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Influence of Spirotetramat 150 OD on the Incidence of Sucking Pests and Natural Enemies in *Bt* and Non-*Bt* Cotton

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The effect of spirotetramat 150 OD (insecticide) application on sucking pests (whitefly, aphids, thrips and mealy bug) and predators (spiders, coccinellids and chrysopids) was investigated in transgenic Bt cotton and non-transgenic cotton agroecosystems at Tamil Nadu Agricultural University, Coimbatore. Transgenic cotton did not cause changes in population of pests and did not reduce number of predators considerably. Pesticide application decreased number of whitefly, aphid and mealy bug population significantly on both transgenic and non-transgenic cotton plants. Reduction in the population of predators was observed immediately after application. Later the population of predators started increasing gradually. However the population was found to be less than that of untreated plots. The result revealed that, transgenic *Bt* cotton did not affect sucking pest populations and did not cause considerable reduction in predator populations. The performance of spirotetramat on the incidence of sucking pests and abundance of natural enemies was similar on both *Bt* and non *Bt* cotton.

Key words: Spirotetramat, 150 OD transgenic cotton, sucking pests, predators

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A rich diversity of parasitoid and arthropod predator species is known to inhabit cotton fields and it is generally recognized that natural enemies play an important role in regulating pest herbivore populations (Naranjo and Ellsworth, 2005). The incessant use of insecticides poses an adverse effect upon the natural enemies biodiversity and is one of the most severe constraints in realizing the full potential of biological control in managing pests of field and other crops (Croft, 1990). Transgenic crops producing insecticidal proteins of *Bacillus thuringiensis* have the potential to contribute to natural enemy conservation through their selective activity and associated reductions in the broad spectrum insecticides usage (Federici, 2003). Studies of the effects of transgenic *Bt* cotton on target and non-target pests and their natural enemies were conducted to assess various aspects of ecological risks (Xingyuan men *et al.,* 2003; Mark *et al.,* 2004). In *Bt* cotton, beneficial arthropod populations in transgenic fields appeared neither to differ significantly nor to negligibly effect those in surrounding non-transgenic fields (Flint *et al.,* 1995). Expression of *Bt* endotoxins in cotton has reduced bollworms *Helicoverpa armigera* Hub. and the number of cotton bollworm parasitoids (Cui and Xia, 1999). Transgenic cotton can have a number of direct and indirect effects on arthropod communities in agroecosystems. The direct impact is the mortality of bollworms feeding on *Bt* cotton (Fitt *et al.,* 1994), which can also provide effective or partial control of some other lepidopteran pests (Bacheler *et al.,* 1998). Transgenic *Bt* cotton can affect the natural enemies indirectly (Huang *et al.*, 1999) through the removal of eggs, larvae and pupae of lepidopteran insects that serve as food sources for parasitic and predatory arthropods. Considerable reduction in the number of insecticide application is another important factor that can affect arthropod communities in *Bt* cotton fields. Such major reductions in pesticide applications can result in increases in the abundance of beneficial insects and some minor pests, which are otherwise suppressed under heavy insecticide application regimes to control boll worms. Therefore, it is important to search for the less persistent chemicals with novel mode of action to overcome the ecological constraints like resurgence, resistance, residues and reduction of natural enemies. At present, the Golden Age of insecticide research has met with selective, neuro active and easily degradable compounds. These newer molecules always have higher stability and superiority over the conventional pesticides to control pest population density in classical manner at field level. In this array, spirotetramat 150 OD is one of the novel and superior chemical introduced with an aim to replace the highly effective broad spectrum compounds, which were restricted due to their high mammalian toxicity and other side effects on non-target organisms over the years.

Spirotetramat is a novel insecticide, belonging to the chemical class of ketoenols. It is a tetramic acid derivative and covers wide spectrum of sucking insects. Its mode of action is completely different from major insecticide families of today; it interferes with the lipid biosynthesis, leading to death of immature stages 2 to 10 days after application. The fertility of adults is reduced, contributing to the overall excellent lasting efficacy. This compound is mainly effective after oral uptake. It is fully systemic, xylem and phloem mobile, allowing acropetal and basipetal translocation in plants. However, only limited information is available on the foliar spray of spirotetramat against sucking pests and natural enemies of cotton and also there is need of indepth study about performance against natural enemies. It is highly essential to understand the long term implications of usage of this compound for the betterment of farmers and the living community. Therefore, the present study was carried out to know the influence of spirotetramat on the incidence of sucking pests and natural enemies in *Bt* and non *Bt* cotton plants.

Materials and Methods

Two field trials were conducted in Eastern block, Tamil Nadu Agricultural university, Coimbatore. Transgenic *Bt* cotton (MRC 6918 *Bt*) containing *Cry 1Ac* and *nptll & aad* marker genes and local non transgenic cotton *var*. MCU 12, were used in this study because both are commonly used in cotton belt of Coimbatore, Tamil Nadu. The experiment was laid out in a completely randomized block design involving four treatments with five replications. Area of replicate plot was five cents. The treatments included, T_1 non transgenic cotton with spirotetramat 150 OD (75 g a.i. ha^{-1}) application, T_2 non transgenic cotton without spirotetramat 150 OD application, T_3 *Bt* cotton with spirotetramat 150 OD application, T_4 *Bt* cotton without spirotetramat 150 OD application. Three sprays were given at 15 days interval starting from 35 days after sowing (DAS) with a pneumatic knapsack sprayer using 750 litres of spray fluid per hectare. The main pests sampled included, whitefly, *Bemisia tabaci* (Gennadius), aphid, *Aphis gossypii* (Glover) and thrips, *Thrips tabaci* Lind. and mealy bug, *Phenacoccus* sp. Ferris in cotton and the major natural enemies *viz.,* spiders, coccinellids and chrysopids. Whitefly, aphid and thrips were recorded on three leaves one each at top, middle and bottom portions and for mealy bug*,* 5 cm length each in the shoot tip and middle of the stem were observed from ten randomly tagged plants per plot. The number of spiders, coccinellids and chrysopids was recorded on ten randomly tagged plants per plot prior to application of insecticides and 1, 3, 5, 7, 10 and 14 days after spraying. Pooled mean for 1, 3, 5, 7, 10 and 14 days after spraying and five replication were worked out for statistical analysis. The insect numbers were transformed into square root values. The data were subjected to ANOVA (Gomez and Gomez, 1984) and the mean values were compared using Duncan's Multiple Range Test (DMRT) (Duncan, 1951).

Results and Discussion

The results of the influence of spirotetramat 150 OD at 75 g a.i. ha^{-1} on the abundance of sucking pests and natural enemies in *Bt* and non *Bt* cotton are presented in Table 1 and 2. The pre treatment count in the first trial ranged from 33.0 - 35.7, 11.90 - 14.53, 4.77- 5.97 and 20.47- 24.37 for aphid, thrips, whitefly and mealy bugs per plant, respectively. After three rounds of insecticide (spirotetramat 150 OD at 75 g a.i. ha^{-1}) application, population of aphids, whitefly, and mealybugs differed significantly between treatments and were supressed significantly by spirotetramat application on both non transgenic (8.20, 0.91 and 5.27 per plant for aphid, whitefly and mealybugs, respectively) and *Bt* cotton (10.14, 1.59 and 5.96 per plant for aphid, whitefly and mealybugs, respectively), whereas the population of thrips was almost identical with unsprayed treatments of both *Bt* and non *Bt* cotton (18.96 and 18.90 per plant, respectively) plants. Moreover, the population of thrips was slightly higher in *Bt* cotton treated with spirotetramat (19.50 thrips per plant) at 75 g a.i. ha^{-1} (Table 1). In the second trial, pretreatment count ranged from 12.27 – 14.63, 4.23 – 5.80, 2.97 – 3.90 and 28.13 – 38.63 for aphid, thrips, whitefly and mealy bugs per plant, respectively. After three rounds of insecticide application aphid population was 2.27 to 2.60 in the insecticide treated plots, where as in the untreated plots it was 19.67 - 20.20 in the non *Bt* and *Bt* cotton, respectively. Whitefly population after three rounds of insecticide application was almost nil both in the non *Bt* and *Bt* cotton plants. Mean population at mealy bug was 4.19 and 5.32 in the non *Bt* and *Bt* cotton, respectively in the insecticide treated plots, whereas in the untreated plots it was 57.66 and 55.26 in the non *Bt* and *Bt* cotton, respectively (Table 1).

The population of natural enemies before first round of application in the first trial ranged from 5.30 - 7.33, 10.30 - 13.50 and 8.30 - 9.97 per ten plants, respectively for spiders, coccinellids and chrysopids. After imposing three rounds of spray, there was significant difference in natural enemy population between the treatments (Table 2). Spirotetramat at 75 g a.i. ha^{-1} foliar application reduced the population of spider, coccinellid and chrysopids on non transgenic cotton (3.79, 6.82 and 6.31 per ten plants, respectively) and on *Bt* cotton (3.41, 6.43 and 5.27 per ten plants, respectively) significantly, compared to unsprayed plots which recorded 9.22, 15.12 and 12.53 per ten plants of spider, coccinellid and chrysopids, respectively on non *Bt* cotton and 8.17, 14.92 and 12.29 per ten plants of spider, coccinellid and chrysopids, respectively on *Bt* cotton. Similar result was observed in the second trial also (Table 2).

Table 1. Influence of spirotetramat 150 OD on the population of sucking pests in *Bt* and non *Bt* cotton plants

Insect	Treatment	Number of insects /plant									
		Trial 1					Trial 2				
		PTC	1st spray	2nd spray	3rd spray	Pooled mean	PTC	1st spray	2nd spray	3rd spray	Pooled mean
Aphids	T1	35.33	14.23	8.57	1.80	8.20	12.27	4.73	1.80	0.27	2.27
			(3.84)a	(3.01)a	(1.52)a			(2.29)a	(1.52)a	(0.88)a	
	T2	34.37	43.37	54.23	58.70	52.10	14.63	16.60	19.27	23.13	19.67
			(6.62)b	(7.40)b	(7.69)b			(4.14)b	(4.45)b	(4.86)b	
	T3	33.00	15.50	11.30	3.63	10.14	12.50	5.27	1.90	0.63	2.60
			(4.00)a	(3.44)a	(2.03)a			(2.40)a	(1.55)a	(1.06)a	
	T4	35.70	42.93	54.83	59.90	52.55	13.43	16.00	20.33	24.27	20.20
			(6.59)b	(7.44)b	(7.77)b			(4.06)b	(4.56)b	(4.98)b	
Thrips	T1	12.43	16.37	18.83	19.23	18.14	4.23	5.37	6.80	7.67	6.61
			(4.11)a	(4.40)a	(4.44)a			(2.42)a	(2.70)a	(2.86)a	
	T2	11.90	15.10	19.97	21.80	18.96	4.67	5.87	7.20	7.73	6.93
			(3.95)a	(4.52)a	(4.72)a			(2.52)a	(2.77)a	(2.87)a	
	T3	12.53	16.93	19.80	21.77	19.50	5.80	5.70	6.87	7.90	6.82
			(4.17)a	(4.51)a	(4.72)a			(2.49)a	(2.71)a	(2.90)a	
	T4	11.97	15.47	19.33	21.00	18.60	5.67	6.20	6.87	8.13	7.07
			(4.00)a	(4.45)a	(4.64)a			(2.59)a	(2.71)a	(2.94)a	
Whitefly	T1	5.30	1.53	0.87	0.33	0.91	3.90	1.30	0.63	0.33	0.75
			(1.42)a	(1.17)a	(0.91)a			(1.34)a	(1.06)a	(0.91)a	
	T2	5.73	5.80	6.63	5.90	6.11	2.97	4.47	4.87	5.27	4.87
			(2.51)b	(2.67)b	(2.53)b			(2.23)b	(2.32)b	(2.40)b	
	T3	4.77	1.83	1.27	1.67	1.59	3.63	1.23	0.67	0.23	0.71
			(1.53)a	(1.33)a	(1.47)a			(1.32)a	(1.08)a	(0.85)a	
	T4	5.97	5.87	6.67	6.37	6.30	3.80	4.60	5.20	5.10	4.97
			(2.52)b	(2.68)b	(2.62)b			(2.26)b	(2.39)b	(2.37)b	
Mealybug	T1	22.73	10.80	4.57	0.43	5.27	38.63	7.47	3.47	1.63	4.19
			(3.36)a	(2.25)a	(0.96)a			(2.82)a	(1.99)a	(1.46)a	
	T2	24.37	36.23	47.17	56.20	46.53	36.90	42.00	54.17	76.80	57.66
			(6.06)b	(6.90)b	(7.53)b			(6.52)b	(7.39)b	(8.79)b	
	T3	20.47	11.17	5.73	0.97	5.96	31.57	10.80	3.20	1.97	5.32
			(3.42)a	(2.50)a	(1.21)a			(3.36)a	(1.92)a	(1.57)a	
	T4	23.30	33.37	49.43	56.60	46.47	28.13	40.13	48.33	77.33	55.26
			(5.82)b	(7.07)b	(7.56)b			(6.37)b	(6.99)b	(8.82)b	

Each data is the mean of five replication and six days after spray observations; T1 - Non *Bt* + Spirotetramat 150 OD (75 g a.i. ha^{-1}); T2 - Non *Bt* alone; T3 - *Bt* + Spirotetramat 150 OD (75 g a.i. ha^{-1}); T4 - *Bt* alone; PTC- Pretreatment count, DAT- Days after treatment; Figures in parentheses are X + 0.5 transformed values; In a column means followed by a common letter are not significantly different by DMRT (P=0.05)

The purpose of this study was to assess the impact of spirotetramat 150 OD on the abundance of sucking pests and natural enemies in *Bt* and non *Bt* cotton crops and in evaluating the consequences of introducing new chemicals into an area of transgenic crop with a chance of replacing local variety. One of the expected consequences of introducing *Bt* cotton is to reduce the number of insecticidal sprays because it induces resistance to certain lepidopteran pests (Huang *et al.,* 1999). This might result in the increase of other pest populations that would be suppressed by insecticide applications primarily targeting lepidopteran pests. Therefore insecticides might still be needed to control these pests in transgenic cottons. Xingyuanman *et al.* (2004) reported that the use of *Bt* cotton did not lead to a reduction in total number of insecticide sprays in the course of three years because additional sprays were required against sucking pests. Further they concluded that pesticide application significantly reduced populations of spiders on *Bt* and non transgenic cotton in China. The results of the present study revealed that there was no significant difference between *Bt* and non *Bt* cottons in terms of abundance of sucking pests and natural enemies. Though the population of sucking pests *viz.* aphids, thrips, whiteflies and mealybugs and natural enemies *viz.,* spiders, coccinellids and chrysopids were slightly higher in *Bt* cotton than non *Bt* cotton, the differences were non significant.

The performance of spirotetramat 150 OD on the incidence of sucking pests and abundance of natural enemies was similar in *Bt* and non *Bt* cotton. In field corn, also beneficial arthropod populations showed little variation between *Bt* and non *Bt* fields (Lozzia, 1999; Pilcher *et al.,* 1997; Cannon, 2000). Naranjo (2002) indicated that natural enemy

Table 2. Influence of spirotetramat 150 OD on the population of natural enemies in *Bt* and non *Bt* cotton plants

Natural enemy	Treatment	Population of natural enemies (number/plant)									
		Trial 1					Trial 2				
		PTC	1st spray	2nd spray	3rd spray	Pooled mean	PTC	1st spray	2nd spray	3rd spray	Pooled mean
Spider	T1	6.57	4.30 (2.19)a	4.27 (2.18)b	2.80 (1.82)b	3.79	8.27	6.37 (2.62)b	5.87 (2.52)b	4.57 (2.25)b	5.60
	T2	5.30	7.20 (2.77)a	9.23 (3.12)a	11.23 (3.42)a	9.22	8.20	8.87 (3.06)a	9.20 (3.11)a	10.50 (3.32)a	9.52
	T3	6.37	3.43 (1.98)a	3.93 (2.10)b	2.87 (1.84)b	3.41	7.80	6.53 (2.65)b	5.47 (2.44)b	4.83 (2.31)b	5.61
	T4	7.33	6.93 (2.73)a	8.47 (2.99)a	9.10 (3.10)a	8.17	7.27	8.63 (3.02)a	8.80 (3.05)a	9.73 (3.20)a	9.05
Coccinellid	T1	12.57	8.57 (3.01)a	6.40 (2.63)b	5.50 (2.45)b	6.82	12.57	9.33 (3.14)a	8.03 (2.92)b	5.23 (2.39)b	7.53
	T2	10.63	13.37 (3.72)a	14.87 (3.92)a	17.13 (4.20)a	15.12	11.20	11.87 (3.52)a	12.63 (3.62)a	12.20 (3.56)a	12.23
	T3	13.50	8.17 (2.94)b	5.93 (2.54)b	5.20 (2.39)b	6.43	13.23	9.67 (3.19)a	7.63 (2.85)b	5.80 (2.51)b	7.70
	T4	10.30	13.43 (3.73)a	15.17 (3.96)a	16.17 (4.08)a	14.92	10.80	12.60 (3.62)a	13.77 (3.78)a	12.83 (3.65)a	13.07
Chrysopid	T1	9.67	7.13 (2.76)b	6.60 (2.66)b	5.20 (2.39)b	6.31	5.77	4.37 (2.21)a	3.23 (1.93)b	2.13 (1.62)b	3.24
	T2	8.53	10.77 (3.36)a	12.90 (3.66)a	13.93 (3.80)a	12.53	6.60	6.83 (2.71)a	7.57 (2.84)a	7.93 (2.90)a	7.44
	T3	8.30	6.47 (2.64)b	4.87 (2.32)b	4.47 (2.23)b	5.27	6.83	4.20 (2.17)a	3.60 (2.02)b	2.77 (1.81)b	3.52
	T4	9.97	11.33 (3.44)a	12.93 (3.66)a	12.90 (3.66)a	12.39	5.87	6.27 (2.60)a	7.27 (2.79)a	7.50 (2.83)a	7.01

Each data is the mean of five replication and six days after spray observations; T1 - Non *Bt* + Spirotetramat 150 OD (75 g a.i. ha^{-1}); T2 - Non *Bt* alone; T3 - *Bt* + Spirotetramat 150 OD (75 g a.i. ha^{-1}); T4 - *Bt* alone; PTC- Pretreatment count, DAT- Days after treatment; Figures in parentheses are X + 0.5 transformed values; In a column means followed by a common letter are not significantly different by DMRT (P=0.05)

abundance and overall arthropod diversity were affected by the use of additional insecticides for other pests, but not directly by transgenic cotton in comparison with non transgenic cotton. Studies suggested that natural enemy function, measured as rates of predation and parasitism on two key pests (*Pectinophora gossypiella* (Saunders) and *B. tabaci)* of cotton in the western united state, were unaffected in *Bt* cotton. Xingyvanmen *et al.* (2003) indicated that *Bt*-cotton increased the diversity of arthropod communities and pest sub-communities; however, it decreased the diversities of natural enemy sub communities. Insecticide treatments increase diversities of communities and sub communities of arthropods in both transgenic *Bt*-cotton and non transgenic cotton agro ecosystems, but the increase may be artifact of increased evenness through mortality of insecticides targeted species. Naranjo (2005) reported that the effects of *Bt* cotton on a representative non target community were minor, especially in comparison with the alternative use of broad spectrum insecticides. Whitehouse *et al.* (2005) compared the canopy invertebrate community in sprayed conventional, unsprayed conventional and unsprayed *Bt* cotton over three seasons using suction sampling method. They found that the diversity or species richness of beneficial communities was reduced in the sprayed crops, and there was a slight difference between the total community in unsprayed conventional and *Bt* crops. In conclusion, transgenic *Bt* cotton did not affect sucking pest populations and did not cause considerable reduction in predator populations. The performance of spirotetramat 150 OD on the incidence of sucking pests and abundance of natural enemies was similar in *Bt* and non *Bt* cotton.

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