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Biological Compatibility of Spinetoram with Selected Agrochemicals against Sucking Pests, Foliar Diseases and Natural Enemies in BT Cotton Ecosystem

B. Rajasekar* and C.P. Mallapur

Department of Agricultural Entomology, University of Agricultural Sciences, Dharwad-580005, India
**Corresponding author*

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A B S T R A C T

A field trial was conducted to evaluate the bioefficacy of combinations of spinetoram 12 SC with fungicides / fertilizer / growth regulator, as foliar application on 90 days old Bt cotton against sucking pests and foliar diseases. The lowest mean population of aphids (3.93 / 3 leaves), leafhoppers (4.20 / 3 leaves), thrips (3.01 / 3 leaves), whiteflies (1.09/ 3 leaves) and mirid bugs (1.67 / five squares) were recorded in spinetoram 12 SC @ 1 ml + carbendazim 50WP @ 1.0 g with (64.99, 63.00, 83.60, 82.82 and 50.35) high per cent reduction over control, respectively. Treatments, spinetoram in combination with carbendazim and copper oxychloride were recorded high per cent disease over control (34.05 and 30.87) for Alternaria blight and Bacterial blight, respectively. Spinetoram in combination with carbendazim and copper oxychloride were found to be more effective in reducing the sucking pests population and foliar diseases incidence, and safer to the three natural enemies (coccinellids, chrysopids and spiders) in cotton crop.

Introduction

Cotton (*Gossypium hirsutum* L.), popularly known as "the white gold", is an important commercial fibre crop grown under diverse agro-climatic conditions around the world. Introduction of second generation Bt cotton has given solution to the bollworm complex to the larger extent but at the same time they are susceptible to most of the sucking pests viz., aphid, leafhopper, thrips, whitefly and mirid bug, which occupied major pest status and contributed to lower yields. Apart from this, the diseases like Alternaria leaf spot and Bacterial blight are also posing threat to cotton cultivation. It requires large number of chemicals and sprays for managing different pests. It is often economical and convenient to apply a mixture of two or more pesticides and nutrients when a wide range of pests or maladies are to be managed at a time. This saves time, labour and cost which are the three major but scarce inputs in agricultural systems nowadays (Govindan *et al.,* 2013). Incompatibility may cause loss of effectiveness, poor application and also phytotoxicity. Chemical incompatibility occurs when the material breaks down in to different compounds or when the products chemically combine to produce another,

which involves deactivation and may result in complete or partial failure. Hence, knowledge on the chemical compatibility is necessary to be familiar with the efficacy of mixed chemicals in managing insect pest and diseases in field condition. In this background, a field experiment was designed to know the biological compatibility of a newer insecticide, spinetoram 12 SC (not at commercialized in India) with other agro-chemicals against sucking pests, foliar diseases and natural enemies.

Materials and Methods

A field trial was conducted to evaluate the bioefficacy of combinations of spinetoram 12 SC with fungicides / fertilizer / growth regulator, as foliar application on Bt cotton. The experiment was laid out in a Randomized Block Design (RBD) at Main Agricultural Research Station, Dharwad during *kharif*, 2014-15 season. The experiment consisted of 11 treatments replicated thrice (Table 1). A cotton hybrid, RCH-2 Bt susceptible to insect pests and diseases was chosen and raised in plots of 5.40 x 2.70 metre with 90 x 60 cm row to row and plant to plant spacing. Crop was raised by following package of practices. For the experiment spraying was carried out using hand operated pneumatic knapsack sprayer with 500 litres of spray fluid/ha at 90 days after sowing. The population of sucking pests' *viz.*, nymphs and adults of aphids, leaf hopper, thrips and whiteflies were recorded from ten randomly selected and tagged plants in each replication. In each plant, three leaves (top, middle and bottom) were considered for observation. Similarly, the counts on mirid bug population on 5 squares per plant were recorded on 5 randomly selected plants. The observations were made prior to spraying, 3, 7 and 14 days after spraying. The insecticide acetamiprid was selected as a standard for further comparison. The observations were recorded on 5 plants on number of fruiting branches per plant in case of NAA and $MgSO_4$ treatment combinations. In the fungicide combination treatments, the observations were made on diseases like Alternaria leaf spot and Bacterial blight at 0-4 disease rating scale on 5 plants. Then these grades were converted into per cent disease indices (PDI) by using the formula (Sheo Raj, 1988).

$$PDI = \frac{\text{Sum of numerical ratings x 100}}{\text{Total number of leaves observed x Maximum disease grade}}$$

The observations were made prior to spraying, 3, 7 and 14 days after spraying. Means of observations 14 days after spray were stated in Table 1 and 2. The data obtained from field experiments was analysed in randomized block design (RBD) (Gomez and Gomez, 1984). The mean values were separated using Duncan's Multiple Range Test (DMRT) (Duncan, 1951).

Results and Discussion

The experimental results of investigations carried out on the evaluation of biological compatibility of spinetoram with fungicides / fertilizer / growth regulator was assessed against sucking pests and foliar diseases and the results are as follows.

Sucking pests

The results of the present investigation revealed that the lowest mean aphid population (14 days after spray) was recorded in spinetoram 12 SC @ 1 ml + carbendazim 50WP @ 1 g (3.93 aphids / 3 leaves) with 64.99 per cent reduction over untreated check (Table 1). Similar trend was noticed in other treatments, spinetoram 12 SC alone and its combinations with copper oxychloride 50 WP @ 2.0 g, NAA 20 ppm and MgSO4 @ 10 g (4.27 to 4.42 aphids / 3 leaves with 61.95 to 60.61 % reduction over control). The

university check acetamiprid 20 SP @ 0.2 g was shown the mean population (5.28 aphids / 3 leaves) with 52.93 per cent reduction over untreated check. The lowest mean population of leafhopper was recorded in spinetoram 12 SC @ 1 ml + carbendazim 50WP @ 1.0 g (4.20 leafhoppers / 3 leaves) with 63.00 per cent reduction over untreated check. Sequentially, the remaining treatments i.e., spinetoram 12 SC alone and its combinations, and acetamiprid 20 SP were recorded mean leafhopper population of 4.49 to 4.98 leafhoppers / 3 leaves with 60.43 to 56.09 per cent reduction over untreated check. The treatment spinetoram 12 SC @ 1 ml + carbendazim 50WP @ 1.0 g was noticed lowest mean thrips population (3.01 thrips / 3 leaves) with 83.60 per cent reduction over untreated check, followed by spinetoram 12 SC alone and its combinations, which were significantly on par with each other in reducing the number of thrips population. The university check acetamiprid 20 SP @ 0.2 g was shown the mean population (4.89 thrips / 3 leaves) with 73.41 per cent reduction over untreated check.

The number of mean whiteflies population per three leaves and percent reduction over control recorded in following treatments, spinetoram 12 SC @ 1ml + carbendazim 50WP @ 1.0 g (1.09/ 3 leaves and 82.82) followed by spinetoram alone @ 1ml (1.22 / 3 leaves and 80.76), spinetoram 12 SC @1 ml + copper oxychloride 50WP @ 2g (1.27 / 3 leaves and 79.86), spinetoram 12 SC @1 ml + NAA @ 20 ppm (1.32 / 3 leaves and 79.12) and spinetoram 12 SC @1 ml + MgSO4 @ 10 g (1.37 / 3 leaves and 78.36) respectively. The university check acetamiprid 20 SP @ 0.2 g was shown the mean population (2.62 whiteflies / 3 leaves) with 58.49 per cent reduction over untreated check. The lowest mean population of mirid bugs were recorded in spinetoram 12 SC @ 1 ml + carbendazim 50WP @ 1.0 g (1.67 mirid bugs / five squares) with 50.35 per cent reduction over untreated check. Consecutively, the remaining treatments i.e., spinetoram 12 SC alone and its combinations, and acetamiprid 20 SP were recorded mean mirid bug population of 1.68 to 2.32 mirid bugs / five squares with 50.06 to 42.36 per cent reduction over untreated check. Whereas, all the non-insecticidal treatments were shown poor results in reducing the all sucking pest population. Spinetoram is showing synergistic action, when it combined with carbendazim in reducing sucking pest population in cotton field. It might be the first report in studying the efficacy of spinetoram in combination with other agrochemicals against sucking pests in cotton. The findings of the present study are in agreement with the findings of Stanley *et al.,* (2010) revealed that diafenthiuron alone has recorded 52.77 per cent reduction while diafenthiuron + carbendazim recorded the maximum reduction of 55.80 per cent against cardamom thrips.

Foliar diseases

The lowest per cent disease index of bacterial blight was recorded in spinetoram 12 SC @ 1 ml + copper oxychloride 50WP @ 2 g (20.82) followed by copper oxychloride @ 2gm (20.94), carbendazim 50WP @ 1.0 g (22.53) and spinetoram 12 SC @ 1 ml + carbendazim 50WP @ 1.0 g (23.45) with 30.87, 30.46, 25.19 and 22.14 per cent disease over control, respectively (Table 1). The treatments, spinetoram 12 SC @ 1ml + carbendazim 50WP @ 1.0 g (19.11 and 34.05) followed by carbendazim 50WP @ 1.0 g (19.45 and 32.85), copper oxychloride 50WP @ 2g (20.18 and 30.33) and spinetoram 12 SC + copper oxychloride 50WP @ 2g (20.70 and 28.55) were recorded low mean per cent disease index and high percent disease over control respectively, in reducing the alternaria blight.

Table.1 Biological compatibility of spinetoram with selected agrochemicals against sucking pests and foliar diseases in cotton

Treatments	Aphids/ 3 leaves		Leafhoppers/ 3 leaves		Thrips/ 3 leaves		Whiteflies/ 3 leaves		mirid bugs/ 5 squares		Bacterial blight		Alternaria blight	
	Mean	PRC	Mean	PRC	Mean	PRC	Mean	PRC	Mean	PRC	PDI	PDC	PDI	PDC
Spinetoram 12 SC	4.27 (2.18)^{a}	61.95	4.49 (2.23)^{a}	60.43	3.19 (1.92)^{a}	82.64	1.22 (1.31)^{a}	80.76	1.68 (1.48)^{a}	50.06	28.80 (32.44)^{cd}	4.37	26.81 (31.17)^{bcd}	7.44
Spinetoram 12 SC + Carbendazim 50WP	3.93 (2.10)^{a}	64.99	4.20 (2.17)^{a}	63.00	3.01 (1.87)^{a}	83.60	1.09 (1.26)^{a}	82.82	1.67 (1.47)^{a}	50.35	23.45 (28.95)$^{a-d}$	22.14	19.11 (25.91)^{a}	34.05
Spinetoram 12 SC + Copper oxychloride 50WP	4.32 (2.20)^{a}	61.47	4.63 (2.27)^{a}	59.18	3.24 (1.93)^{a}	82.35	1.27 (1.33)^{a}	79.86	1.72 (1.49)^{a}	50.04	20.82 (27.14)^{a}	30.87	20.70 (27.05)^{abc}	28.55
Spinetoram 12 SC + NAA	4.35 (2.20)^{a}	61.23	4.87 (2.32)^{a}	57.12	3.34 (1.96)^{a}	81.82	1.32 (1.35)^{a}	79.12	1.76 (1.50)a	49.94	27.78 (31.80)$^{a-d}$	7.75	26.46 (30.94)^{bcd}	8.66
Spinetoram 12 SC + $MgSO_4$	4.42 (2.22)^{a}	60.61	4.98 (2.34)^{a}	56.09	3.48 (1.99)^{a}	81.08	1.37 (1.37)^{a}	78.36	1.74 (1.50)^{a}	49.48	28.00 (31.94)^{bcd}	7.02	26.61 (31.04)^{bcd}	8.16
Acetamaprid 20SP	5.28 (2.40)^{b}	52.93	4.90 (2.32)^{a}	56.83	4.89 (2.32)^{b}	73.41	2.62 (1.77)^{b}	58.49	2.32 (1.68)^{ab}	42.36	27.59 (31.67)$^{a-d}$	8.41	27.36 (31.53)^{cd}	5.55
Carbendazim 50WP	9.79 (3.21)^{b}	12.75	9.23 (3.12)^{b}	18.72	17.55 (4.25)^{b}	4.51	5.81 (2.51)^{c}	8.00	3.81 (2.08)^{b}	5.42	22.53 (28.33)^{abc}	25.19	19.45 (26.16)^{ab}	32.85
Copper oxychloride 50WP	10.06 (3.25)^{b}	10.29	9.49 (3.16)^{b}	16.37	17.88 (4.29)^{b}	2.69	5.94 (2.54)^{c}	6.02	3.88 (2.09)^{b}	3.51	20.94 (27.22)^{ab}	30.46	20.18 (26.69)^{abc}	30.33
NAA	10.18 (3.27)^{b}	9.29	9.53 (3.17)^{b}	16.01	17.92 (4.29)^{b}	2.50	6.09 (2.57)^{c}	3.56	3.95 (2.11)^{b}	1.96	27.76 (31.78)$^{a-d}$	7.83	27.28 (31.47)^{cd}	5.85
$MgSO_4$	10.28 (3.28)^{b}	8.37	9.52 (3.16)^{b}	16.15	18.11 (4.31)^{b}	1.48	6.21 (2.59)^{c}	1.74	4.01 (2.12)^{b}	0.49	28.35 (32.16)^{cd}	5.88	27.45 (31.58)^{cd}	5.26
Untreated check	11.22 (3.42)^{b}	0.00	11.35 (3.44)^{b}	0.00	18.38 (4.34)^{b}	0.00	6.32 (2.61)^{c}	0.00	4.02 (2.13)^{b}	0.00	30.12 (33.27)^{d}	0.00	28.97 (32.55)^{d}	0.00
S. Em±	0.21		0.17		0.19		0.15		0.17		1.77		1.92	
CD(0.05)	0.63		0.50		0.57		0.44		0.50		5.22		5.66	
CV (%)	11.15		8.93		8.91		10.95		13.50		8.18		9.15	

Mean = Mean of observations 14 days after spray; PRC = Percent Reduction over Control; PDI = Percent Disease Index; PDC = Percent Disease Control; Figures in the parenthesis are √x + 0.5 transformed values. Means followed by same letter do not differ significantly by DMRT (P = 0.05); spinetoram, carbendazim, copper oxychloride, NAA, $MgSO_4$ and acetamiprid, dosage @ 1 ml, 1.0 g, 2.0 g, 20 ppm, 10 g and 0.2 g per litre, respectively.

Table.2 Biological compatibility of spinetoram with selected agrochemicals on natural enemies and yield parameters in cotton

Treatments	Coccinellids/ 5 plants	Chrysopids/ 5 plants	Spiders/ 5 plants	Fruiting branches per plant		Yield (Q/ha)	Cost of cultivation*	Net returns	B:C Ratio
	Mean	Mean	Mean	Mean	PIC				
Spinetoram 12 SC	1.58 (1.44) [a]	1.22 (1.31)[a]	1.65 (1.47) [a]	20.58	1.04	14.20	43494.00	14715.88	0.34
Spinetoram 12 SC + Carbendazim 50WP	1.58 (1.44) [a]	1.21 (1.31) [a]	1.62 (1.46) [a]	20.53	0.78	17.63	44519.00	27751.23	0.62
Spinetoram 12 SC + Copper oxychloride 50WP	1.59 (1.45) [a]	1.21 (1.31) [a]	1.63 (1.46) [a]	20.55	0.86	17.08	44666.00	25354.58	0.57
Spinetoram 12 SC + NAA	1.58 (1.44) [a]	1.21 (1.31) [a]	1.65 (1.47) [a]	23.39	12.93	14.95	43867.50	17435.66	0.40
Spinetoram 12 SC + $MgSO_4$	1.57 (1.44) [a]	1.22 (1.31) [a]	1.66 (1.47) [a]	22.44	9.22	14.33	44234.00	14538.29	0.33
Acetamaprid 20SP	1.62 (1.46) [a]	1.20 (1.30) [a]	1.61 (1.45) [a]	20.43	0.31	13.48	35860.00	19397.20	0.54
Carbendazim 50WP	1.70 (1.48) [a]	1.21 (1.31) [a]	1.81 (1.52) [a]	20.47	0.49	10.36	36550.00	5912.28	0.16
Copper oxychloride 50WP	1.71 (1.49) [a]	1.23 (1.32) [a]	1.82 (1.52) [a]	20.51	0.70	9.95	36672.00	4103.03	0.11
NAA	1.69 (1.48) [a]	1.24 (1.32) [a]	1.83 (1.53) [a]	23.49	13.28	9.40	35873.50	2651.88	0.07
$MgSO_4$	1.72 (1.49) [a]	1.22 (1.31) [a]	1.82 (1.52) [a]	22.34	8.83	8.92	36240.00	316.93	0.01
Untreated check	1.77 (1.51) [a]	1.30 (1.34) [a]	1.84 (1.53) [a]	20.37	0.00	8.57	35000.00	150.89	0.00
S. Em±	0.09	0.09	0.09	-	-	-	-	-	-
CD(0.05)	NS	NS	NS	-	-	-	-	-	-
CV (%)	9.73	10.57	9.42	-	-	-	-	-	-

Mean = Mean of observations 14 days after spray; PIC = Percent Increase over Control; Figures in the parenthesis are √x + 0.5 transformed values. Means followed by same letter do not differ significantly by DMRT (P = 0.05); NS = Non Significant; Cost of cultivation: *-Including plant protection measures; Market price of cotton: 4,100/q; cost of spinetoram approx = cost of spinosad ₹ 800/100 ml; carbendazim ₹ 105/100 g; copper oxychloride ₹ 293/500 g ; NAA ₹ 83/100 ml; $MgSO_4$ ₹ 74/1 Kg and acetamiprid ₹ 180/100 g, and dosage @ 1 ml, 1.0 g, 2.0 g, 20 ppm, 10 g and 0.2 g, respectively.

Whereas, the treatments, doesn't have fungicide / its combination shown poor results in reducing the bacterial blight and alternaria blight. The results are in agreement with the studies of Jagtap *et al.,* (2012) reported that low disease incidence of bacterial blight was recorded in treatment copper oxychloride 0.25 % + streptocycline 100 ppm. Carbendazim and copper oxychloride were found effective against *A. macrospora* (Gholve *et al.,* 2012).

Natural enemies

The observations in treatments like spinetoram 12 SC, carbendazim 50 WP, copper oxychloride 50 WP, NAA, MgSO4 and acetamiprid alone and combinations were revealed that there was non-significant difference among the treatments, which were statistically on par with each other and found to be safer towards three natural enemies viz., coccinellids, chrysopids and spiders (Table 2). The results are in line with the reports of Medina *et al.,* (2001) revealed that spinosad was found safer to the chrysopids.

Yield and economics

The highest fruiting branches per plant mean values were recorded in NAA @ 20ppm (23.49), spinetoram 12 SC @ 1ml + NAA @ 20ppm (23.39), spinetoram 12 SC @ 1ml + $MgSO_4$ @ 10 g (22.44) and $MgSO_4$ @ 10g (22.34) with 13.28, 12.93, 9.22 and 8.83 percent increase over control, respectively (Table 2). Whereas, the treatments, doesn't have fertilizer / growth regulator / its combination shown poor results in increasing the fruiting branches per plant. The results of present study are in line with the investigations of Rajendran *et al.,* (2005) reported that foliar application of NAA 40 ppm recorded higher number of sympodial branches per plant, bolls per plant and seed cotton yield. Foliar application of 1% MgSO4 during flowering to boll development stage significantly resulted in higher seed cotton yield (2066 Kg ha^{-1}) (Basavanneppa *et al.,* 2009). In all the treatments, no phytotoxicity symptom was observed. The highest yield per hectare was recorded in spinetoram 12 SC @ 1ml + carbendazim 50WP @ 1.0 g (17.63 q/ha) and spinetoram 12 SC @ 1ml + copper oxychloride 50WP @ 2g (17.08 q/ha) found to be significantly superior over rest of the treatments but were on par among themselves, however, these treatments recorded 0.62 and 0.57 of benefit cost ratio's, respectively, which were comparable with the treatment acetamiprid 20 SP @ 0.2 g (13.48 q/ha) recorded 0.54 benefit cost ratio. Even though, spinetoram 12 SC + carbendazim 50WP and spinetoram 12 SC + copper oxychloride 50WP recorded highest yield but given low benefits because of high cost of the spinetoram. Treatment, spinetoram when sprayed in combination with carbendazim was found to be more effective against aphids, leafhoppers, thrips, whiteflies and mirid bugs with higher pest reduction values over control than when used alone or their combinations with copper oxychloride, NAA and $MgSO_4$. Carbendazim and copper oxychloride alone, in their combination with spinetoram were found more effective against bacterial blight and alternaria blight with more percent disease control when compared to the fungicides were used alone. All the treatments were found safer to the natural enemies.

The results proved that all the test treatments were biologically compatible with each other. The treatments, spinetoram in combination with carbendazim and copper oxychloride were found to be more effective in reducing the sucking pests' population and foliar diseases incidence in cotton. These two treatments can be wished-for farmer's usage in cotton field.

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