



Drip Chemigation of Insecticides in Bell Pepper against *Spodoptera litura* (Fabricius) under Protected Cultivation

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ABSTRACT

Background: Capsicum (Sweet pepper or Bell pepper), *Capsicum annuum* L. also popularly called as Simla mirch in India is one of the leading vegetables grown in open conditions as well as under protected conditions. It is attacked by various insect and mite pests from seedling to fruiting stage. The damage caused by *Spodoptera litura* (Fabricius) during flowering and fruit formation is the most concern and farmers everywhere feel the need to protect such high value crops from any type of damage caused by insect pests.

Methods: The trial was conducted under poly house condition during *kharif* 2019 at horticulture garden, College of Agriculture, Rajendranagar, Hyderabad. The experiment was laid out in randomized block design (RBD) with eight treatments replicated thrice in a 7.5 m × 1 m plot size with a spacing of 45 cm × 40 cm. The capsicum hybrid WS 234 was raised as per the recommended package of practices except plant protection measures. The observations on pest incidence were recorded one day before treatment imposition as pre-treatment count. Post treatment counts were recorded at one, three, five and seven days after each chemigation/spray.

Result: The present study indicated that treatment of cyantraniliprole 10.26% OD @ 90 g a.i. ha⁻¹ applied through drip chemigation was effective by recording minimum larval population with lowest fruit damage over all the other treatments. The next best treatment was cyantraniliprole 10.26% OD @ 60 g a.i. ha⁻¹ applied as foliar spray. The order of moderate effective treatments were drip applications of cyantraniliprole 10.26% OD @ 60 g a.i. ha⁻¹ > cyantraniliprole + thiamethoxam 19.8+19.8 w/w @ 64 g a.i. ha⁻¹ > cyantraniliprole + thiamethoxam 19.8+19.8 w/w @ 32 g a.i. ha⁻¹ > imidacloprid 70 WG @ 50 g a.i. ha⁻¹ > imidacloprid 70 WG @ 25 g a.i. ha⁻¹.

Key words: Capsicum, Chemigation, Cyantraniliprole, *Spodoptera litura*.

INTRODUCTION

India is a land of diverse agro climatic zones and each of these zones offers a great potential for cultivation of wide range of crops across all seasons. Vegetables form major and important part of our dietary requirements, which are widely grown in rural and peri-urban areas. Capsicum (Sweet pepper or Bell pepper), *Capsicum annuum* L. also popularly called as Simla mirch in India is one of the leading vegetables grown in open conditions as well as under protected conditions. It is rich in vitamin A (8943 IU), vitamin C (283 mg) and minerals like calcium (13.4 mg), magnesium (14.9 mg), phosphorous (28.3 mg) and potassium (263.7 mg) per 100 g fresh weight (Protected cultivation of Capsicum, IIHR Technical bulletin 2011). Often the productivity of capsicum is very low due to several factors. Among them, insect pests cause severe loss. It is attacked by various insect and mite pests from seedling to fruiting stage. It was reported that a total of 293 insects and mite species attacking the Capsicum crop in the field as well as in storage (Anonymouse, 1987). The damage caused by *Spodoptera litura* (Fabricius) during flowering and fruit formation is the most concern and farmers everywhere feel the need to protect such high value crops from any type of damage caused by insect pests. They often use synthetic insecticides indiscriminately and insect develop resistance to insecticides is very common in the tropics. Many vegetable growers currently use drip irrigation system for water and nutrient management. The use of such system for specific insecticide applications *i.e.* drip chemigation would result in an environmentally suitable and

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cost effective IPM system with less total inputs (time, labour, insecticides) and with less effect on non- target species as compared with multiple foliar sprays of broad spectrum insecticides (Ghidu *et al.*, 2012). Chemigation' is a term defined as the application of agricultural chemicals, including herbicides, insecticides, fungicides and fertilizers through a center pivot system (Chalfant and Young, 1984) and if it is through drip irrigation system, it is said to be 'drip chemigation' (Wildman and Cone, 1986). Neonicotinoids are

effective both as contact insecticides and are also taken up by roots from the soil as systemic insecticides which are transported to the foliage contributing to their success.

MATERIALS AND METHODS

Experimental layout

The trial was conducted under poly house condition during *kharif* 2019 at Horticulture Garden, College of Agriculture, Rajendranagar, Hyderabad. The experiment was laid out in randomized block design (RBD) with eight treatments, i.e. imidacloprid 70 WG @ 25 g a.i ha⁻¹ (T1), imidacloprid 70 WG @ 50 g a.i ha⁻¹ (T2), cyantraniliprole 10.26% OD @ 60 g a.i ha⁻¹ (T3), cyantraniliprole 10.26% OD @ 90 g a.i ha⁻¹ (T4), cyantraniliprole + thiamethoxam 19.8+19.8 w/w @ 32 g a.i ha⁻¹ (T5), cyantraniliprole + thiamethoxam 19.8+19.8 w/w @ 64 g (T6), cyantraniliprole 10.26% OD @ 60 g (foliar spray) (T7) and control (T8), replicated thrice in a 7.5 m × 1 m plot size with a spacing of 45 cm × 40 cm. The capsicum hybrid WS 234 was raised as per the recommended package of practices except plant protection measures.

The chemigation system was custom designed to facilitate the experimental design chosen for the study. Treatments were pumped from a 25 litres capacity plastic container, containing insecticide mixed with required quantity of water, using a 1 H.P self-priming pump that pumps the insecticide solution into the pre-determined sub-main as controlled by the valve at the 8-valve manifold. A single treatment was given by operating each valve at a time that directs the insecticide solution to the selected plots through the drip lines.

The foliar spray treatment was done with a high-volume knapsack sprayer. Both chemigation and foliar spray were executed at the same time.

Observations

The observations on pest incidence were recorded one day before treatment imposition as pre-treatment count. Post treatment counts were recorded at one, three, five and seven days after each chemigation/spray. Fruit borer (*Spodoptera litura*) larvae counts were recorded on randomly selected plants in each replication. The percentage reduction of thrips and *S. litura* in all the treatments over control were calculated using modified Abbott's formula (Fleming and Ratnakaran, 1985).

Statistical analysis

The observations recorded were subjected to statistical analysis to know the significance of difference among treatments. Values in numbers were transformed to square root values. The means values of treatments were compared using Duncan's multiple range test (DMRT) as suggested by Gomez and Gomez (1984).

% population reduction =

$$1 - \left[\frac{\text{Post treatment population in treatment}}{\text{Pre treatment population in treatment}} \times \frac{\text{Pre treatment population in control}}{\text{Post treatment population in control}} \right] \times 100$$

All the treatments were applied through drip chemigations, except T7 (Cyantraniliprole 10.26% OD @ 60 g a.i. ha⁻¹) which is applied as foliar spray, simultaneously at the imposition of treatments through drip chemigation.

RESULTS AND DISCUSSION

The results on the efficacy of different insecticides on *Spodoptera litura* population at one, three, five and seven days after 1st chemigation applied at 75 days after transplanting (DAT) coinciding with the fruiting stage of capsicum are presented in Table 1. There was no significant difference in larval population at pre count.

At 1 day after treatment (DAT), the insecticidal treatment cyantraniliprole 10% OD @ 60 g a.i. ha⁻¹ (foliar spray) recorded the larval population of 2.06/5 plants/bed and found to be significantly superior compared to other treatments at one day after treatment. The next effective treatments followed were drip applied cyantraniliprole 10% OD @ 90 g a.i. ha⁻¹, cyantraniliprole 10% OD @ 60 g a.i. ha⁻¹, cyantraniliprole + thiamethoxam 19.8+19.8 w/w @ 64 g a.i. ha⁻¹ and 32 g a.i. ha⁻¹, imidacloprid 70 WG @ 50 g a.i. ha⁻¹ and 25 g a.i. ha⁻¹ with 2.40, 2.60, 2.72, 2.84, 3.08 and 3.20 larvae/5 plants/bed respectively, which were found to be significantly different with each other, whereas untreated control recorded 4.60 larvae/plant.

At 3 DAT, the insecticidal treatment cyantraniliprole 10% OD @ 90 g a.i. ha⁻¹ (drip applied) recorded the larval population of 1.20/5 plants/bed and was found to be significantly superior compared to other treatments at one day after treatment. Cyantraniliprole 10% OD @ 60 g a.i. ha⁻¹ (foliar spray), the drip applied cyantraniliprole 10% OD @ 60 g a.i. ha⁻¹, cyantraniliprole + thiamethoxam 19.8+19.8 w/w @ 64 g a.i. ha⁻¹ and 32 g a.i. ha⁻¹, imidacloprid 70 WG @ 50 g a.i. ha⁻¹ and 25 g a.i. ha⁻¹ with 1.28, 1.82, 2.02, 2.16, 2.43 and 2.59 larvae/5 plants/bed respectively, which were found to be significantly different with each other, but superior to untreated control with 4.62 larvae/5 plants/bed.

Similar trend was observed at 5 days after treatment, wherein cyantraniliprole 10% OD @ 90 g a.i. ha⁻¹ proved to be the most effective treatment recording least number of larvae/plant (0.80). The next effective treatments were cyantraniliprole 10% OD @ 60 g a.i. ha⁻¹ (foliar spray), cyantraniliprole 10% OD @ 60 g a.i. ha⁻¹, cyantraniliprole + thiamethoxam 19.8+19.8 w/w @ 64 g a.i. ha⁻¹, cyantraniliprole + thiamethoxam @ 32 g a.i. ha⁻¹, imidacloprid 70 WG @ 50 g a.i. ha⁻¹ and imidacloprid 70 WG @ 25 g a.i. ha⁻¹ with 0.90, 1.45, 1.68, 1.82, 2.12 and 2.30 larvae/5 plants/bed, which were significantly different from each other, whereas control plot recorded 4.58 larvae/5 plants/bed.

At 7 days after treatment, the trend continued where in cyantraniliprole 10% OD @ 90 g a.i. ha⁻¹ proved to be the most effective treatment recording least number of larvae/5 plants/bed (0.60). The next effective treatments followed were cyantraniliprole 10% OD @ 60 g a.i. ha⁻¹ (foliar spray), cyantraniliprole 10% OD @ 60 g a.i. ha⁻¹, cyantraniliprole + thiamethoxam 19.8+19.8 w/w @ 64 g a.i. ha⁻¹,

Table 1: Efficacy of selected insecticides against *Spodoptera litura* in capsicum crop after 1st and 2nd chemigation, per cent fruit damage due to *S. litura* at 1st and 2nd harvest.

S. no	Treatment	Dosage @g a.i. ha ⁻¹	Mean no. of larvae/ 5 plants after treatment								Mean no. of larvae/ 5 plants after treatment				% fruit damage at 1 st and 2 nd harvest							
			Pre-count				DAT				Pre-count				DAT				1 st harvest		2 nd harvest	
			1	DAT	3	DAT	5	DAT	7	DAT	1	DAT	3	DAT	5	DAT	7	DAT	% Reduction in loss compared to untreated control	% Reduction in loss compared to untreated control		
T1	Imidacloprid 70 WG	25	4.40 (2.21)	3.20 ^g (1.92)	2.59 ^g (1.75)	2.30 ^g (1.67)	2.19 ^g (1.64)	2.19 ^g (1.64)	2.19 ^g (1.64)	4.26 (2.18)	2.82 ^{de} (1.82)	2.27 ^a (1.66)	1.97 ^g (1.57)	1.86 ^g (1.53)	27.80	50.10%	22.66 ^b	67.32%				
T2	Imidacloprid 70 WG	50	4.48 (2.23)	3.08 ^f (1.89)	2.43 ^f (1.71)	2.12 ^f (1.61)	2.00 ^f (1.58)	2.00 ^f (1.58)	2.00 ^f (1.58)	4.40 (2.21)	2.76 ^d (1.80)	2.19 ^f (1.64)	1.86 ^f (1.53)	1.75 ^f (1.50)	25.70 ^c	53.87%	21.00 ^b	69.72%				
T3	Cytraniliprole 10.26% OD	60	4.30 (2.19)	2.60 ^c (1.76)	1.82 ^c (1.52)	1.45 ^c (1.39)	1.28 ^c (1.33)	1.28 ^c (1.33)	1.28 ^c (1.33)	4.36 (2.21)	2.46 ^c (1.72)	1.69 ^c (1.47)	1.30 ^c (1.34)	1.16 ^c (1.28)	6.24 ^a	88.80%	5.34 ^a	92.30%				
T4	Cytraniliprole 10.26% OD	90	4.40 (2.21)	2.40 ^b (1.70)	1.20 ^a (1.30)	0.80 ^a (1.14)	0.60 ^a (1.04)	0.60 ^a (1.04)	0.60 ^a (1.04)	4.46 (2.22)	2.32 ^b (1.67)	1.34 ^a (1.35)	0.90 ^a (1.18)	0.71 ^a (1.10)	5.16 ^a	90.73%	4.60 ^a	93.36%				
T5	Cytraniliprole + Thiamethoxam 19.8+19.8 w/w	32	4.36 (2.20)	2.84 ^e (1.82)	2.16 ^e (1.63)	1.82 ^e (1.52)	1.68 ^e (1.47)	1.68 ^e (1.47)	1.68 ^e (1.47)	4.50 (2.23)	2.65 ^d (1.77)	2.05 ^e (1.59)	1.70 ^e (1.48)	1.58 ^e (1.44)	8.30 ^{ab}	85.10%	6.44 ^a	90.71%				
T6	Cytraniliprole + Thiamethoxam 19.8+19.8 w/w	64	4.40 (2.21)	2.72 ^d (1.79)	2.02 ^d (1.58)	1.68 ^d (1.47)	1.53 ^d (1.42)	1.53 ^d (1.42)	1.53 ^d (1.42)	4.40 (2.21)	2.50 ^c (1.73)	1.86 ^d (1.53)	1.49 ^d (1.41)	1.36 ^d (1.36)	7.04 ^a	87.36%	5.76 ^a	91.69%				
T7	Cytraniliprole 10.26% OD- Foliar	60	4.26 (2.18)	2.06 ^a (1.60)	1.28 ^b (1.33)	0.90 ^b (1.18)	0.72 ^b (1.10)	0.72 ^b (1.10)	0.72 ^b (1.10)	4.30 (2.19)	2.10 ^a (1.61)	1.41 ^b (1.38)	1.00 ^b (1.22)	0.85 ^b (1.16)	5.46 ^a	90.20%	4.90 ^a	92.93%				
T8	Control	-	4.56 (2.24)	4.60 ^h (2.25)	4.62 ^h (2.26)	4.58 ^h (2.25)	4.60 ^h (2.25)	4.60 ^h (2.25)	4.60 ^h (2.25)	4.64 (2.26)	4.68 ^h (2.27)	4.74 ^h (2.28)	4.76 ^h (2.29)	4.80 ^h (2.30)	55.72 ^d	-	69.36 ^c	-				

cyantraniliprole + thiamethoxam @ 32 g a.i. ha⁻¹, imidacloprid 70 WG @ 50 g a.i. ha⁻¹ and imidacloprid 70 WG @ 25 g a.i. ha⁻¹ with 0.72, 1.28, 1.53, 1.68, 2.00 and 2.19 larvae/5 plants/bed, which were significantly different from each other, whereas control plot recorded 4.58 larvae/5 plants/bed.

The 2nd chemigation was taken up at an interval of 20 days after 1st chemigation @ 95 days after transplanting, when the crop is at fruit development to final stage.

At one day after treatment, the insecticidal treatment cyantraniliprole 10% OD @ 60 g a.i. ha⁻¹ (foliar spray) recorded the larval population of 2.10 larvae/5 plants/bed and found to be significantly superior compared to other treatments at one day after treatment. The next effective treatments followed were drip applied cyantraniliprole 10% OD @ 90 g a.i. ha⁻¹ cyantraniliprole 10% OD @ 60 g a.i. ha⁻¹, cyantraniliprole + thiamethoxam 19.8+19.8 w/w @ 64 g a.i. ha⁻¹ and 32 g a.i. ha⁻¹ recording 2.32, 2.46, 2.50 and 2.65 larvae/5 plants/bed respectively, and were significantly different from each other. However, imidacloprid 70 WG @ 50 g a.i. ha⁻¹ and 25 g a.i. ha⁻¹ are less effective, and recorded 2.72 and 2.86 larvae/5 plants/bed respectively, were found to be on par with each other, whereas untreated control recorded 4.68 larvae/5 plants/bed.

At 3 days after treatment, the insecticidal treatment cyantraniliprole 10% OD @ 90 g a.i. ha⁻¹ (drip applied) recorded the larval population of 1.34/5 plants/bed and was found to be significantly superior compared to other treatments at one day after treatment. Cyantraniliprole 10% OD @ 60 g a.i. ha⁻¹ (foliar spray), cyantraniliprole 10% OD @ 60 g a.i. ha⁻¹, cyantraniliprole + thiamethoxam 19.8+19.8 w/w @ 64 g a.i. ha⁻¹ and 32 g a.i. ha⁻¹, imidacloprid 70 WG @ 50 g a.i. ha⁻¹ and 25 g a.i. ha⁻¹ with 1.41, 1.69, 1.86, 2.05, 2.19 and 2.27 larvae/5 plants/bed respectively, which were found to be significantly different with each other, but superior to untreated control with 4.74 larvae/5 plants/bed.

Similar trend was observed at 5 days after treatment, wherein cyantraniliprole 10% OD @ 90 g a.i. ha⁻¹ proved to be the most effective treatment recording least number of larvae/5 plants/bed (0.90). The next effective treatments were cyantraniliprole 10% OD @ 60 g a.i. ha⁻¹ (foliar spray), cyantraniliprole 10% OD @ 60 g a.i. ha⁻¹, cyantraniliprole + thiamethoxam 19.8+19.8 w/w @ 64 g a.i. ha⁻¹, cyantraniliprole + thiamethoxam @ 32 g a.i. ha⁻¹, imidacloprid 70 WG @ 50 g a.i. ha⁻¹ and imidacloprid 70 WG @ 25 g a.i. ha⁻¹ with 1.00, 1.30, 1.49, 1.70, 1.86 and 1.97 larvae/5 plants/bed, which were significantly different from each other, whereas control plot recorded 4.76 larvae/5 plants/bed.

At 7 days after treatment, the trend continued where in cyantraniliprole 10% OD @ 90 g a.i. ha⁻¹ proved to be the most effective treatment recording least number of larvae/5 plants/bed (0.71). The next effective treatments followed were cyantraniliprole 10% OD @ 60 g a.i. ha⁻¹ (foliar spray), cyantraniliprole 10% OD @ 60 g a.i. ha⁻¹, cyantraniliprole + thiamethoxam 19.8+19.8 w/w @ 64 g a.i. ha⁻¹, cyantraniliprole + thiamethoxam @ 32 g a.i. ha⁻¹, imidacloprid

70 WG @ 50 g a.i. ha⁻¹ and imidacloprid 70 WG @ 25 g a.i. ha⁻¹ with 0.85, 1.16, 1.36, 1.58, 1.75 and 1.86 larvae/5 plants/bed, which were significantly different from each other, whereas control plot recorded 4.80 larvae/5 plants/bed.

The insecticides in the decreasing order of their efficacy were Cyantraniliprole 10.26% OD @ 90 g a.i. ha⁻¹ > cyantraniliprole 10.26% OD @ 60 g a.i. ha⁻¹ (foliar spray) > cyantraniliprole 10.26% OD @ 60 g a.i. ha⁻¹ > cyantraniliprole + thiamethoxam 19.8+19.8 w/w @ 64 g a.i. ha⁻¹ > cyantraniliprole + thiamethoxam 19.8+19.8 w/w @ 32 g a.i. ha⁻¹ > imidacloprid 70 WG @ 50 g a.i. ha⁻¹ > imidacloprid 70 WG @ 25 g a.i. ha⁻¹.

The results pertaining to fruit damage due to *S. litura* at 1st harvest (85 days after transplanting and 10 days after 1st chemigation) are presented in Table 1 revealed that treatments of cyantraniliprole 10% OD @ 90 g a.i. ha⁻¹, cyantraniliprole 10% OD @ 60 g a.i. ha⁻¹ (foliar spray), lower dose of drip applied cyantraniliprole 10% OD @ 60 g a.i. ha⁻¹, cyantraniliprole + thiamethoxam 19.8+19.8 w/w @ 64 g a.i. ha⁻¹ and 32 g a.i. ha⁻¹ were on par with each other recording per cent fruit damage @ 5.16, 5.46, 6.24, 7.04 and 8.30 respectively. Imidacloprid 70 WG @ 50 g a.i. ha⁻¹ (25.70%) and 25 g a.i. ha⁻¹ (27.80%) were found to be on par with each other, whereas untreated control recorded 55.72% fruit infestation, and was significantly different from other treatments.

The results pertaining to fruit damage due to *S. litura* at 2nd harvest (105 days after transplanting and 15 days after 2nd chemigation) are presented in Table 1 revealed that treatments of cyantraniliprole 10% OD @ 90 g a.i. ha⁻¹, cyantraniliprole 10% OD @ 60 g a.i. ha⁻¹ (foliar spray), lower dose of drip applied cyantraniliprole 10% OD @ 60 g a.i. ha⁻¹, cyantraniliprole + thiamethoxam 19.8+19.8 w/w @ 64 g a.i. ha⁻¹ and 32 g a.i. ha⁻¹ were on par with each other recording per cent fruit damage @ 4.60, 4.90, 5.34, 5.76 and 6.44 respectively. However, imidacloprid 70 WG @ 50 g a.i. ha⁻¹ and 25 g a.i. ha⁻¹, which have recorded the per cent fruit damage @ 21.00% and 22.66% respectively were on par with each other, whereas untreated control recorded 69.36% fruit damage and was significantly different from other treatments.

Since sufficient literature was not available on the efficacy of cyantraniliprole applied via drip chemigation in vegetable crops, the present investigation results were compared with chlorantraniliprole (as both cyantraniliprole and chlorantraniliprole belong to anthranilic diamide class).

The present investigations are in line with Ghidui *et al.* (2009) who reported that chlorantraniliprole injected through drip irrigation system at either 0.05 kg ha⁻¹ or 0.07 kg ha⁻¹ was more effective in reducing percentage of European corn borer in peppers than standard grower pesticide program of two applications of acephate followed by several applications of indoxacarb. Schuster *et al.* (2009) reported that drip application of chlorantraniliprole 200 SC @ 5.0 oz/acre minimized the attack of army worm *Spodoptera* spp., damage in tomatoes.

In comparison with foliar spray, Patel *et al.* (2012) reported that cyantraniliprole @ 105 and 90 g a.i. ha⁻¹ recorded higher per cent larval mortality of *Spodoptera litura* in cotton than the rest of treatments. Further, Yadav *et al.* (2012) also reported that cyantraniliprole at the rate of 70 and 80 g a.i. ha⁻¹ was found to be most effective in reducing the *S. litura* population in table grapes.

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