging from 8.30 to 9.03/plant and the difference was not significant. The post treatments data recorded at 3, 7 and 14 days after first and second spray showed that all the treatments effectively controlled thrips population as compared to untreated control. Among the treatments, Cyantraniliprole 10.26% OD @ 750 ml/ha was found to be highly effective and closely followed by

Table: 1. Effectiveness of treatments against thrips, *Scirtothrips dorsalis* on chilli crop

Treatment	Formulation dose	Thrips population per plant						
		Before first spray	Days after first spray			Days after second spray		
			3 days	7 days	14 days	3 days	7 days	14 days
Cyantraniliprole 10.26% OD	450 ml/ha	8.47 (2.99)	4.23 (2.17)	3.90 (2.10)	6.20 (2.59)	3.73 (2.04)	2.87 (1.83)	1.60 (1.45)
Cyantraniliprole 10.26% OD	600 ml/ha	8.70 (3.03)	1.93 (1.56)	1.33 (1.35)	2.57 (1.75)	1.97 (1.57)	1.17 (1.29)	0.47 (0.98)
Cyantraniliprole 10.26% OD	750 ml/ha	8.57 (3.01)	1.60 (1.45)	1.17 (1.28)	2.23 (1.65)	1.80 (1.52)	1.03 (1.24)	0.27 (0.87)
Lufenuron 5.4% EC	600 ml/ha	9.03 (3.09)	4.63 (2.27)	3.47 (1.99)	6.47 (2.64)	4.30 (2.19)	3.43 (1.98)	2.13 (1.62)
Lambda cyhalothrin 4.9% CS	500 ml/ha	8.90 (3.07)	3.07 (1.89)	2.07 (1.60)	4.93 (2.33)	2.30 (1.67)	2.17 (1.63)	0.97 (1.21)
Emamectin benzoate 5% SG	200 g/ha	8.53 (3.01)	3.43 (1.98)	2.30 (1.67)	5.43 (2.44)	2.83 (1.82)	2.53 (1.74)	1.07 (1.25)
Untreated Control	-	8.30 (2.97)	9.50 (3.16)	12.07 (3.54)	19.20 (4.44)	14.53 (3.87)	12.90 (3.66)	8.87 (3.06)
S Em±		0.03	0.04	0.05	0.04	0.09	0.05	0.04
CD at 5%		NS	0.13	0.17	0.12	0.28	0.14	0.13

NS – Non significant, Figures in parentheses are square root transformed values (x + 0.5)

Table 2. Effectiveness of treatments against fruit borer, *Helicoverpa armigera* on chilli crop

Treatment	Formulation dose	Fruit borer larval population per plant						
		Before first spray	Days after first spray			Days after second spray		
			3 days	7 days	14 days	3 days	7 days	14 days
Cyantraniliprole 10.26% OD	450 ml/ha	2.43 (1.71)	2.10 (1.61)	1.73 (1.49)	1.90 (1.55)	1.47 (1.40)	0.80 (1.14)	0.67 (1.08)
Cyantraniliprole 10.26% OD	600 ml/ha	2.33 (1.68)	1.20 (1.30)	0.63 (1.06)	1.10 (1.26)	0.60 (1.05)	0.37 (0.93)	0.20 (0.83)
Cyantraniliprole 10.26% OD	750 ml/ha	2.30 (1.67)	1.07 (1.25)	0.57 (1.03)	0.87 (1.17)	0.47 (0.98)	0.27 (0.88)	0.13 (0.79)
Lufenuron 5.4% EC	600 ml/ha	2.47 (1.72)	1.67 (1.47)	1.40 (1.38)	1.57 (1.44)	1.20 (1.30)	0.87 (1.17)	0.57 (1.03)
Lambda cyhalothrin 4.9% CS	500 ml/ha	2.20 (1.64)	1.53 (1.43)	1.23 (1.31)	1.47 (1.40)	1.03 (1.24)	0.60 (1.05)	0.47 (0.98)
Emamectin benzoate 5% SG	200 g/ha	1.93 (1.56)	1.70 (1.48)	1.07 (1.25)	1.30 (1.34)	1.10 (1.26)	0.67 (1.08)	0.50 (1.00)
Untreated Control	-	2.10 (1.61)	3.97 (2.11)	6.17 (2.58)	6.60 (2.66)	5.87 (2.52)	4.37 (2.21)	3.80 (2.07)
S Em±		0.05	0.05	0.06	0.04	0.05	0.04	0.05
CD at 5%		NS	0.15	0.17	0.11	0.15	0.12	0.14

NS – Non significant, Figures in parentheses are square root transformed values (x + 0.5)

its lower dose 600 ml/ha at each observation time. The population at 14 days after second spray in the treatment Cyantraniliprole 10.26% OD @ 750 ml/ha reduced to 0.27/plant, which was closely followed by lower dose 600 ml/ha (0.47/plant). Rest of the treatments Lambda cyhalothrin 4.9% CS @ 500 ml/ha, Emamectin benzoate 5% SG @ 200 g/ha, Cyantraniliprole 10.26% OD @ 450 ml/ha and Lufenuron 5.4% EC @ 600 ml/ha with 0.97 to 2.13/plant were next in order of effectiveness and significantly superior to untreated control (8.87/plant). The per cent reduction in thrips population over control based on mean data of two sprays resulted that treatments Cyantraniliprole 10.26% OD @ 750 ml/ha and 600 ml/ha were highly effective at each time interval as compared to other treatments with 82.52 to 92.29% and 79.78 to 90.66% mean reduction in thrips population.

The present studies corroborate the findings of Sahani and Mondal (2020) from Bhirbhum, West Bengal, Italiya *et al*. (2023) and Kakadiya *et al.* (2024) from Anand, Gujarat, Layek *et al*. (2024) from Nadia West Bengal and Poornima *et al.* (2024) from Raichur, Karnataka that Cyantraniliprole 10.26% OD effectively controlled thrips in chilli crop. Cyantraniliprole 10.6% OD is also reported to be effective against sucking insect pests in watermelon crop (Layek *et al*., 2023). Reduction in chilli leaf curl disease transmitted by whitefly has also been reported by Daunde and Khandare (2020) with the application of Cyantraniliprole 10.6% OD @ 1.2 ml/L. Similarly, Cyantraniliprole 10.26% OD @ 90 g a.i/ha was found effective in controlling thrips in pomegranate orchard (Satyanarayana *et al*., 2024). Additionally, Priyanka *et al*. (2023) also reported Cyantraniliprole 300 g/L OD @ 70 and 90 g a.i./ha to be most effective in controlling thrips in grapes.

Control of fruit borer *(H. armigera)*

The larval population of fruit borer recorded at each time interval has been presented in Table 2. It was recorded that before first spray the fruit borer larval population was ranging from 1.93 to 2.47/ plant in different plots and the difference was not significant. The post treatments data recorded at 3, 7 and 14 days after first and second spray showed that at each observation time all the treatments effectively controlled fruit borer larval population on chilli crop as compared to untreated control. It is evident from the data that the treatment

Cyantraniliprole 10.26% OD @ 750 ml/ha was highly effective and closely followed by its lower dose 600 ml/ha at each observation time. The larval population at 14 days after second spray showed that Cyantraniliprole 10.26% OD @ 750 ml/ha was most effective with 0.13 larvae/ plant followed by lower dose 600 ml/ha (0.20 larvae/ plant). Rest of the treatments Lambda cyhalothrin 4.9% CS @ 500 ml/ha, Emamectin benzoate 5% SG @ 200 g/ha, Lufenuron 5.4% EC @ 600 ml/ha and Cyantraniliprole 10.26% OD @ 450 ml/ha with 0.47 to 0.67 larvae/ plant were next in order of effectiveness and significantly superior to untreated control (3.80 larvae/ plant). The per cent reduction in fruit borer larval population over control calculated for mean data of two sprays revealed that Cyantraniliprole 10.26% OD on application @ 750 and 600 ml/ha was highly effective as compared to other treatments for reducing the mean fruit borer larval population at each observation time by 85.38 to 92.67% and 83.06 to 90.66%, respectively.

The present findings are in conformity with Layek *et al*. (2024) reporting from Nadia, West Bengal that Cyantraniliprole 10.26% OD @ 120 g a.i./ha was efficient in controlling larval population of *H. armigera* in chilli crop. Likewise, Sahu and Mandal (2019) reported from Bhubaneswar, Odisha that Cyantraniliprole 10.26% OD @ 70 g a.i./ha was most effective followed by Emamectin benzoate 5% SG @ 10 g a.i./ha to control the larval population of *H. armigera* in capsicum. On okra crop Cyantraniliprole 10.26% OD on application @ 120 g a.i./ha and 90 g a.i./ha was also found equally effective against *H. armigera, Aphis gossypii, Earias vitella* and *S, litura* (Patel and Rahaman, 2021). Additionally, the Cyantraniliprole 10.26% OD @ 600 ml/ha and as a combination product Cyantraniliprole 7.3% w/w + Diafenthiuron 36.4% w/w SC @ 750 and 625 ml/ha were evaluated against sucking and fruit borer pests of okra crop by Kalyan and Kalyan (2022). They have reported that the combination product @ 750 and 625 ml/ha doses was equally effective against jassids, whitefly, mites, *H. armigera* and *Earias* spp. and superior to solo formulation Cyantraniliprole 10.26% OD @ 600 ml/ha.

Control of tobacco caterpillar *(S. litura)*

The larval population of *S. litura* recorded at each time interval has been presented in Table 3. It was recorded that before first spray the larval population of *S. litura* was ranging from 3.40 to 3.87/ plant in different plots and the difference was not significant signifying that

Table 3. Effectiveness of treatments against tobacco caterpillar, *Spodoptera litura* on chilli crop

Treatment	Formulation dose	Tobacco caterpillar larvae per plant						
		Before first spray	Days after first spray			Days after second spray		
			3 days	7 days	14 days	3 days	7 days	14 days
Cyantraniliprole 10.26% OD	450 ml/ha	3.67 (2.04)	2.03 (1.59)	1.77 (1.51)	2.47 (1.72)	1.80 (1.52)	1.33 (1.35)	0.90 (1.18)
Cyantraniliprole 10.26% OD	600 ml/ha	3.40 (1.97)	1.13 (1.28)	0.50 (0.99)	0.93 (1.20)	0.77 (1.12)	0.60 (1.04)	0.47 (0.98)
Cyantraniliprole 10.26% OD	750 ml/ha	3.53 (2.01)	0.87 (1.16)	0.37 (0.93)	0.87 (1.16)	0.63 (1.06)	0.53 (1.02)	0.33 (0.90)
Lufenuron 5.4% EC	600 ml/ha	3.83 (2.08)	1.53 (1.43)	1.30 (1.34)	2.20 (1.64)	1.47 (1.40)	1.07 (1.25)	0.67 (1.08)
Lambda cyhalothrin 4.9% CS	500 ml/ha	3.87 (2.09)	1.67 (1.47)	1.13 (1.28)	2.33 (1.68)	1.17 (1.29)	1.10 (1.26)	0.73 (1.10)
Emamectin benzoate 5% SG	200 g/ha	3.43 (1.98)	1.40 (1.38)	1.07 (1.25)	1.63 (1.46)	1.03 (1.24)	0.87 (1.17)	0.83 (1.15)
Untreated Control	-	3.73 (2.06)	6.53 (2.65)	6.17 (2.58)	6.80 (2.70)	6.53 (2.65)	6.23 (2.59)	4.60 (2.26)
S Em±		0.05	0.03	0.04	0.05	0.06	0.04	0.06
CD at 5%		NS	0.10	0.13	0.14	0.18	0.13	0.18

NS – Non significant, Figures in parentheses are square root transformed values (x + 0.5)

Table 4. Effectiveness of treatments on per cent fruit infestation by *Helicoverpa armigera* and *Spodoptera litura* and crop yield

Treatment	Formulation dose	Per cent fruits infested by *H. armigera*				Per cent fruits infested by *S. litura*				Chilli yield (q/ha)
		Before first spray	10 DAFS	10 DASS	20 DASS	Before first spray	10 DAFS	10 DASS	20 DASS	
Cyantraniliprole 10.26% OD	450 ml/ha	10.00 (18.85)	9.33 (18.26)	7.33 (16.22)	5.33 (13.82)	14.00 (22.35)	11.33 (20.11)	10.00 (18.85)	6.67 (15.31)	10.65
Cyantraniliprole 10.26% OD	600 ml/ha	10.67 (19.29)	6.67 (15.50)	4.00 (12.04)	2.00 (8.47)	10.00 (18.85)	8.00 (16.88)	4.67 (13.09)	3.33 (11.20)	13.83
Cyantraniliprole 10.26% OD	750 ml/ha	12.00 (20.66)	6.00 (14.66)	3.33 (11.20)	0.67 (5.74)	13.33 (21.75)	6.67 (15.50)	4.00 (12.04)	2.00 (8.47)	14.70
Lufenuron 5.4% EC	600 ml/ha	13.33 (21.79)	10.00 (18.85)	8.67 (17.60)	4.67 (13.09)	14.67 (22.85)	12.00 (20.66)	8.67 (17.60)	4.00 (12.04)	11.67
Lambda cyhalothrin 4.9% CS	500 ml/ha	12.67 (21.22)	8.67 (17.60)	8.00 (16.88)	4.00 (12.04)	10.67 (19.51)	10.00 (18.73)	7.33 (16.22)	5.33 (13.61)	11.45
Emamectin benzoate 5% SG	200 g/ha	10.67 (19.41)	8.00 (16.88)	6.00 (14.66)	3.33 (11.20)	12.67 (21.22)	9.33 (18.26)	5.33 (13.93)	4.67 (13.09)	11.02
Untreated Control	-	11.33 (19.94)	18.67 (25.92)	25.33 (30.50)	21.33 (27.82)	12.00 (20.66)	23.33 (29.14)	27.33 (31.82)	28.67 (32.63)	9.10
S Em±		1.66	1.10	1.20	1.68	1.22	1.24	1.04	1.93	0.62
CD at 5%		NS	3.38	3.68	5.18	NS	3.83	3.19	5.96	1.90

NS- Non significant, Figures in parentheses are angular transformed values (x + 0.5)

the larval population was more or less similar in all the experimental plots. The post treatment data recorded at 3, 7 and 14 days after first and second spray showed that at each observation time all the treatments effectively controlled larval population of tobacco caterpillar as compared to untreated control. Amongst the treatments Cyantraniliprole 10.26% OD @ 750 ml/ha was found to be highly effective closely followed by lower dose 600 ml/ha at each observation time. The larval population at 14 days after second spray showed that Cyantraniliprole 10.26% OD @ 750 ml/ha resulted in lowest population 0.33 larvae/ plant followed by lower dose 600 ml/ha with 0.47 larvae/ plant. Remaining treatments Lufenuron 5.4% EC @ 600 ml/ha, Lambda cyhalothrin 4.9% CS @ 500 ml/ha, Emamectin benzoate 5% SG @ 200 g/ha and Cyantraniliprole 10.26% OD @ 450 ml/ha with 0.67 to 0.90 larvae/ plant were next in order of effectiveness and significantly superior to untreated control (4.60 larvae/ plant). The per cent reduction in *S. litura* larval population calculated over untreated control based on mean data of two sprays for 3, 7 and 14 days showed that Cyantraniliprole 10.26% OD on application @ 750 and 600 ml/ha reduce the mean larval population of *S. litura* more efficiently 88.51 to 92.75% and 85.45 to 91.13%, respectively than other treatments.

It is on record that Cyantraniliprole 10.26% OD on application @ 120 g a.i./ha and 90 g a.i./ha on okra crop effectively controlled *H. armigera, Aphis gossypii, Earias vitella* and *S. litura*; and on application over cabbage crop @ 70 g a.i./ha and 60 g a.i./ha the product was effective to control *Brevicoryne brassicae, Lipaphis erysimi, Plutella xylostella* and *S. litura* (Patel and Rahaman, 2021). Tompe *et al*. (2020) conducted polyhouse trial in capsicum crop and reported that Cyantraniliprole 10.26% OD was most promising insecticide to control *S. litura* among the pesticides tested. Other treatments Chlorantraniliprole 18.5% SC, Lufenuron 50% EC, Flubendiamide 39.35% SC, Lambda cyhalothrin 5% EC, Spinosad 45% SC and Indoxacarb 14.5% SC were next in order of effectiveness. The studies carried out on soybean crop to control *S. litura* by Natikar *et al*. (2016) resulted that Flubendiamide 480 SC @ 0.2 ml/l was most effective treatment followed by Indoxacarb 15.8% EC @ 0.3 ml/l and Cyantraniliprole 10% OD @ 0.2 ml/l twice at 15 days interval. Similarly on groundnut crop Jagmohan *et al*. (2024) reported that Chlorantraniliprole 18.5% SC @ 30 g a.i./ha was most effective to control *H. armigera* and *S. litura* which was followed by Cyantraniliprole 10% OD @ 90 g a.i./ha whereas Lambda cyhalothrin 5% EC @ 25 g a.i./ha was comparatively less effective.

The higher efficacy of Cyantraniliprole compared to other tested insecticides in most of the cases may be due to the fact that Cyantraniliprole primarily acts through ingestion and secondarily through contact. As a result, the exposed insects exhibit lethargy and muscle paralysis and stop feeding, ultimately leading to insect death. The present study under Haryana agroclimatic conditions are in support of the results reported from other locations.

Control of fruit damage by *H. armigera* and *S. litura*

The per cent fruit infestation by *H. armigera* and *S. litura* recorded at each time interval has been presented in Table 4. It was recorded that before first spray the fruit infestation by *H. armigera* ranged from 10.00 to 13.33% whereas the fruit infestation by *S. litura* ranged from 10.00 to 14.67% in different plots and the differences were not significant. The post-treatment data recorded at 10 days after first spray and at 10 and 20 days after second spray, indicated that all the treatments were significantly more effective to control fruit infestation by both the pests as compared to untreated control. At 20 days after second spray, Cyantraniliprole 10.26% OD applied @ 750 ml/ha was most effective treatment with fruit infestations of 0.67% by *H. armigera* and 2.00% by *S. litura*. This was followed by Cyantraniliprole 10.26% OD @ 600 ml/ha, which showed fruit damage 2.00% by *H. armigera* and 3.33% by *S. litura*. Other treatments, Emamectin benzoate 5% SG @ 200 g/ha, Lambda cyhalothrin 4.9% CS @ 500 ml/ha, Lufenuron 5.4% EC @ 600 ml/ha and Cyantraniliprole 10.26% OD @ 450 ml/ha resulted in infestations ranging from 3.33 to 5.33% by *H. armigera* and 4.00 to 6.67% by *S. litura.*

Impact on crop yield

The chilli fruit yield recorded periodically and cumulative yield expressed in terms of q/ha has been presented in Table 4. The yield data showed that significantly increased yield was recorded in all the treatments as compared to untreated control except Cyantraniliprole 10.26% OD @ 450 ml/ha. The higher fruit yield 14.70 q/ha was recorded in Cyantraniliprole 10.26% OD @ 750 ml/ha treatment, which was closely followed by the lower dose of the product @ 600 ml/ha (13.83 q/ha). Other treatments Lufenuron 5.4% EC @ 600 ml/ha (11.67 q/ha), Lambda cyhalothrin 4.9% CS @ 500 ml/ha (11.45 q/ha) and Emamectin benzoate 5% SG @ 200 g/ha (11.02 q/ha) were next in order of effectiveness and significantly superior to untreated control. The least effective treatment in terms of fruit yield was Cyantraniliprole 10.26% OD @ 450 ml/ha with 10.65 q/ha, which was not significantly different from untreated control (9.10 q/ha). The relation between percent fruit damage by pests and yield is an indirect indicator for the efficacy of any chemical tested. The chilli yield with the application of Cyantraniliprole 10.26 OD @ 1.2 ml/l has been reported as high as 93.67 q/ha by Kakadiya *et al*. (2024). Patel and Rahaman (2021) reported the lowest (6.01%) mean okra fruit damage by fruit borer *H. armigera* which resulted in higher fruit yield (10.90 t/ha) with the application of Cyantraniliprole 10.26% OD @ 120 g a.i./ha. Higher chilli fruit yield with the application of Cyantraniliprole 10.26% OD has also been reported in comparison to untreated control (Sahani and Mondal, 2020, Kalyan and Kalyan, 2022, Italiya *et al*., 2023, Kakadiya *et al*., 2024).

Phytotoxicity evaluation on chilli crop

The observation for the phytotoxicity parameters recorded visually at 3, 7, 10 and 14 days after each application of treatments showed that no phytotoxicity symptoms were observed due to the application of Cyantraniliprole 10.26% OD @ 450, 600, 750 and 1200 ml/ha and other treatments at respective doses on chilli crop. On potato crop, Cyantraniliprole 10% OD @ 75, 150 and 300 g a.i./ha (Bojan, 2021) and Cyantraniliprole 10.26% OD @ 75 g a.i./ha (Subburaj and Bojan, 2023) have been reported to be non-phytotoxic. Also, Priyanka *et al*. (2023) observed no visible phytotoxicity symptoms on grapes with the application of Cyantraniliprole 300 g/L OD @ 70 and 140 g a.i./ha.

Impact on natural enemies

The prevailing population of natural enemies in the crop field recorded before first spray and at 3 and 7 days after each spray showed that spiders and coccinellids were most prevalent natural enemies in the experimental plots. There was no adverse impact of all the treatments on spiders and coccinellids at each observation time, since there was no significant difference in their populations. The investigations reporting biosafety of Cyantraniliprole to natural enemies like spiders and coccinellids under different crop agro ecosystems are on record. The safety to spiders and coccinellids with the application of Cyantraniliprole 10.26% OD @ 75 g a.i./ha on potato crop (Subburaj and Bojan, 2023) and Cyantraniliprole 300 g/L OD up to 90 g a.i./ha application on grapes (Prinyanka *et al*., 2023) has been reported. In another case sudden decline in coccinellids population with the application of Cyantraniliprole 10 OD @ 60, 75 and 90 g a.i./ha on potato crop has been reported by Bojan (2021), however gradual increase in population was observed thereafter. It is a common fact that the

population of natural enemies often tends to be decline after application of treatments. One of the main basic reasons may be insufficient food available for feeding (low pest population) and predators forced to migrate to other area in search of adequate food availability.

CONCLUSION

The treatment of Cyantraniliprole 10.26% OD on application @ 750 ml/ha and 600 ml/ha resulted to be effective in controlling the incidence of thrips, (*Scirtothrips dorsalis*), fruit borer (*Helicoverpa armigera*) and tobacco caterpillar (*Spodoptera litura*) in chilli crop with low pest population and higher per cent reduction in population over control. The low per cent fruit damage and higher crop yield were also recorded by using these two treatments. Other treatments Lufenuron 5.4% EC @ 600 ml/ha, Lambda cyhalothrin 4.9% CS @ 500 ml/ha, Emamectin benzoate 5% SG @ 200 g/ha and Cyantraniliprole 10.26% OD @ 450 ml/ha were also effective but to some lesser extent. No phytotoxicity to chilli crop and no adverse impact on predators like spiders and coccinellids were observed with the application of all the treatments, which indicated the biosafety and eco-friendly nature of the tested molecules.

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