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Bioefficacy and Safety of Cyantraniliprole 10 % (W/V) OD Against Sucking Pests in Cotton

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ABSTRACT

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Cyantraniliprole 10% OD at 90 g a.i.ha⁻¹ was significantly effective when sprayed twice at 15 days interval, minimized the sucking pests population and increased cotton kapas yield. Cyantraniliprole 10% OD treatments at 90, 180 and 320 g a.i. ha⁻¹ concentrations had not caused any phytotoxic effects like injury to leaf tip, leaf surface, wilting, vein clearing, necrosis, epinasty and hyponasty. Cyantraniliprole 10% (w/v) OD showed the least effect against the spiders. Spider's population in cotton ecosystem showed considerable decrease initially in all the treatments, it started increasing in later.

Introduction

Cotton (*Gossypium spp.*), is an important agricultural commodity, traded all over the world. In general, the conditions required for the cultivation of cotton are met within the seasonally dry tropics and subtropics in the Northern and Southern hemispheres. India has progressed substantially in improving both production and productivity of cotton over the last five years, transforming from a net importer of cotton, to becoming one of the largest exporters, shipping 5.5 million bales in 2010-11, second only to the USA. About 70 per cent of the global cotton production comes from four countries, which include China (27%), India (22%), USA (13%) and Pakistan (8%). Cotton cultivation is a very

important part of the Indian agrarian landscape and provides sustainable livelihood to a sizeable population in India. It is cultivated about 10.31 million hectares in the country, which accounts for 30 per cent of the global cotton area and contributes to 22 per cent of the global cotton production. It is estimated that more than 5.8 million farmers cultivate cotton in India and about 40-50 million people are employed directly or indirectly by the cotton industry. Cotton is cultivated about 1.21 lakh hectares in Tamil Nadu (Anonymous, 2012). The yield loss to cotton due to insect pests is 87 per cent (Taley *et al.*, 1988). Nearly 1,326 insects and mites all over the world and about 200 insects in

India have been documented of which ten are economically important in Tamil Nadu (Venugopal, 1998). Major sucking pests consisting of *Amrasca biguttula biguttula*, *Aphis gossypii*, *Thrips tabaci* and *Bemisia tabaci* inflict heavy damage.

Chemical insecticides are used as the frontline defence sources against these insect pests, in spite of their drawbacks and the cotton growers in India depend heavily on synthetic pesticides to combat pests and it has been estimated that cotton consumes about 54 per cent of the total insecticides used in the country (Anonymous, 1997). Indiscriminate use of organophosphates, carbamates and synthetic pyrethroids has created a number of problems such as pests developing resistance to insecticides (McCaffery *et al.*, 1989; Armes *et al.*, 1994), pest resurgence (Hardin *et al.*, 1995) and bioconcentrations of pesticide residues in consumable produce at harvest (Rolando *et al.*, 1982). Among the harmful effects of insecticides, persistence of toxic pesticide residues in plants, soil and water are of great concern for consumer's health and safety to animals. It is estimated that more than 50 per cent of applied insecticides reach the soil and water bodies during application (Awasthi *et al.*, 2002).

As chemical pesticides continue to be the mainstay of most of the pest control programmes. At the same time, to overcome the above problems, identification of new molecules are needed to combat the associated drawbacks. At present, the golden age of insecticide research has come with selective, neuro active and easily degradable compounds. These newer molecules always have a higher stability and superiority over conventional pesticides to control the pest population in a classical manner at field level. In this array, newer groups with higher insecticidal property, selective action and lower mammalian toxicity fits well in the

integrated pest management (IPM) concept. In IPM programmes, insecticides having selectivity, favouring non-target organisms like parasitoids and predators are highly preferred. Formulations that are safe to the applicator and more environment friendly are encouraged. One such new molecule, cyantraniliprole 10% OD is a novel class of insecticide having a unique chemical structure used against broad spectrum of insects and safe to non-target insects (parasitoids, predators and pollinators) and acts on ryanodine receptor modulator. It is also used to control insects which are found resistant to other insecticides and fits into IPM programs. With the above background, investigations were carried out on cyantraniliprole 10% OD, a new formulation.

Materials and Methods

***In-vivo* evaluation**

Cyantraniliprole 10% OD was tested along with eight treatments including untreated check replicated thrice in cotton during 2012 and 2013 at Tamil Nadu Agricultural University, Coimbatore. The experiments were conducted in a randomized block design with a plot size of 3 x 7m with three replications using the variety Surabhi. Applications of different treatments were imposed three times at an interval of 15 days during fruit formation stage using a high volume sprayer. The spraying was done during morning hours in such a way as to give uniform coverage on foliage and to avoid drift. A second spray was given 14 days after first application or considering the sucking pests and larval population crossing the ETL. The treatments were imposed commencing from 65th day after planting with pneumatic knapsack sprayer using 500 litres of spray fluid per hectare. The data on percentage were transformed in to arcsine values and the population number into $\sqrt{X+0.5}$ before

statistical analysis. The mean values were separated using Duncan's Multiple Range Test (DMRT). The treatments evaluated were as follows:

S. No	Name of the treatment	Dose g a.i ha ⁻¹
1	Cyantraniliprole 10% OD	45
2	Cyantraniliprole 10% OD	60
3	Cyantraniliprole 10% OD	75
4	Cyantraniliprole 10% OD	90
5	Cyantraniliprole 10% OD	105
6	Chlorantraniliprole 20% SC	40
7	Acetamiprid 20 % SP	100
8	Untreated check	-

Assessment of pest population

Sucking pests

Observations on sucking insect pests *viz.*, aphids, jassids, thrips, and whiteflies were made before as well as on 7 day after each application at three leaves per plant, one each from top, middle and bottom region from 5 randomly selected plants per plot, random, leaving border rows.

Natural enemies (Spiders)

In both the field trials, the natural enemies' fauna *viz.*, spiders were recorded and the diversity of spiders was assessed at insecticide treated plots in cotton ecosystem from first and second experiment. The number of spiders was recorded on 5 randomly tagged plants per plot prior to application of insecticides and on 7 and 14 DAT in order to assess the effect of insecticides.

Yield assessment

Cotton yield per plot was recorded from each picking and pooled to arrive the total yield.

Finally, it was computed to quintal ha⁻¹ and the same was subjected to statistical analysis.

Results and discussion

Efficacy of cyantraniliprole 10% (w/v) OD against sucking pests

Jassids, *Amrasca biguttula biguttula*

The first and second season experiment was conducted to evaluate the bioefficacy of cyantraniliprole 10% OD against jassids on cotton at TNAU, Coimbatore. After 7 days of first spraying, significant reduction in jassids population was observed in cyantraniliprole 10% OD treatments at 90 and 105 g a.i. ha⁻¹ which recorded 8.90, 8.57 and 0.24, 0.23 jassids per three leaves plant⁻¹, respectively. The standard insecticides *viz.*, chlorantraniliprole 20% SC at 40 g a.i. ha⁻¹ and acetamiprid 20% SP at 100 g a.i. ha⁻¹ recorded 61.23, 52.92 and 62.19, 50.42 per cent reduction of jassids populations in first and second seasons, respectively. After second application, cyantraniliprole 10% OD at 90 and 105 g a.i. ha⁻¹ recorded 90.15, 90.15 and 95.87, 95.87 per cent reduction in jassids population at 7 days after spraying in first and second seasons, respectively (Table1).

Whiteflies, *Bemisia tabaci*

Seven days after application of cyantraniliprole 10% OD at 105 and 90 g a.i. ha⁻¹ were on par with each other in first and second spray (1.00, 1.33 and 0.30, 0.47 nos. three leaves⁻¹) followed by 75 g a.i. ha⁻¹ which recorded the lowest level of whitefly population (2.47 and 1.67 nos. five leaves⁻¹), (Table 2). The same trend was noticed in second season also. More than 90 per cent reduction of whitefly was observed after 7 days of application of cyantraniliprole 10% OD at 105 g a.i. ha⁻¹ and 90 g a.i. ha⁻¹.

Table.1 Effect of cyantraniliprole 10% OD on leaf hopper, *A.biguttula biguttula* in cotton for season I and season II

S. No	Treatments	Leaf hopper population (Nos. 3 leaves ⁻¹) (Mean of three replication)									
		PTC	Season I				PTC	Season II			
			I spray		II spray			I spray		II spray	
			7DAS	%RC	7DAS	%RC		7DAS	%RC	7DAS	%RC
1	Cyantraniliprole 10% OD at 45 g a.i.ha ⁻¹	12.23	11.77 (3.41) ^c	59.85	9.33 (3.29) ^c	69.37	6.75	2.69 (1.78) ^b	62.21	1.70 (1.48) ^b	78.75
2	Cyantraniliprole 10% OD at 60 g a.i.ha ⁻¹	12.00	10.77 (3.32) ^c	59.85	9.00 (3.29) ^c	70.46	6.80	2.50 (1.73) ^b	64.88	1.30 (1.34) ^b	83.75
3	Cyantraniliprole 10% OD at 75 g a.i.ha ⁻¹	12.47	10.00 (3.32) ^c	62.72	8.00 (2.91) ^b	73.74	6.87	2.27 (1.66) ^b	68.11	1.27 (1.33) ^b	84.12
4	Cyantraniliprole 10% OD at 90 g a.i.ha ⁻¹	12.00	8.90 (3.06) ^{ab}	66.82	3.00 (1.87) ^a	90.15	6.07	0.24 (0.86) ^a	96.62	0.33 (0.91) ^a	95.87
5	Cyantraniliprole 10% OD at 105 g a.i.ha ⁻¹	12.43	8.57 (2.99) ^a	68.05	3.00 (1.87) ^a	90.15	6.67	0.23 (0.85) ^a	96.76	0.33 (0.91) ^a	95.87
6	Chlorantraniliprole 20% SC at 40 g a.i.ha ⁻¹	12.67	10.40 (3.30) ^c	61.23	9.13 (3.10) ^{bc}	70.03	6.47	2.69 (1.78) ^b	62.19	1.07 (1.25) ^b	86.62
7	Acetamiprid 20 % SP at 100 g a.i.ha ⁻¹	12.69	12.63 (3.59) ^d	52.92	10.20 (3.27) ^c	66.52	6.27	3.53 (2.01) ^c	50.42	2.27 (1.66) ^c	71.62
8	Untreated check	12.20	26.83 (5.31) ^e	-	30.47 (5.56) ^d	-	6.00	7.12 (2.76) ^d	-	8.00 (2.91) ^d	-

PTC- Pretreatment count

Values in parentheses are $\sqrt{x + 0.5}$ transformed values

In a column means followed by a common letter are not significantly different by DMRT (P=0.05)

Table.2 Effect of cyantraniliprole 10% OD on whiteflies, *B. tabaci* in cotton for season I and season II

S. No	Treatments	Whiteflies (Nos. 3 leaves ⁻¹) (Mean of three replication)									
		PTC	Season I				PTC	Season II			
			I spray		II spray			I spray		II spray	
			7DAS	%RC	7DAS	%RC		7DAS	%RC	7DAS	%RC
1	Cyantraniliprole 10% OD at 45 g a.i.ha ⁻¹	4.67	3.67 (2.04) ^c	26.15	2.67 (1.78) ^{bc}	61.69	7.23	5.27 (2.40) ^c	38.50	5.00 (2.34) ^c	54.54
2	Cyantraniliprole 10% OD at 60 g a.i.ha ⁻¹	4.93	2.57 (1.75) ^b	48.28	2.00 (1.58) ^{bc}	71.30	7.47	4.37 (2.20) ^{bc}	49.00	4.00 (2.12) ^{bc}	63.63
3	Cyantraniliprole 10% OD at 75 g a.i.ha ⁻¹	4.67	2.47 (1.72) ^b	50.30	1.67 (1.47) ^b	76.04	7.00	3.27 (1.94) ^b	61.84	3.00 (1.87) ^b	72.72
4	Cyantraniliprole 10% OD at 90 g a.i.ha ⁻¹	4.00	1.33 (1.35) ^a	73.23	0.47 (0.98) ^a	93.25	7.27	1.77 (1.50) ^a	79.34	0.27 (0.87) ^a	97.54
5	Cyantraniliprole 10% OD at 105 g a.i.ha ⁻¹	4.57	1.00 (1.22) ^a	79.89	0.30 (0.89) ^a	95.69	7.79	1.03 (1.23) ^a	87.98	0.27 (0.87) ^a	97.54
6	Chlorantraniliprole 20% SC at 40 g a.i.ha ⁻¹	4.97	2.70 (1.78) ^b	45.67	2.33 (1.68) ^{bc}	66.57	7.83	3.33 (1.95) ^b	61.14	4.67 (2.27) ^c	57.54
7	Acetamiprid 20 % SP at 100 g a.i.ha ⁻¹	4.03	3.67 (2.04) ^c	26.15	3.00 (1.87) ^d	56.95	7.49	5.69 (2.48) ^c	33.60	5.27 (2.40) ^c	52.09
8	Untreated check	4.33	4.97 (2.33) ^d	-	6.97 (2.73) ^e	-	7.53	8.57 (3.81) ^d	-	11.00 (4.06) ^d	

PTC- Pretreatment count

Values in parentheses are $\sqrt{x + 0.5}$ transformed values

In a column means followed by a common letter are not significantly different by DMRT (P=0.05)

Table.3 Effect of cyantraniliprole 10% OD on thrips, *T. tabaci* in cotton for season I and season II

S. No	Treatments	PTC	Thrips population (Nos. 3 leaves ⁻¹) (Mean of three replication)								
			Season I				PTC	Season II			
			I spray		II spray			I spray		II spray	
7DAS	%RC	7DAS	%RC	7DAS	%RC	7DAS	%RC				
1	Cyantraniliprole 10% OD at 45 g a.i.ha ⁻¹	5.00	3.37 (1.96) ^c	61.13	2.30 (1.14) ^{bc}	80.78	5.20	4.00 (2.12) ^b	64.91	3.69 (2.04) ^{bc}	71.89
2	Cyantraniliprole 10% OD at 60 g a.i.ha ⁻¹	4.33	2.00 (1.58) ^b	76.93	2.00 (1.08) ^{bc}	83.29	5.57	3.83 (2.08) ^b	66.40	3.00 (1.87) ^b	77.15
3	Cyantraniliprole 10% OD at 75 g a.i.ha ⁻¹	4.00	1.87 (1.53) ^b	78.43	1.43 (0.91) ^b	88.05	5.23	3.43 (1.98) ^b	69.91	2.67 (1.78) ^b	79.66
4	Cyantraniliprole 10% OD at 90 g a.i.ha ⁻¹	5.00	0.57 (0.87) ^a	93.42	0.30 (0.89) ^a	97.49	5.67	1.07 (1.25) ^a	90.61	0.80 (1.14) ^a	93.90
5	Cyantraniliprole 10% OD at 105 g a.i.ha ⁻¹	4.97	0.27 (0.87) ^a	96.88	0.20 (0.83) ^a	98.32	5.93	0.93 (1.19) ^a	91.84	0.73 (1.10) ^a	94.44
6	Chlorantraniliprole 20% SC at 40 g a.i.ha ⁻¹	4.00	2.00 (1.58) ^b	76.93	2.90 (1.18) ^{bc}	75.77	5.57	4.50 (2.23) ^{bc}	60.52	4.00 (2.12) ^c	69.53
7	Acetamiprid 20 % SP at 100 g a.i.ha ⁻¹	4.33	2.00 (1.58) ^b	76.93	2.00 (1.22) ^{bc}	83.29	5.27	3.67 (2.04) ^b	67.80	3.27 (1.94) ^{bc}	75.09
8	Untreated check	4.67	8.67 (3.02) ^d	-	11.97 (3.53) ^d	-	5.50	11.40 (3.44) ^d	-	13.13 (3.70) ^d	-

PTC- Pretreatment count

Values in parentheses are $\sqrt{x + 0.5}$ transformed values

In a column means followed by a common letter are not significantly different by DMRT (P=0.05)

Table.4 Effect of cyantraniliprole 10% OD on aphids, *A. gossypii* in cotton for season I and season II

S. No	Treatments	Aphids population (Nos. 3 leaves ⁻¹) (Mean of three replication)									
		PTC	Season I				PTC	Season II			
			I spray		II spray			I spray		II spray	
			7DAS	%RC	7DAS	%RC		7DAS	%RC	7DAS	%RC
1	Cyantraniliprole 10% OD at 45 g a.i.ha ⁻¹	12.00	9.27 (3.12) ^{bc}	49.97	7.00 (2.73) ^b	66.23	10.00	7.27 (2.78) ^{bc}	56.01	6.00 (2.54) ^b	69.58
2	Cyantraniliprole 10% OD at 60 g a.i.ha ⁻¹	12.23	9.00 (3.08) ^{bc}	51.43	6.67 (2.67) ^b	67.82	9.33	7.00 (2.73) ^{bc}	57.65	5.67 (2.48) ^b	71.26
3	Cyantraniliprole 10% OD at 75 g a.i.ha ⁻¹	12.29	8.47 (2.99) ^{bc}	54.29	6.27 (2.60) ^b	69.75	10.33	6.47 (2.64) ^{bc}	60.85	5.27 (2.40) ^b	73.28
4	Cyantraniliprole 10% OD at 90 g a.i.ha ⁻¹	12.47	6.33 (2.61) ^a	65.83	4.53 (2.24) ^a	78.14	9.67	4.33 (2.19) ^a	73.80	3.53 (2.00) ^a	82.10
5	Cyantraniliprole 10% OD at 105 g a.i.ha ⁻¹	12.73	5.23 (2.39) ^a	71.17	4.00 (2.12) ^a	80.70	9.87	3.23 (1.93) ^a	80.45	3.00 (1.87) ^a	84.79
6	Chlorantraniliprole 20% SC at 40 g a.i.ha ⁻¹	12.69	9.13 (3.10) ^c	50.72	7.47 (2.82) ^{bc}	63.96	10.67	7.13 (2.76) ^c	56.86	6.47 (2.64) ^{bc}	67.20
7	Acetamiprid 20 % SP at 100 g a.i.ha ⁻¹	12.00	8.47 (2.99) ^{bc}	54.29	6.47 (2.64) ^b	68.78	10.33	6.47 (2.64) ^{bc}	60.85	5.47 (2.44) ^b	72.27
8	Untreated check	12.47	18.53 (4.36) ^d	-	20.73 (4.60) ^d	-	10.00	16.53 (4.12) ^d	-	19.73 (4.50) ^d	-

PTC- Pretreatment count

Values in parentheses are $\sqrt{x + 0.5}$ transformed values

In a column means followed by a common letter are not significantly different by DMRT (P=0.05)

Table.5 Effect of cyantraniliprole 10% OD on the yield of cotton

Treatments	Dose (g a.i.ha ⁻¹)	Kapas Yield (q ha ⁻¹)	
		Season I	Season II
Cyantraniliprole 10% OD	45	15.32 ^c	14.32 ^c
Cyantraniliprole 10% OD	60	16.80 ^b	16.87 ^b
Cyantraniliprole 10% OD	75	16.20 ^b	16.20 ^b
Cyantraniliprole 10% OD	90	19.45 ^a	18.45 ^a
Cyantraniliprole 10% OD	105	19.88 ^a	18.47 ^a
Chlorantraniliprole 20% SC	40	15.47 ^c	14.49 ^c
Acetamiprid 20 % SP	100	12.23 ^d	11.43 ^d
Untreated check	-	12.08 ^d	10.02 ^e

*Mean of three plots; in a column,

Means followed by a common letter(s) are not significantly different by DMRT (P=0.05)

Table.6 Phytotoxicity of cyantraniliprole 10 OD on cotton

Treatment	Dose (g a.i.ha ⁻¹)	Phytotoxic symptoms*				
		Injury to leaf tip	Wilting	Vein clearing	Necrosis	Epinasty and Hyponasty
Cyantraniliprole 10% OD	90	0	0	0	0	0
Cyantraniliprole 10% OD	180	0	0	0	0	0
Cyantraniliprole 10% OD	360	0	0	0	0	0
Untreated check	-	0	0	0	0	0

*Symptoms for phytotoxicity observed on 1, 3, 7, 10, 14 days after spray

0 – No phytotoxicity

Table.7 Effect of cyantraniliprole 100D on spiders in cotton for season I and season II

S. No	Treatments	Spiders population (No./ 5 plants)* (Mean of three replication)									
		PTC	Season I				PTC	Season II			
			I spray		II spray			I spray		II spray	
			7DAS	14DAS	7DAS	14DAS		7DAS	14DAS	7DAS	14DAS
1	Cyantraniliprole 10% OD at 45 g a.i.ha ⁻¹	3.67	4.87 (2.32) ^a	6.00 (2.55) ^{ab}	6.33 (2.61) ^{ab}	7.87 (2.89) ^{ab}	4.33	4.33 (2.20) ^{ab}	5.67 (2.48) ^{ab}	6.33 (2.61) ^b	7.77 (2.88) ^{ab}
2	Cyantraniliprole 10% OD at 60 g a.i.ha ⁻¹	3.80	4.67 (2.27) ^{ab}	5.60 (2.47) ^{ab}	6.00 (2.55) ^{bc}	7.00 (2.74) ^{bcd}	4.00	4.00 (2.12) ^{abc}	5.50 (2.45) ^{ab}	6.07 (2.56) ^{bc}	7.33 (2.80) ^{abc}
3	Cyantraniliprole 10% OD at 75 g a.i.ha ⁻¹	3.67	4.33 (2.20) ^{ab}	5.33 (2.41) ^b	6.00 (2.55) ^{bc}	7.33 (2.80) ^{abc}	3.33	4.00 (2.12) ^{abc}	5.50 (2.45) ^{ab}	6.10 (2.57) ^{bc}	7.30 (2.79) ^{abc}
4	Cyantraniliprole 10% OD at 90 g a.i.ha ⁻¹	2.87	4.33 (2.20) ^{ab}	5.00 (2.35) ^b	5.87 (2.52) ^{bc}	6.60 (2.66) ^{cde}	3.67	3.50 (2.00) ^{bc}	5.37 (2.42) ^{bc}	5.87 (2.52) ^{bc}	6.67 (2.68) ^{cd}
5	Cyantraniliprole 10% OD at 105 g a.i.ha ⁻¹	3.17	4.00 (2.12) ^{bc}	4.67 (2.27) ^{bc}	5.33 (2.41) ^c	6.00 (2.55) ^e	3.67	3.17 (1.92) ^c	5.30 (2.41) ^{bc}	5.67 (2.48) ^{bc}	6.33 (2.61) ^d
6	Chlorantraniliprole 20% SC at 40 g a.i.ha ⁻¹	2.93	4.00 (2.12) ^{bc}	5.00 (2.35) ^{bc}	5.67 (2.48) ^{bc}	7.00 (2.74) ^{bcd}	4.33	3.67 (2.04) ^{bc}	5.00 (2.35) ^{bc}	5.97 (2.54) ^{bc}	7.00 (2.74) ^{bcd}
7	Acetamiprid 20 % SP at 100 g a.i.ha ⁻¹	3.00	3.33 (1.96) ^c	5.00 (2.35) ^{bc}	5.33 (2.41) ^c	6.33 (2.61) ^{de}	3.33	3.33 (1.96) ^c	4.67 (2.27) ^c	5.33 (2.41) ^c	6.33 (2.61) ^d
8	Untreated check	3.00	5.00 (2.35) ^a	6.33 (2.61) ^a	7.00 (2.74) ^a	8.00 (2.92) ^a	3.67	4.80 (2.30) ^a	6.37 (2.62) ^a	7.33 (2.80) ^a	8.00 (2.92) ^a

PTC- Pretreatment count

Values in parentheses are $\sqrt{x + 0.5}$ transformed values

In a column means followed by a common letter are not significantly different by DMRT (P=0.05)

Thrips, Thrips tabaci

Significant reduction in thrips population was observed in cyantraniliprole 10% OD treatments at 90 and 105 g a.i. ha⁻¹ which recorded 0.57, 0.30 and 0.27, 0.20 thrips three leaves plants⁻¹ after first and second spray, respectively at 7 DAS.

While the untreated check recorded 8.67 and 11.97 thrips three leaves⁻¹ plant⁻¹ at 7 days after first and second application respectively.

During second season, cyantraniliprole 10% OD at 90 and 105 g a.i. ha⁻¹ recorded 90.61, 91.84 and 93.90, 94.44 per cent reduction in thrips population after first and second spray at 7 DAS, respectively (Table 3).

Aphid, Aphis gossypii

The pretreatment population of aphids varied from 12.0 to 12.73 nos. five leaves⁻¹ (Table 4). After 7 days of first spraying, significant reduction in aphids population was observed in cyantraniliprole 10 % OD treatments at 105 and 90 g a.i. ha⁻¹ which recorded 71.17, 65.83 and 80.70, 78.14 per cent reduction of aphids population in first season at first and second spray, respectively. Whereas, the standard insecticides *viz.*, chlorantraniliprole 20% SC at 40 g a.i. ha⁻¹ and acetamprid 20% SP at 100 g a.i. ha⁻¹ recorded 50.72, 54.29 and 63.96, 68.78 per cent reduction in aphids population in first season at first and second spray, respectively.

While second season, cyantraniliprole 10% OD at 90 and 105 g a.i. ha⁻¹ recorded 73.80, 80.45 and 82.10, 84.79 per cent reduction in aphids population at 7 days after spraying, respectively whereas chlorantraniliprole 20% SC and acetamprid 20% SP recorded 56.86, 60.85 and 67.20, 72.27 per cent reduction in aphids population at 7 days after first and second spraying, respectively.

Phytotoxicity of cyantraniliprole 10% (w/v) OD in cotton

Results of the field trial conducted at TNAU of Coimbatore district revealed that cotton plants sprayed with cyantraniliprole 10 OD at 90, 180 and 360 g a.i. ha⁻¹ doses did not show any phytotoxic symptoms like leaf tip injury, vein clearing, wilting, necrosis, epinasty and hyponasty. The phytotoxic rating of zero in all the doses was observed on 1, 3, 7, 10 and 14 DAS (Table 5).

Bio-safety of cyantraniliprole 10% (w/v) OD on coccinellids and spiders

Spiders

In the first and second field experiment, pretreatment population of spiders ranged from 2.87 to 3.80 and 3.33 to 4.33 per five plants, respectively. The lowest concentration of cyantraniliprole 10 OD at 45 g a.i. ha⁻¹ harbored maximum spider population of 4.87, 6.00 and 6.33, 7.87 at 7 and 14th days after first and second spray per five plants followed by cyantraniliprole 10 OD at 60 g a.i. ha⁻¹ (4.67, 5.60 and 6.00, 7.00 nos. after first and second spray, respectively) and cyantraniliprole 10 OD at 75 g a.i. ha⁻¹ (4.33, 6.00 and 5.33, 7.33 nos. after first and second spray, respectively). After second season, cyantraniliprole 10 OD treated plots at 75, 60 and 45 g a.i. ha⁻¹ recorded the maximum spider population per five plants which was on par with untreated check (Table 6).

The results of the field experiments on cotton revealed that after second application cyantraniliprole 10% OD at 90 and 105 g a.i. ha⁻¹ recorded 90.15, 90.15 and 95.87, 95.87 per cent reduction in jassids population at 7 days after spraying in first and second seasons, respectively. Cyantraniliprole 10% OD at 105 and 90 g a.i. ha⁻¹ were on par with each other in first and second spray (1.00,

1.33 and 0.30, 0.47 nos. three leaves⁻¹) and Ninety per cent reduction of whitefly population was observed after 7 days of. This is in conformity with finding of Patel *et al.*, 2014 stated that after 3rd day, newer molecule of cyantraniliprole at 105 g a.i. ha⁻¹ was found significantly more effective than all the doses of cyantraniliprole, except 90 g a.i. ha⁻¹ and recorded lower population of whitefly *i.e.* 0.92 and 0.75 per leaf after 3rd day and 0.26 and 0.14 per leaf after 7th day of spray during 2010- 11 and 2011-12, respectively.

In case of cyantraniliprole at 90 g a.i. ha⁻¹, it was 1.01 and 0.82 after 3rd day of spray and 0.31 and 0.17 per leaf after 7th day of spray. Similarly, cyantraniliprole (90 and 105 g a.i. ha⁻¹) was also effective against whitefly on okra, brinjal and tomato as reported by Patel *et al.*, 2011, Patel and Kher, 2012.

After seven days of first spraying, significant reduction in aphids population was observed in cyantraniliprole 10 % OD treatments at 90 and 105 g a.i. ha⁻¹ which recorded 71.17, 65.83 and 80.70, 78.14 per cent reduction of aphids population in first season at first and second spray, respectively. The superiority of cyantraniliprole against *A. gossypii* revealed in present study is in accordance with reports of Patel *et al.*, 2014 who reported that among the insecticidal treatments, cyantraniliprole at highest dose *i.e.* 105 g a.i. ha⁻¹ significantly reduced the aphid population and recorded 1.38 and 2.22 per leaf at 3rd day after spray and 0.17 and 0.42 per leaf at 7th day after spray during 2010-11 and 2011-12, respectively.

The treatment of cyantraniliprole at 90 g a.i.ha⁻¹ stood next to this and was at par with the highest dose cyantraniliprole of 105 g a.i.ha⁻¹. Misra (2013) reported that cyantraniliprole (HGW86) 10 per cent OD at the rate of 90 and 105 g a.i. ha⁻¹ (4.87 and 7.40) with 98.79, 93.85 and 95.95 per cent reduction in aphid population over untreated

control, respectively. Mandal (2012) who reported that cyantraniliprole at 90 and 105 g a.i.ha⁻¹ was more effective in reducing the pest population in tomato.

The anthranillic diamide insecticide group possesses anti-feedant properties that differ between chemicals of this group and insects (Gonzales-Coloma *et al.*, 1999) which might be the reason of record of low population of aphids. Cyantraniliprole 10% OD at 90 and 105 g a.i. ha⁻¹ recorded 90.61, 91.84 and 93.90, 94.44 per cent reduction in thrips population after first and second spray after second season at 7 DAS, respectively.

Patel (2014) revealed that After the 3rd and 7th day of spray, cyantraniliprole at 105 g a.i./ha found significantly more effective in controlling thrips and it was at par with cyantraniliprole at 90 g a.i./ha. According to Misra (2012), both the doses of cyantraniliprole *i.e.* 105 and 90 g a.i./ha were found equally effective against *T. tabaci* infesting tomato. This is in agreement with the present finding.

The lowest concentration of cyantraniliprole 10 OD at 45 g a.i. ha⁻¹ harbored maximum spider population of 4.87, 6.00 and 6.33, 7.87 at 7 and 14th days after first and second spray per five plants followed by cyantraniliprole 10 OD at 75 g a.i. ha⁻¹. Cyantraniliprole 10 OD treated plots at 90, 75, 60 and 45 g a.i. ha⁻¹ recorded the maximum spider population per five plants which was on par with untreated check. Anon (2013) was revealed that Cyazypyr played a role to maximize the population of natural enemies by conserving predators and parasitoids and there thereby giving excellent control of whiteflies, aphids, thrips, leafminers, beetles and Lepidoptera on various vegetables and fruit crops. Flubendiamide 480 SC was reported as safe to the natural enemies like spiders and lady bird beetles (Latif *et al.*, 2009) (Table 7).

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