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Impact of seed dressing insecticides on natural enemies of *Bt* cotton ecosystem

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ABSTRACT: Investigations were carried out on the effect of seed dressing chemicals on the beneficial predators in the *Bt* cotton ecosystem during 2021-22. All seed dressing insecticides were found safer to the natural enemies as the population of *Chrysoperla* and ladybird beetle were found comparable to population of untreated control treatment up to 37 days of seed treatment. Similarly, the spider population was also not affected up to 17 days of seed treatment. Thereafter, the population of natural enemies was found higher with the higher prey (sucking pests) populations in the untreated check compared to treatments of seed dressing chemicals and in later treatments, there was no significant difference. The maximum population of spiders (0.52/plant), *Chrysoperla* (0.42/plant) and ladybird beetle (0.42/plant) was observed in the untreated control. Yield data indicated that the treatment with imidacloprid 70 WG @ 3 g kg^{-1} obtained highest seed cotton yield (21.69 q ha^{-1}) and it was found superior over the other seed treatments.

KEYWORDS: *Chrysoperla*, ladybird beetle, spider, insecticides

Cotton (*Gossypium hirsutum* L.) is an important commercial fibre crop grown under diverse agro-climatic conditions and is called as 'White Gold' and also as King of Fibre. Owing to the introduction of *Bt* cotton having gene from *Bacillus thuringiensis* (Berliner) expressing delta endotoxin, the pest status of bollworm complex has declined (Peshin *et al*., 2007). Though genetically engineered *Bt* cotton provide effective management of bollworm complex but nowadays sucking pests *viz*., thrips, *Thrips tabaci* (Lindeman), leafhopper; *Amrasca biguttula biguttula* (Ishida), aphid, *Aphis gossypii* (Glover) and whitefly; *Bemisia tabaci* (Gennadius) attained the status of key pests in Gujarat and cause considerable damage (> 10%) to the cotton crop during its early stages of development resulting in pre-mature shedding of leaves and fruiting parts. In the early stage of growing the crop, farmers use foliar insecticides to avoid damage from these pests. These early foliar applications of insecticide often kill the natural enemies which then results in a resurgence of the pests. With the introduction of the systemic insecticides for seed treatment, farmers have been able to use them to protect their crop from the early season, sap- sucking insect pests. The effects of imidacloprid and thiamethoxam on sucking pests (Kagabu, 1999; Yamada *et al.,* 1999; Maienfisch

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Table 1. Effect of seed treatment of various chemicals on population of spider in *Bt* cotton

Treatments	Dose (kg^{-1} seed)	Average spider per plant- DAS										
		10	17	23	30	37	44	51	58	65	72	Pooled
Carbosulfan 25 DS	60 g	0.71^{a} (0.00)	0.73^{a} (0.03)	0.72^{a} (0.02)	0.74^{b} (0.04)	0.74^{b} (0.05)	0.74^{b} (0.04)	0.74^{b} (0.05)	0.74^{b} (0.05)	0.75^{b} (0.06)	0.77^{b} (0.09)	0.74^{b} (0.05)
Imidacloprid 70 WG	3 g	0.71^{a} (0.00)	0.74^{a} (0.04)	0.74^{a} (0.04)	0.75^{b} (0.06)	0.76^{b} (0.08)	0.77^{b} (0.09)	0.78^{b} (0.10)	0.76^{b} (0.08)	0.76^{b} (0.07)	0.77^{b} (0.09)	0.75^{b} (0.06)
Imidacloprid 48 FS	8 ml	0.71^{a} (0.00)	0.71^{a} (0.00)	0.71^{a} (0.00)	0.71^{b} (0.00)	0.77^{b} (0.09)	0.79^{b} (0.12)	0.72^{b} (0.02)	0.72^{b} (0.02)	0.76^{b} (0.07)	0.77^{b} (0.09)	0.74^{b} (0.04)
Imidacloprid + Hexaconazole 20 FS	2 ml	0.71^{a} (0.00)	0.71^{a} (0.00)	0.71^{a} (0.00)	0.73^{b} (0.03)	0.73^{b} (0.04)	0.74^{b} (0.04)	0.74^{b} (0.05)	0.74^{b} (0.05)	0.73^{b} (0.03)	0.71^{b} (0.01)	0.72^{b} (0.02)
Thiamethoxam 30 FS	10 ml	0.71^{a} (0.00)	0.73^{a} (0.03)	0.74^{a} (0.04)	0.74^{b} (0.04)	0.75^{b} (0.06)	0.76^{b} (0.08)	0.77^{b} (0.09)	0.75^{b} (0.06)	0.75^{b} (0.06)	0.77^{b} (0.09)	0.74^{b} (0.05)
Thiamethoxam 70 WS	4 g	0.71^{a} (0.00)	0.73^{a} (0.03)	0.74^{a} (0.04)	0.74^{b} (0.04)	0.74^{b} (0.05)	0.74^{b} (0.04)	0.74^{b} (0.05)	0.74^{b} (0.05)	0.75^{b} (0.06)	0.77^{b} (0.09)	0.74^{b} (0.05)
Chlorantraniliprole 9.3 SC + lamda cyhalothrin 4.6 CS (13.9 ZC)	2.5 ml	0.71^{a} (0.00)	0.71^{a} (0.00)	0.71^{a} (0.00)	0.74^{b} (0.04)	0.73^{b} (0.04)	0.74^{b} (0.05)	0.75^{b} (0.06)	0.74^{b} (0.05)	0.73^{b} (0.03)	0.72^{b} (0.01)	0.73^{b} (0.03)
Control	-	0.82^{a} (0.17)	0.86^{a} (0.24)	0.90^{a} (0.31)	0.95^{a} (0.41)	0.97^{a} (0.44)	1.02^{a} (0.55)	1.07^{a} (0.65)	1.12^{a} (0.75)	1.19^{a} (0.91)	1.19^{a} (0.91)	1.01^{a} (0.52)
CD at 5% (T)		NS	NS	0.11	0.12	0.12	0.11	0.11	0.11	0.12	0.11	0.04
CD at 5% (TxP)	-	-	-	-	-	-	-	-	-	-	-	0.10

Figures in parentheses are retransferred values, those outside are square root transformed values. In each column means followed by a same alphabet are not significantly different from each other

et al., 2001) and their effects on predators are well documented (Woolweber and Tietjen, 1999). However, very little information is available on the effect of these seed treatment insecticides on the *Chrysoperla,* ladybird beetle and spider under field conditions. Seed treatment insecticides are used commercially to protect against injury by early season sucking pests (Wilde *et al.,* 1999; Mckirdy and Jones, 1996). It is also effective at controlling many sucking insects, including aphids, thrips, jassid, whitefly, and mealybugs when used as a seed treatment (Harvey *et al.,* 1996) and is commonly used on several crops, including cotton (Hernandez *et al*., 1999). This study was initiated to gain confidence on the safety of these compounds against the predators in order to include these compounds for the management of early season sucking pests.

The present investigation was conducted during *Kharif* 2021 at Main Cotton Research Station, Navsari Agricultural University, Surat. Systemic insecticides were used as seed treatment under field condition on *Bt* cotton variety, Ajeet 155 BG II used. The untreated seed was used as control treatments. The experiment was laid out in a randomized block design with three replications. Treated and untreated seeds were sown by hand using a dibbing method on bed and furrow. The plots consisted of 18518 plants per hectare spaced

0.45cm within row and 1.20m between rows. No foliar spray application was given during the study period.

The required quantity of *Bt* cotton seeds and insecticides (Table 1) were put in polythene bag and mixed thoroughly. Few drops of water *i.e.* @ 2 ml 100 g^{-1} seed were sprinkled on the mixture of seeds and insecticide. The mixture was stirred frequently till uniform coating of insecticides occurred. The treated seeds were spread on a paper in a room and kept overnight for drying.

Five plants were selected randomly from each plots tagged. While plants located at border were avoided for recording observation. The total number of grubs and adult of lady bird beetle, *Chrysoperla* and spider was count. Observations were recorded on all 5 randomly selected plants up to 72 days at weekly intervals and data were subjected to statistical analysis. The cotton from each net plot (3.60 x 4.50cm) was picked at each picking and weighed separately. The picking was carried out till the end of season. Total yield from each plot was calculated and computed on hectare basis. The data collected during the course of experimentation were subjected to statistical analysis with appropriate transformation for interpretation of results in Randomized Block Design (RBD) in order

Table 2. Effect of seed treatment of various chemicals on population of *Chrysoperla* in *Bt* cotton

Treatments	Dose (kg^{-1} seed)	Average spider per plant- DAS										
		10	17	23	30	37	44	51	58	65	72	Pooled
Carbosulfan 25 DS	60 g	0.71^{b} (0.00)	0.73^{b} (0.03)	0.74^{b} (0.05)	0.75^{b} (0.06)	0.72^{b} (0.02)	0.78^{ab} (0.11)	0.72^{b} (0.02)	0.72^{b} (0.02)	0.76^{b} (0.07)	0.77^{b} (0.09)	0.71^{b} (0.00)
Imidacloprid 70 WG	3 g	0.71^{b} (0.00)	0.74^{b} (0.04)	0.75^{b} (0.06)	0.76^{b} (0.07)	0.77^{ab} (0.09)	0.79^{ab} (0.12)	0.80^{b} (0.14)	0.78^{b} (0.11)	0.77^{b} (0.10)	0.79^{b} (0.13)	0.71^{b} (0.00)
Imidacloprid 48 FS	8 ml	0.71^{b} (0.00)	0.71^{b} (0.00)	0.71^{b} (0.00)	0.71^{b} (0.00)	0.77^{ab} (0.09)	0.78^{b} (0.10)	0.72^{b} (0.02)	0.72^{b} (0.02)	0.76^{b} (0.07)	0.77^{b} (0.09)	0.71^{b} (0.00)
Imidacloprid1+ Hexaconazole 20 FS	2 ml	0.71^{b} (0.00)	0.71^{b} (0.00)	0.71^{b} (0.00)	0.74^{b} (0.04)	0.76^{ab} (0.08)	0.75^{b} (0.07)	0.71^{b} (0.00)	0.71^{b} (0.00)	0.71^{b} (0.00)	0.71^{b} (0.01)	0.71^{b} (0.00)
Thiamethoxam 30 FS	10 ml	0.71^{b} (0.00)	0.74^{b} (0.04)	0.73^{b} (0.03)	0.76^{b} (0.07)	0.75^{ab} (0.06)	0.77^{b} (0.09)	0.78^{b} (0.10)	0.75^{b} (0.06)	0.75^{b} (0.06)	0.77^{b} (0.09)	0.71^{b} (0.00)
Thiamethoxam 70 WS	4 g	0.71^{b} (0.00)	0.71^{b} (0.00)	0.71^{b} (0.00)	0.71^{b} (0.00)	0.73^{ab} (0.03)	0.79^{ab} (0.12)	0.72^{b} (0.02)	0.72^{b} (0.02)	0.77^{b} (0.09)	0.77^{b} (0.09)	0.71^{b} (0.00)
Chlorantraniliprole 9.3 SC + lamda cyhalothrin 4.6 CS (13.9 ZC)	2.5 ml	0.71^{b} (0.00)	0.71^{b} (0.00)	0.71^{b} (0.00)	0.75^{b} (0.06)	0.76^{ab} (0.08)	0.75^{b} (0.07)	0.71^{b} (0.00)	0.71^{b} (0.00)	0.71^{b} (0.00)	0.72^{b} (0.01)	0.71^{b} (0.00)
Control	-	0.71^{a} (0.00)	0.81^{a} (0.16)	0.81^{a} (0.16)	0.86^{a} (0.24)	0.92^{a} (0.35)	0.97^{a} (0.44)	1.04^{a} (0.58)	1.13^{a} (0.78)	1.16^{a} (0.84)	1.19^{a} (0.91)	0.71^{a} (0.00)
CD at 5% (T)		NS	NS	NS	NS	NS	0.11	0.11	0.12	0.12	0.12	NS

Figures in parentheses are retransferred values, those outside are square root transformed values. In each column means followed by a same alphabet are not significantly different from each other

Table 3. Effect of seed treatment of various chemicals on population of ladybird beetle in *Bt* cotton

Treatments	Dose (kg^{-1} seed)	Average spider per plant- DAS										
		10	17	23	30	37	44	51	58	65	72	Pooled
Carbosulfan 25 DS	60 g	0.71^{a} (0.00)	0.73^{a} (0.03)	0.74^{a} (0.04)	0.74^{a} (0.04)	0.74^{ab} (0.05)	0.74^{b} (0.04)	0.74^{b} (0.05)	0.74^{b} (0.05)	0.75^{b} (0.06)	0.77^{b} (0.09)	0.74^{b} (0.05)
Imidacloprid 70 WG	3 g	0.71^{a} (0.00)	0.74^{a} (0.04)	0.75^{a} (0.06)	0.76^{a} (0.07)	0.77^{ab} (0.09)	0.79^{ab} (0.12)	0.75^{ab} (0.06)	0.78^{b} (0.11)	0.77^{b} (0.09)	0.77^{b} (0.09)	0.75^{b} (0.07)
Imidacloprid 48 FS	8 ml	0.71^{a} (0.00)	0.71^{a} (0.00)	0.71^{a} (0.00)	0.71^{a} (0.00)	0.75^{ab} (0.06)	0.79^{ab} (0.12)	0.72^{b} (0.02)	0.72^{b} (0.02)	0.76^{b} (0.07)	0.77^{b} (0.09)	0.74^{b} (0.04)
Imidacloprid1 + Hexaconazole 20 FS	2 ml	0.71^{a} (0.00)	0.71^{a} (0.00)	0.71^{a} (0.00)	0.75^{a} (0.06)	0.76^{ab} (0.08)	0.75^{b} (0.07)	0.71^{b} (0.00)	0.71^{b} (0.00)	0.71^{b} (0.00)	0.71^{b} (0.01)	0.72^{b} (0.02)
Thiamethoxam 30 FS	10 ml	0.71^{a} (0.00)	0.74^{a} (0.04)	0.75^{a} (0.06)	0.76^{a} (0.07)	0.72^{b} (0.02)	0.79^{ab} (0.12)	0.72^{b} (0.02)	0.72^{b} (0.02)	0.76^{b} (0.07)	0.77^{b} (0.09)	0.74^{b} (0.05)
Thiamethoxam 70 WS	4 g	0.71^{a} (0.00)	0.71^{a} (0.00)	0.71^{a} (0.00)	0.71^{a} (0.00)	0.77^{ab} (0.09)	0.79^{ab} (0.12)	0.72^{b} (0.02)	0.72^{b} (0.02)	0.76^{b} (0.07)	0.77^{b} (0.09)	0.74^{b} (0.04)
Chlorantraniliprole 9.3 SC+lamda cyhalothrin 4.6 CS (13.9 ZC)	2.5 ml	0.71^{a} (0.00)	0.71^{a} (0.00)	0.71^{a} (0.00)	0.75^{a} (0.06)	0.76^{ab} (0.08)	0.75^{b} (0.07)	0.71^{b} (0.00)	0.71^{b} (0.00)	0.71^{b} (0.00)	0.72^{b} (0.01)	0.72^{b} (0.02)
Control	-	0.82^{a} (0.17)	0.81^{a} (0.16)	0.81^{a} (0.16)	0.86^{a} (0.24)	0.92^{a} (0.35)	0.97^{a} (0.44)	1.04^{a} (0.58)	1.13^{a} (0.78)	1.16^{a} (0.84)	1.19^{a} (0.91)	0.96^{a} (0.42)
CD at 5% (T)		NS	NS	NS	NS	NS	0.11	0.11	0.11	0.12	0.11	0.05
CD at 5% (TxP)	-	-	-	-	-	-	-		-	-	-	0.10

Figures in parentheses are retransferred values, those outside are square root transformed values. In each column means followed by a same alphabet are not significantly different from each other

to test the level of significance among the various treatments.

Spiders: Pooled analysis of spider population showed that population ranging from 0.02 to 0.06 per plant in seed dressing chemical treatments while in control plots spider population was found 0.52 per plant. Significantly highest population of spider recorded in plots which were treated with imidacloprid 70 WG at 3 g kg^{-1} seed (0.06) except control. Significantly equal population (0.05) recorded in thiamethoxam 30 FS at 10 ml kg^{-1} seed, thiamethoxam 70 WS at 4 g kg^{-1} seed (3.26) and carbosulfan 25 DS at 60 g kg^{-1} seed (3.06). Among all chemical treatments, lowest spider population (0.02) recorded in plots which were treated with imidacloprid +hexaconazole 20 FS at 2 ml kg^{-1} (Table 1). Seed treatment of transgenic cotton with imidacloprid at 5 g kg^{-1} seed was not only safe but also attracted predators, *viz.,* Lynx spider, orb spider wolf and long-jawed spider in transgenic cotton (Kannan *et al*., 2004). Thakre *et al*. (2009) reported by the seed treatments of thiamethoxam at 4 g kg^{-1} seed and imidacloprid at 10 g kg^{-1} seed were proved safer to spider . Seed treatment with imidacloprid at 7.5 g kg^{-1} seed and thiamethoxam at 7.5 g kg^{-1} seed among the natural enemy complex spider was the dominant predators which were observed in good numbers in the cotton ecosystem (Sayala *et al*., 2009).

Chrysoperla: Pooled analysis of *Chrysoperla* population in various chemical treatments ranged from 0.02 to 0.07 per plant (Table 2). Significantly highest population of *Chrysoperla* was 0.52 per plant in control plots. Among seed dressing chemical treatments, significantly maximum population (0.06) of *Chrysoperla* recorded in plots which were treated with imidacloprid 70 WG at 3 g kg^{-1} seed and which was followed by thiamethoxam 30 FS at 10 ml kg^{-1} seed (0.06) and carbosulfan 25 DS at 60 g kg^{-1} seed (0.05). Seed treatment with thiamethoxam 70 WS at 4 g kg^{-1} seed (0.04) and imidacloprid 48 FS at 8 ml kg^{-1} seed (0.04) recorded equal population. Lowest population (0.02) of *Chrysoperla* recorded in plots which were treated chlorantraniliprole 9.3 SC+lamda cyhalothrin 4.6 CS (13.9 ZC) at 2.5 ml kg^{-1} seed and imidacloprid + hexaconazole 20 FS at 2 ml kg^{-1} seed. The seed treatments of thiamethoxam at 4 g kg^{-1} and imidacloprid at10 g kg^{-1} seed were proved safer to *Chrysoperla* (Thakre *et al.,* 2009). Seed treatment with imidacloprid at 7.5 g kg^{-1} seed and thiamethoxam at 7.5 g kg^{-1} seed, among the natural enemy complex *Chrysoperla* was the dominant predators which were observed in good numbers in the cotton ecosystem (Sayala *et al*., 2009). Seed treatment with imidacloprid 70 WS at 7 g kg^{-1} seed was conserved more number of *Chrysoperla* (Jayaprakash *et al*., 2015).

Ladybird beetle: In pooled analysis over period (Table 3), the population of ladybird beetle in various seed dressing chemical plots was ranging from 0.02 to 0.07. Population of ladybird beetle was recorded significantly maximum (0.42) per plant in control plots. Among all chemical treatments, significantly maximum population (0.07) of ladybird beetle recorded in plots which were treated with imidacloprid 70 WG at 3 g kg^{-1} seed it was followed by carbosulfan 25 DS at 60 g kg^{-1} seed (0.05). Significantly equal population was recorded in seed treatment with thiamethoxam 70 WS at 4 g kg^{-1} seed (0.04), and imidacloprid 48 FS at 8 ml kg^{-1} seed (0.04). Lowest population (0.02) of ladybird beetle recorded in plots which were treated with imidacloprid+hexaconazole 20 FS at 2 ml kg^{-1} seed and chlorantraniliprole 9.3 SC+lamda cyhalothrin 4.6 CS (13.9 ZC) at 2.5 ml kg^{-1} seed. The seed treatments of thiamethoxam 70 WS at 4 g kg^{-1} seed and imidacloprid 70 WS at10 g kg^{-1} seed were proved safer to ladybird beetle (Thakre *et al.,* 2009). Seed treatment with imidacloprid 70 WS at 7 g kg^{-1} seed was conserved more number of ladybird beetle (Jayaprakash *et al*., 2015).

Yield: Seed cotton yield was ranging from 17.90 to 21.69 q ha^{-1}. Imidacloprid 70 WG at 3 g kg^{-1} seed, recorded significantly higher yield (21.69 q ha^{-1}) and it was at par with carbosulfan 25 DS at 60 g kg^{-1} seed (19.99 q ha^{-1}), thiamethoxam 70 WS 4 g kg^{-1} seed (19.96 q ha^{-1}), imidacloprid 48 FS 8 ml kg^{-1} seed (19.66 q ha^{-1}), chlorantraniliprole (9.3%) + lamda cyhalothrin (46% ZC) at 2.5 ml kg^{-1} (18.95 q ha^{-1}), and imidacloprid (18.5%) + hexaconazole (1.5% FS) at 2 ml kg^{-1} seed (17.90 q ha^{-1}). Imidacloprid (18.5%) + hexaconazole (1.5% FS) at 2 ml kg^{-1}recorded lowest yield (15.42 q ha^{-1}), even lower than the control plots (16.95 q ha^{-1}). Amin *et al*. (2008) reported that seed treatment with gaucho at all threshold levels gave significantly higher yield and profitable benefit cost ratio. Seed cotton yield was maximum in imidacloprid 70 WS seed treatment with at 5.5 and 4.5 g kg^{-1}. CB9 cotton cultivar gave a higher benefit cost ratio, when seed were treated with imidacloprid 70 WS at 5.5 g kg^{-1} seed fuzzy seed (Hossain *et al*., 2012). Rao *et al*. (2014) reported maximum seed cotton yield in seed treatment with imidacloprid 70 WS followed by thiamethoxam 70 WS. Sanganna (2018) also recorded maximum seed cotton yield in seed treatment with imidacloprid 75 WS at 3.5 g kg^{-1} of seed followed by seed treated with carbosulfan 25 DS at 30 g. kg^{-1}.

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