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Bioefficacy of bistrifluron 10% EC against cotton sucking pests and its natural enemies

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Abstract
Bistrifluron 10% EC at five different doses *viz.*, 50, 75, 100, 125 and 250 g a.i. /ha along with acetamiprid 20% SP (20 g a.i/ha) and buprofezin 25% SC (250 g a.i./ha) as standard checks for whitefly, leaf hoppers, thrips, aphid and mealybug were evaluated for bio-efficacy under field condition during *Kharif* 2017-18 and 2018-19. After four rounds of spraying initiating at ETL of sucking pests at 10 days interval, bistrifluron (10% EC) @ 250 g *a.i.*/ha recorded significantly lowest population of whiteflies (Av.3.57/3 leaves), leafhopper (Av.2.48/3leaves), thrips (Av.10.13/3leaves), aphid (Av.9.84/3leaves) and mealybug (Av.1.18 grade/plant) as well as maximum seed cotton yield followed by bistrifluron (10% EC) @ 125 g *a.i.*/ha whiteflies (Av.4.58/3leaves), leafhopper (Av.3.28/3 leaves), thrips (Av.11.41/3 leaves), aphid (Av.11.49/3leaves) and mealybug (Av.1.40 grade/plant). Further, all the doses of Bistrifluron (10% EC) @ 50, 75, 100, 125 and 250 g *a.i.*/ha were found significantly superior than standard check acetamiprid 20% SP and buprofezin 25% SC. Amongst five doses, lower dose (Bistrifluron 10 EC @50 g a.i. /ha) was found safer to predator populations. No phytotoxicity symptoms were formed at higher dose *viz.*, 100 and 250 g a.i. /ha. Considering efficacy to sucking pests, higher seed cotton yield and no phytotoxicity to plants; Bistrifluron (10% EC) @ 125 g a.i./ha can be taken advantage of.

Keywords: Cotton, Bistrifluron, acetamiprid, buprofezin, sucking pests, natural enemies

1. Introduction
Cotton is most important commercial and fiber crops in India as well as in Gujarat. In India, cotton is cultivated in an area of over 122.35 lakh hectares which is almost 25% of the world area (33.39 million ha) under the crop. However, average yield of cotton (524 kg/ha) is far below the world average (792 kg/ha) and the production is only 377 lakh bales of the world production of 12.14 million tons (Anon., 2017) [2]. In cotton growing states of India, sucking pests have become quite serious and their heavy infestation at a times reduces the crop yield to a great extent (Bhanderi *et al*. 2016) [3]. The estimated yield loss in cotton was 21.20 per cent due to sucking pests (Dhawan *et al.* 2002) [4]. The sucking pests *viz.* whitefly (*Bemisia tabaci),* leafhoppers (*Amrasca biguttula biguttula* Ishida), thrips (*Thrips tabaci* Linn), aphids *(Aphis gossypii* Glover) and mealybug (*Phenacoccus solenopsis* Tinsley) were causing significant losses in cotton yield. Commercially, many conventional and neonicotinoids insecticides are available for management of cotton sucking pests but most of the insecticides amenable to resistance built up in sucking pests. Therefore, it is necessitated to search for alternative product in sucking pests' management. Bistrifluron a substituted benzo phenyl urea is unique contact insect growth regulator worked as inhibitors of chitin biosynthesis to be useful against sucking insect pests. Garry Anthony Webb (2017) [5] found bistrifluron, a benzoylphenyl urea compound, as effective compound against *Coptotermes lacteus* (Froggatt), a mound-building species in southern Australia. Min-Kikim *et al.* (2007) [7] assessed the insecticidal properties of bistrifluron on the insect life stages of the cotton caterpillar, *Palpita indica*. Shumichi *et al.* (2006) [9] reported the effectiveness of bistrifluron as a bait toxicant at 5,000 ppm; however, bistrifluron may cause some feeding repellency at > 5,000 ppm. As a new product in India, an attempt was made to evaluate the bioefficacy of bistrifluron 10 EC against sucking pests along with its safety to natural enemies in Bt cotton.

2. Materials and Methods
Field experiments were conducted at Main Cotton Research Station, Navsari Agricultural University, Surat during *Kharif* seasons of 2017-18 and 2018-19 with eight treatments

replicated thrice in Randomized Block Design. Bistrifluron 10 EC at five doses *viz.*, 50, 75, 100, 125 and 250 g a.i./ha was evaluated in comparison to acetamiprid 20% @ 20 g a.i./ha (standard check for sucking pests) and Buprofezin 25% SC @ 250 g a.i. /ha (standard check for bollworm) and untreated check. G.Cot.Hy.10 BG II was grown at 120 × 45cm spacing in the plots of 6.00 × 5.40m with standard agronomic practices. Insecticides were applied as and when sucking pests attained economic threshold level. The populations of key sucking pests *viz.*, whitefly, leafhoppers, thrips and aphid were recorded from three leaves / plant on five randomly selected plants from net plots. The incidence of mealybug was assessed using grades and expressed as average grade per plant. Observations on natural enemies *viz.*, lady bird beetle, chrysoperla and spider was also recorded on five plants. Seed cotton yield at each picking was also recorded. The pooled data of sucking pests and natural enemies before and 3, 7 and 10 days after each spray were analyzed through t-test after due transformation and interpreted. Bistrifluron 10 EC at higher doses *viz.*, 1000 and 2500 ml/ha were also assessed for phytotoxicity symptoms on cotton plants by adopting 0 to 10 phytotoxicity scale rating of necrosis, vein clearing, wilting epinasty, hyponasty and leaf injury in separate plots.

3. Results and Discussion

The data obtained on of sucking pests and natural enemies before and 3, 7 and 10 days after each spray during both the years were pooled and analyzed through t-test after due transformation and interpreted as under.

3.1 Bio-efficacy of bistrifluron against sucking pests

The pooled results on bioefficacy of bistrifluron against sucking pests before and 3, 7 and 10 days after spray are summarized in Table 1. The data revealed that all the insecticidal treatments were significantly superior to untreated control at 3, 7 and 10 days after treatment. The interaction was found not significant indicating consistent performance of the treatments. The results were discussed based on pooled analysis. Bistrifluron 10% EC @ 250 g *a.i.*/ha recorded significantly lowest whiteflies population (3.57/3leaves) followed by bistrifluron (10% EC) @ 125 g *a.i.*/ha (4.58 whiteflies/3 leaves). The other doses of bistrifluron (10% EC) @ 100, 75 and 50 g *a.i.*/ha were also found mediocre and differed to each other in effectiveness (5.37, 6.89 and 8.58 whiteflies/3 leaves, respectively) and were statistically superior to of standard check, acetamiprid 20% SP @ 20 g *a.i.*/ha (10.13 whiteflies/3 leaves). The maximum population of whitefly was noticed in the control (19.60 whiteflies/3 leaves). In case of leafhopper bistrifluron 10% EC @ 250 g *a.i.*/ha recorded significantly lowest population (2.48/3 leaves) followed by bbistrifluron 10% EC@ 125 g *a.i.*/ha (3.28 /3 leaves) and bistrifluron (10% EC) @ 100 g *a.i.*/ha (3.78/3 leaves). The Bistrifluron (10% EC) @ 75 g *a.i.*/ha and standard check, acetamiprid 20% SP @20 g *a.i.*/ha showed equal effectiveness registering 4.76 and 6.81 leafhoppers/3leaves, respectively. The superiority of bistrifluron (10% EC) @ 250 g *a.i.*/ha recording significantly lowest thrips population (10.13 /3 leaves). Other doses of bistrifluron (10% EC) @ 50, 75,100 and 125 g *a.i.*/ha (11.41 to 16.49 thrips/3 leaves) were also found significantly superior than standard check acetamiprid 20%SP @ 20 g *a.i.*/ha (19.11 thrips/3 leaves). Bistrifluron (10% EC) @ 250 g *a.i.*/ha recorded lowest (9.84/3 leaves) aphid population and was comparable to bistrifluron (10% EC) @ 100 and 125 g *a.i.*/ha (11.49 to 12.24 aphids/3 leaves) and all three treatments were significantly superior to standard check (Mean 23.66 aphids/3 leaves).

The data on pooled analysis of mealybug (Table 2) infestation over years revealed that all the insecticides significantly superior to control. Bistrifluron 10% EC @ 250 g *a.i.*/ha recorded significantly lowest infestation (1.18 grade/plant) and was comparable to bistrifluron 10% EC @ 125 g *a.i.*/ha (1.40 grade/plant) which in turn was also comparable to bistrifluron 10% EC @ 100 g *a.i.*/ha (1.58 grade/plant) on the other side.

From the above results, bistrifluron 10% EC at 250 g a.i./ha found most effective against for cotton sucking pests management. It remained effective up to 10 days of application in controlling sucking pests. More or less similar findings were reported by Shunichi Kubota *et al*. (2006) [9] reported that bistrifluron is effective as a bait toxicant at 5,000 ppm; however, bistrifluron may cause some feeding repellency at > 5,000 ppm. Insecticidal properties of bistrifluron on different stages of cotton caterpillar, *Palpita indica* with emphasis on hatching rate, mortality, pre-oviposition period, longevity and fecundity (Min-Ki Kim *et al.*, 2007 and Qian Huang *et al.*, 2019) [7, 8]. The efficacy of bistrifluron (benzoylphenyl urea compound) against *Coptotermes lacteus* (Froggatt) in southern Australia and found that the 7 to 309 g bait was most effective for destroy the termite mound in Southern Australia (Garry Anthony Webb, 2017) [5]. Anonymous (2010) [1] reported that bristriliuron was breakdown of MoAs available for lepidopteran, aphids, whitefly, hoppers, mites and mosquitoes. Bistrifluron 10% EC at 50 µg/ml controlled *P. xylostella* larvae 7.34, 51.5, 61.1 and 86.3% at 1, 3, 5, and 7 days, respectively, after treatment, while 100 µg/ml provided 21.9, 56.2, 79.0, and 90.2% control, respectively, and 200 µg/ml gave 31.5, 76.3, 82.7, and 96.1% control, respectively in South China (Zhao Hai-zhen *et al.*, 2006) [11]. Qian Huang *et al.* (2019) [8] found that the life span of the egg and pupa stage of *Spodoptera litura* was prolonged and also showed shorter adult duration and lower fecundity in vegetable crops in Sichuan, China. Bistrifluron was harmless (IOBC Class 1) as parasitism ratios were reduced by 9.2% and 27.6%, respectively. Longevity of adults exposed to bistrifluron was 3.6 days (Jamal Hajjar and Al-Masoud, 2018) [6]. Tanani *et al.* (2015) [10] evaluated the effects of Cyromazine on survival, growth, development and metamorphosis of *Spodoptera littoralis* in cotton and found that cyromazine at 200.0 ppm caused larval and pupal mortalities. The data on seed cotton yield pooled over years (Table 2) revealed that the seed cotton yield was the highest (2227 kg/ha) in the plots treated with bistrifluron 10% EC @ 250 g *a.i.*/ha and was comparable to bistrifluron 10% EC @ 125 g *a.i.*/ha and bistrifluron 10% EC @ 100 g *a.i.*/ha (2094 to 2150 kg/ha). The product, bistrifluron 10% EC was found safer to apply on cotton plants as both the x and 2.5x doses of Bistrifluron 10% EC (100 and 250 g *a.i.*/ha) did not show any adverse effect on G.Cot.Hy.10 BG II applied during two consecutive years (Table 4).

3.2 Safety of bistrifluron on natural enemies

Pooled results on population of predators' *viz.*, lady bird beetle, chrysoperla, and spider before spray and 3, 7 and 10 days after spray are presented in Table 3. The data revealed that untreated control had significantly higher population of lady bird beetle, chrysoperla and spider than all insecticide treatments. The interaction was found not significant

indicating consistent performance of the treatments. There was an inverse correlation with respect to the doses of the bistrifluron 10% EC and their safety to the LBB. The higher population of *Chrysoperla* was recorded in untreated control (2.58 larvae/plant) followed by acetamiprid 20 SP @ 20 *g a.i./*ha (2.12 larvae/plant) which in turn was also comparable to bistrifluron (10% EC) @ 50 g *a.i.*/ha (1.94 larvae/plant). The highest spider population recorded in untreated control. The next better treatments was found in standard check, acetamiprid 20%SP @ 20 g *a.i.*/ha and it was at par with bistrifluron (10% EC) @ 50 g *a.i.*/ha (2.48 spiders/plant).

Table 1: Bioefficacy of Bistrifluron 10% EC against sucking pest infesting on cotton at MCRS, NAU, Surat (2017-18 and 2018-19)

Treatments	Dose (g a.i./ha)	Av. Whitefly/3 leaves			Av. Leafhopper/3 leaves			Av. Thrips/3 leaves			Av. Aphid/3 leaves		
		2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Bistrifluron 10% EC	50	2.71	3.20	2.96	2.42	2.58	2.50	4.05	3.95	4.00	4.22	3.76	3.99
		(7.02)	(10.14)	(8.58)	(5.41)	(6.37)	(5.89)	(16.95)	(16.04)	(16.49)	(20.73)	(14.94)	(17.84)
Bistrifluron 10% EC	75	2.53	2.81	2.67	2.17	2.38	2.28	3.85	3.78	3.82	3.86	3.26	3.56
		(5.99)	(7.78)	(6.89)	(4.30)	(5.23)	(4.76)	(15.40)	(14.75)	(15.07)	(17.47)	(11.16)	(14.31)
Bistrifluron 10% EC	100	2.12	2.59	2.36	1.90	2.18	2.04	3.54	3.46	3.50	3.55	2.85	3.20
		(4.10)	(6.63)	(5.37)	(3.18)	(4.39)	(3.78)	(13.18)	(12.40)	(12.79)	(15.48)	(9.01)	(12.24)
Bistrifluron 10% EC	125	1.95	2.41	2.18	1.81	2.02	1.92	3.32	3.26	3.29	3.47	2.66	3.07
		(3.42)	(5.73)	(4.58)	(2.83)	(3.73)	(3.28)	(11.73)	(11.08)	(11.41)	(14.89)	(8.09)	(11.49)
Bistrifluron 10% EC	250	1.69	2.13	1.91	1.58	1.77	1.67	3.16	2.99	3.08	3.11	2.45	2.78
		(2.49)	(4.64)	(3.57)	(2.07)	(2.89)	(2.48)	(10.70)	(9.55)	(10.13)	(12.53)	(7.16)	(9.84)
Acetamiprid 20% SP	20	2.91	3.51	3.21	2.61	2.77	2.69	4.33	4.35	4.34	5.03	4.24	4.64
		(8.06)	(12.21)	(10.13)	(6.39)	(7.23)	(6.81)	(18.99)	(19.23)	(19.11)	(28.60)	(18.73)	(23.66)
Buprofezin 25% SC	250	2.65	3.15	2.90	2.33	2.52	2.42	4.02	3.93	3.97	4.07	3.63	3.85
		(6.72)	(9.77)	(8.24)	(4.98)	(5.92)	(5.45)	(16.49)	(15.70)	(16.09)	(19.28)	(13.93)	(16.61)
Control (water spray)	-	3.83	4.93	4.38	3.33	3.77	3.55	5.96	5.98	5.97	10.00	8.19	9.10
		(14.34)	(24.86)	(19.60)	(10.76)	(14.03)	(12.39)	(35.19)	(34.47)	(35.33)	(103.39)	(72.36)	(87.87)
Mean		2.55	3.09	2.82	2.27	2.50	2.38	4.03	3.96	3.99	4.66	3.88	4.27
		(6.52)	(10.22)	(8.37)	(4.99)	(6.22)	(5.61)	(17.33)	(16.78)	(17.05)	(29.04)	(19.42)	(24.23)
S. Em. ±		0.05	0.10	0.06	0.05	0.08	0.05	0.09	0.09	0.07	0.25	0.25	0.18
CD @ 5%		0.13	0.29	0.17	0.14	0.23	0.14	0.26	0.24	0.18	0.70	0.71	0.50
S.Em. ± (Y x T)		1.17	0.20	1.18	0.15	0.17	0.16	0.28	0.25	0.26	0.27	0.23	0.25
CD @ 5%		NS	0.54	0.50	NS	0.47	0.44	NS	NS	NS	0.76	0.64	0.69
CV%		11.28	10.97	11.15	11.18	11.55	11.40	11.87	10.91	11.41	10.09	10.23	10.19
Figures in parentheses are retransformed values; those outside are $\sqrt{X+0.5}$ transformed values													

Table 2: Bioefficacy of Bistrifluron 10% EC against mealybug infesting on cotton and seed cotton yield at MCRS, NAU, Surat (2017-18 and 2018-19)

Treatments	Dose (g a.i./ha)	Av. Mealy bug Grade/plant			Seed cotton yield (kg/ha)		
		2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Bistrifluron 10% EC	50	1.15	1.84	1.49	1852	1564	1708
		(0.84)	(2.89)	(1.87)			
Bistrifluron 10% EC	75	1.09	1.75	1.42	2057	1883	1970
		(0.71)	(2.60)	(1.66)			
Bistrifluron 10% EC	100	1.03	1.75	1.39	2263	1924	2094
		(0.58)	(2.58)	(1.58)			
Bistrifluron 10% EC	125	0.98	1.66	1.32	2335	1965	2150
		(0.47)	(2.33)	(1.40)			
Bistrifluron 10% EC	250	0.94	1.56	1.25	2387	2068	2227
		(0.40)	(1.96)	(1.18)			
Acetamiprid 20% SP	20	1.23	1.87	1.55	1687	1132	1409
		(1.02)	(3.02)	(2.02)			
Buprofezin 25% SC	250	1.12	1.81	1.46	1934	1369	1651
		(0.76)	(2.80)	(1.78)			
Control (water spray)	-	1.33	1.94	1.64	1214	844	1029
		(1.31)	(3.29)	(2.30)			
Mean		1.11	1.77	1.44	1966	1593	1780
		(0.76)	(2.68)	(1.72)			
S. Em. ±		0.04	0.06	0.03	64.84	72.34	52.45
CD @ 5%		0.12	0.16	0.10	196.68	219.44	150.70
S.Em. ± (Y x T)		0.08	0.11	0.10	-	-	68.69
CD @ 5%		NS	NS	NS	-	-	NS
CV%		13.12	10.54	11.63	5.71	7.86	6.69

Table 3: Safety of Bistrifluron 10% EC against natural enemies on cotton at MCRS, NAU, Surat (2017-18 and 2018-19)

Treatments	Dose (g a.i./ha)	Av. Ladybird beetle/3 leaves			Av. *Chrysoperla*/3 leaves			Av. Spider/3 leaves		
		2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Bistrifluron 10% EC	50	1.66	1.62	1.64	1.48	1.62	1.55	1.70	1.74	1.72
		(2.30)	(2.16)	(2.23)	(1.75)	(2.14)	(1.94)	(2.41)	(2.54)	(2.48)
Bistrifluron 10% EC	75	1.55	1.47	1.51	1.40	1.49	1.45	1.56	1.56	1.56
		(1.93)	(1.68)	(1.80)	(1.51)	(1.73)	(1.62)	(1.98)	(1.96)	(1.97)
Bistrifluron 10% EC	100	1.49	1.37	1.43	1.35	1.43	1.39	1.49	1.51	1.50
		(1.75)	(1.42)	(1.59)	(1.39)	(1.57)	(1.48)	(1.76)	(1.80)	(1.78)
Bistrifluron 10% EC	125	1.35	1.29	1.32	1.33	1.36	1.34	1.40	1.36	1.38
		(1.35)	(1.19)	(1.27)	(1.31)	(1.36)	(1.34)	(1.49)	(1.37)	(1.43)
Bistrifluron 10% EC	250	1.22	1.16	1.19	1.21	1.22	1.22	1.30	1.21	1.26
		(1.01)	(0.87)	(0.94)	(1.02)	(1.01)	(1.02)	(1.23)	(1.02)	(1.13)
Acetamiprid 20% SP	20	1.76	1.66	1.71	1.54	1.67	1.60	1.75	1.78	1.76
		(2.61)	(2.30)	(2.45)	(1.95)	(2.30)	(2.12)	(2.61)	(2.66)	(2.63)
Buprofezin 25% SC	250	1.62	1.55	1.58	1.46	1.58	1.52	1.65	1.65	1.63
		(2.13)	(1.92)	(2.03)	(1.66)	(2.00)	(1.83)	(2.12)	(2.24)	(2.18)
Control (water spray)	-	1.84	1.79	1.82	1.69	1.79	1.74	1.85	1.81	1.83
		(2.90)	(2.73)	(2.81)	(2.41)	(2.75)	(2.58)	(2.93)	(2.82)	(2.88)
Mean		1.56	1.49	1.52	1.43	1.52	1.48	1.58	1.58	1.58
		(2.00)	(1.78)	(1.89)	(1.63)	(1.86)	(1.74)	(2.07)	(2.05)	(2.06)
S. Em. ±		0.03	0.03	0.02	0.03	0.03	0.02	0.03	0.03	0.02
CD @ 5%		0.08	0.08	0.05	0.08	0.08	0.06	0.07	0.08	0.06
S.Em. ± (Y x T)		0.09	0.10	0.10	0.11	0.10	0.10	0.09	0.10	0.09
CD @ 5%		NS	NS	NS	NS	NS	NS	NS	NS	NS
CV%		10.43	11.12	10.77	12.71	10.98	11.83	9.91	10.76	10.34

Figures in parentheses are retransformed values; those outside are $\sqrt{X + 0.5}$ transformed values

Table 4: Phytotoxicity effect of Bistrifluron 10% EC on cotton at MCRS, NAU, Surat (2017-18 and 2018-19)

Treatments	Dose/ha (g *a.i.*/ha)	Phytotoxicity symptoms (Scale)					
		Leaf injury	Wilting	Vein clearing	Necrosis	Epinasty	Hyponasty
Bistrifluron 10% EC	100	0	0	0	0	0	0
Bistrifluron 10% EC	250	0	0	0	0	0	0
Untreated control	-	0	0	0	0	0	0

4. Conclusion

Based on two year study, the bistrifluron (10% EC) @ 125 and 250 g a.i./ha were found more effective against all the sucking pests (whitefly, leafhopper, thrips, aphid and mealybug) compared to standard check, acetamiprid 20% SP @ 20 g a.i./ha. As far as safety to natural enemies is concerned, there was more or less inverse correlations with the doses of bistrifluron (10% EC) @ 50, 75, 100, 125 and 250 g a.i./ha. Further, the product bistrifluron (10% EC) at x and 2.5x doses @ 100 and 250 g a.i./ha did not show any phytotoxicity symptoms on cotton crop. The seed cotton yield was found comparable in the treatments of bistrifluron (10% EC) @ 100, 125 and 250 g a.i./ha. Looking to the above results, bistrifluron (10% EC) @ 125 g a.i./ha can be taken advantage of considering efficacy to sucking pest, safety to natural enemies, higher seed cotton yield and no phytotoxicity to plants so it can be use in integrated pest management or insecticide resistant management programme.

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