

Original Research Article

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Impact of Repeated Application of Synthetic Insecticides on Thrips and their Natural Enemies of *Bt* Cotton

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ABSTRACT

In order to study the effects of repeated use of various insecticides on thrips and their natural enemies viz., Ladybird beetle and Predatory spiders, an experiment was conducted during *Kharij*, 2018-19 at the Experimental farm, Department of Agricultural Entomology, Vasanttrao Naik Marathwada Krishi Vidyapeeth, Parbhani. The insecticides selected included those used commonly among the farmers viz., Imidacloprid 17.8% SL, Fipronil 5% SC, Lambda cyhalothrin 5% EC, Spinosad 45% SC, Acephate 75% SP, Buprofezin 25% SC, Flonicamid 50% WG, Acetamiprid 20% SP, Profenofos 50% EC, Diafenthiuron 50% WP, Acephate 50% + Imidacloprid 1.8% SP, Pyriproxyfen 5% + Fenpropathrin 15% EC and Profenofos 40% + Cypermethrin 4% EC. From the first spraying onwards, Flonicamid 50% WG was found to be the best in reducing the thrips population steadily up to 0.50/leaf in second spraying. But, a sudden increase in population mean was found in the third (6.80/leaf) and fourth spraying (11.50). Same trend was followed in Fipronil 5% SC, Buprofezin 25% SC and Diafenthiuron 50% WP. The effect of repeated applications of synthetic insecticides on the natural enemies depicted that Spinosad 45% SC, Flonicamid 50% WG and Buprofezin 25% SC were the safest insecticides, showing maximum natural enemies population. Imidacloprid 17.8% SL, Fipronil 5% SC and Lambda cyhalothrin 5% EC recorded minimum natural enemies population marking its intense toxicity against them.

Keywords

Cotton thrips,
Natural enemies,
Flonicamid,
Spinosad, *Bt* cotton

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Introduction

Cotton (*Gossypium spp.*) (Family: Malvaceae) popularly known as "White gold" is a major commercial crop unanimously designated as the "KING OF FIBRES" and has global significance which is grown for its lint and seed. It contains about 80% of the raw material to textile industry in the country providing livelihood for more than 100 million people, through production, processing,

trading and marketing (Rakesh and Kathane, 1989). Cotton pest management has always been the most challenging task for entomologists all over the world as it suffers severe economic damage from several insects which comes around 1326 species (Matthews and Tunstall, 1994).

The decision of GEAC (Genetic Engineering and Approval Committee) of Government of India clearing the release of *Bt* cotton for commercial cultivation during 2002-2003 crop

season, is considered as one of the major milestones in the history of cotton improvement in India. Even though this transgenic *Bt* cotton can effectively control specific lepidopterous species, there is lack of resistance against sucking pests (Hofs *et al.*, 2004). So the sucking pests have warranted monitoring and intervention with insecticides in the early stage of the crop (Kilpatrick *et al.*, 2005). The sucking pests including whitefly (*Bemisia tabaci*), Thrips (*Thrips tabaci*) and jassid (*Amrasca biguttula biguttula*) are more injurious to cotton which cause 40-50 percent damage in the crop (Naqvi, 1976). Thrips (*Thrips tabaci* Lind.) have already attained the status of a regular insect pest of cotton, probably due to overuse of insecticides. *Thrips tabaci* is the most important early season sucking insect pest of cotton. It attacks cotton crop early in the season, where both nymph and adult stages damage the tissue and destroy the crop by sucking the cell sap. This leads to the curling of leaves which eventually ends up in the stunting of plants in the initial stage. Ghahn, 1948 and Bournier, 1969 have reported that *T.tabaci* was responsible for the loss of 50% of young cotton plants and can also act as vector of plant diseases (Sakimura, 1963). To combat the sucking pests in India, atleast 2-3 sprays are directed against the sucking pests (Acharya *et al.*, 2002). Farmers use higher doses on account of perception that recommended doses are not working very well in fields.

Heavy reliance and indiscriminate use of pesticides to control insect pests has led to the development of resistance to all classes of pesticides (Jayekumar and Gupta, 2000). Insecticide resistance rendered insecticides ineffectiveness necessitating repeated applications of insecticides on resorting to higher doses of insecticides, which inturn contributed to the development of resistance (Kranthi *et al.*, 2002). Prolonged uses of the same insecticides not only elevate the problem

of insecticide resistance but also disturbs the occurrence of natural enemies.

Materials and Methods

The field experiment was conducted during *Kharif* 2018-2019, at the experimental farm of the Department of Agricultural Entomology, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani (Maharashtra). The repeated application of thirteen insecticides including three major combinations were selected for evaluation and comparison with untreated control. The insecticides selected included those used commonly among the farmers *viz.*, Imidacloprid 17.8% SL, Fipronil 5% SC, Lambda cyhalothrin 5% EC, Spinosad 45% SC, Acephate 75% SP, Buprofezin 25% SC, Flonicamid 50% WG, Acetamiprid 20% SP, Profenofos 50% EC, Diafenthiuron 50% WP, Acephate 50% + Imidacloprid 1.8% SP, Pyriproxyfen 5% + Fenpropathrin 15% EC and Profenofos 40% + Cypermethrin 4% EC. The treatment details regarding the synthetic insecticides are given in the Table 1. Battery operated sprayer was used for spraying the insecticides on the crop and proper safety measures were taken while applying.

The required quantity of insecticides was mixed in water in order to prepare the spray solution. Five foliar sprays were taken at an interval of 15 days. The first spray was taken 30 days after the emergence of the crop. Care was taken to avoid the drifts to neighbouring plots. Spraying was done during the morning hours when the weather is calm and humid. The sprayer was washed after each treatment application to avoid mixing of insecticides.

The observations were recorded 1 day before spraying, then 1, 3, 7, 14 days after each spraying by selecting five plants randomly from each plot. The population of thrips was taken from three leaves (each from bottom,

middle and top canopy) per plant. The natural enemy population was observed taking the whole plant into consideration.

Results and Discussion

Effect of repeated application of synthetic insecticides on Thrips, *Thrips tabaci* on *Bt* cotton during *Kharif* 2018-2019

Observations regarding the repeated application of synthetic insecticides is given in Table 2 where all treatments were found to be significantly superior over the untreated control.

Effect of different insecticides on thrips on *Bt* cotton after first spraying during *Kharif* 2018-2019

A uniformly distributed and low population was recorded on one day before spraying, with the population mean ranging from 2.13-2.93/leaf. No significant variations were seen between the treatments. The population means after the first spraying recorded Profenofos 50% EC as the best treatment in reducing thrips population (0.02/leaf). It was followed by Lambda cyhalothrin 5% EC and Buprofezin 25% SC with a mean thrips population of 0.13 and 0.15/leaf. All these were on par with Flonicamid 50% WG, Spinosad 45% SC, Fipronil 5% SC, Pyriproxyfen 5% + Fenpropathrin 15% EC, Acetamiprid 20% SP, Profenofos 40% + Cypermethrin 4% EC and Diafenthiuron 50% WG.

Effect of different insecticides on thrips on *Bt* cotton after second spraying during *Kharif* 2018-2019

The observations after second spraying are given in the Table 2, where all treatments were found to be statistically superior over the untreated control. The mean thrips population

after the second spraying depicted that Fipronil 5% SC, Flonicamid 50% WG, Buprofezin 25% SC, Spinosad 45% SC were on par with each other with mean populations of 0.42, 0.50, 0.55 and 0.65/leaf, respectively. The least effectiveness in reducing thrips population was noted in Pyriproxyfen 5% + Fenpropathrin 15% EC which was at par with Acephate 75% SP, Lambda cyhalothrin 5% EC, Acephate 50% + Imidacloprid 1.8% SP and Profenofos 40% + Cypermethrin 4% EC.

Effect of different insecticides on thrips on *Bt* cotton after third spraying during *Kharif* 2018-2019

Flonicamid 50% WG was found to be the most efficient treatment on 14 days after third spraying, marking the least thrips population. The overall mean indicated that Flonicamid 50% WG, Fipronil 5% SC, Spinosad 45% SC, Buprofezin 25% SC and Diafenthiuron 50% WP were on par and most effective treatments in reducing the thrips population. The next effective treatments were Acetamiprid 20% SP, Acephate 50% + Imidacloprid 1.8% SP, Profenofos 40% + Cypermethrin 4% EC, Lambda cyhalothrin 5% EC, Profenofos 50% EC, Imidacloprid 17.8 % SL and Pyriproxyfen 5% + Fenpropathrin 15% EC. The untreated control recorded significantly maximum thrips population.

Effect of different insecticides on thrips on *Bt* cotton after fourth spraying during *Kharif* 2018-2019

Flonicamid 50% WG was the most effective treatment in reducing thrips population on one day after fourth spraying with a lowest mean population. The overall mean population after fourth spraying revealed that all insecticidal treatments were significantly superior over untreated control. The most effective insecticides were Flonicamid 50% WG,

Spinosad 45% SC and Buprofezin 25% SC which were on par with each other with mean populations of 11.50, 15.85 and 12.75/leaf, respectively. These were followed by Fipronil 5% SC. The least effective treatment was Acephate 50% + Imidacloprid 1.8% SP which was at par with Imidacloprid 17.8% SL, Lambda cyhalothrin 5% EC and Profenofos 50% EC.

Effect of different insecticides on thrips on *Bt* cotton after fifth spraying during *Kharif* 2018-2019

The pooled mean data analysis after fifth spray revealed that Flonicamid 50% WG was the most effective insecticide which marked the least population mean of 4.80/leaf and was at par with Buprofezin 25% SC (7.83/leaf) and Spinosad 45% SC (8.03/leaf). The next effective treatments were Diafenthiuron 50% WP, Pyriproxyfen 5% + Fenpropathrin 15% EC, Profenofos 40% + Cypermethrin 4% EC, Acephate 75% SP, Fipronil 5% SC, Acetamiprid 20% SP and Lambda cyhalothrin 5% EC. Acephate 50% + Imidacloprid 1.8% SP and Imidacloprid 17.8% SL were found to be the least efficient ones with high population means of 36.88 and 31.95/leaf, respectively among all.

Effect of repeated application of different insecticides on thrips on *Bt* cotton on *Kharif* 2018-2019

The effect of repeated application of different insecticides on thrips is given in the Table 2 and Figure 1 where the pretreatment count indicated no statistical difference among the treatments and the count ranged from 2.13-2.93/leaf. The post treatment findings indicated that all insecticidal treatments increased the thrips population gradually up to fourth spraying. Again a dip in the mean population was found during the fifth spraying. But a decline in the thrips population

up to second spraying was noticed in Fipronil 5% SC, Flonicamid 50% WG, Buprofezin 25% SC and Diafenthiuron 50% WP.

From the first spraying onwards, Flonicamid 50% WG was found to be the best in reducing the thrips population steadily up to 0.50/leaf in second spraying. But, a sudden increase in population mean was found in the third (6.80/leaf) and fourth spraying (11.50/leaf). Same trend was followed in Fipronil 5% SC, Buprofezin 25% SC and Diafenthiuron 50% WP. The thrips population was suddenly increased after fourth and fifth spraying in Lambda cyhalothrin 5% EC, Imidacloprid 17.8% SL and Acephate 50%+ Imidacloprid 1.8% SP.

The present findings are in line with Sasikumar *et al.*, (2015) who found Flonicamid, Diafenthiuron, Fipronil, Buprofezin to be highly effective in reducing the thrips population with higher yield. Similar results were earlier reported by Shinde and Bhede (2017) where the effect of repeated application of insecticides on thrips population showed positive results and found Flonicamid 50% WG and Buprofezin 25% SC to be the most effective in reducing population at the end of last spray. Similar findings were in agreement with Sathyan *et al.*, (2016) who brought out the effectiveness of Fipronil 5SC and Flonicamid 50WG against *T. tabaci*. The data on efficacy of Diafenthiuron 50WP in reducing thrips population of cotton as reported by Bharpoda *et al.*, (2014) also supported the above findings.

Effect of application of different synthetic insecticides on Ladybird beetles on *Bt* cotton during *Kharif* 2018-2019

The data in the Table 3 revealed that the population of ladybird beetle per five plants did not vary significantly at one day before spraying (pre-count) recording 0.07-0.20/plant

indicating their uniform distribution throughout the experimental plots. On 1 day after the first spraying zero ladybird population was noticed in all treated plots. The population mean after the first spraying indicated that the Spinosad 45% SC and Flonicamid 50% WG marked the highest population of ladybird beetle (0.55 and 0.57/plant, respectively), which was on par with the untreated control (0.53/plant). The toxicity of Lambda cyhalothrin 5% EC was on par with Acetamiprid 20% SP, Profenofos 50% EC, Diafenthiuron 50% WG, Acephate 50% + Imidacloprid 1.8% SP, Fipronil 5% SC, Imidacloprid 17.8% SL and Profenofos 40% + Cypermethrin 4% EC.

The overall pooled data after the second spraying depicted that Flonicamid 50% WG (0.90/plant) was the most safest insecticide for ladybird beetles, which was on par with the untreated control (1.18/plant). It was followed by Buprofezin 25% SC (0.82/plant) and Spinosad 45% SC (0.77/plant). Fipronil 5% SC was observed as the most toxic treatment among all, with least population of ladybird

beetle (0.07/plant), followed by Imidacloprid 17.8% SL, Acephate 50% + Imidacloprid 17.8% SP and Lambda cyhalothrin 5% EC.

The overall mean after the third spraying indicated that Spinosad 45% SC and Flonicamid 50% WG was on par with the untreated control and proved to be the safest insecticides for ladybird beetles.

There were significant differences among treatments after the fourth spraying. Spinosad 45% SC was on par with untreated control on 1 day after the fourth spraying, depicting its least toxicity towards coccinellid beetles. But, the trend was found to change a little 14 days after fourth spraying, where Spinosad 45% EC was observed having the same population as seen in the untreated control, followed by Flonicamid 50% EC and Buprofezin 25% SC. The treatment with the minimum population after fourth spraying was Fipronil 5% SC (0.02/plant), followed by Lambda cyhalothrin 5% EC (0.09/plant) and Acephate 50% + Imidacloprid 1.8% SP (0.10/plant).

Table.1 Treatment details for field trials in *Bt* cotton

Tr. No.	Treatments	Dose (g or ml/10 L)	Conc. (%)
T ₁	Imidacloprid 17.8 % SL	4 ml	0.0712%
T ₂	Fipronil 5% SC	30 ml	0.15%
T ₃	Lambda cyhalothrin 5 %EC	6 ml	0.03%
T ₄	Spinosad 45 %SC	4 ml	0.18%
T ₅	Acephate 75 %SP	20 g	1.5%
T ₆	Buprofezin 25% SC	20 ml	0.5%
T ₇	Flonicamid 50% WG	2 g	0.1%
T ₈	Acetamiprid 20 %SP	2 g	0.04%
T ₉	Profenofos 50 %EC	30 ml	1.5%
T ₁₀	Diafenthiuron 50 %WG	12 g	0.6%
T ₁₁	Acephate 50% + Imidacloprid 1.8 %SP	20 g	1% +0.036%
T ₁₂	Pyriproxyfen 5%+ Fenpropathrin15% EC	10 ml	0.05%+0.15%
T ₁₃	Profenofos 40 % + Cypermethrin 4% EC	20 ml	0.8% +0.08%
T ₁₄	Untreated control	—	—

Table.2 Effect of repeated application of different insecticides on thrips on *Bt* cotton on *Kharif* 2018-2019

Tr. No	Treatments	Conc. (%)	Mean no. of thrips/ leaf					
			Pre-count	Spra y I	Spray II	Spra y III	Spra y IV	Spra y V
T ₁	Imidacloprid 17.8 % SL	0.0712%	2.33 (1.82)*	0.59 (1.24)	1.37 (1.50)	14.07 (3.55)	41.00 (6.28)	31.95 (5.73)
T ₂	Fipronil 5% SC	0.15%	2.20 (1.79)	0.30 (1.13)	0.42 (1.17)	7.53 (2.66)	24.98 (4.81)	19.63 (4.47)
T ₃	Lambda cyhalothrin 5 %EC	0.03%	2.40 (1.84)	0.13 (1.06)	2.17 (1.72)	13.30 (3.47)	39.35 (5.96)	26.73 (5.22)
T ₄	Spinosad 45 %SC	0.18%	2.13 (1.77)	0.28 (1.12)	0.65 (1.27)	7.95 (2.73)	12.75 (3.65)	8.03 (2.94)
T ₅	Acephate 75 %SP	1.5%	2.93 (1.98)	0.44 (1.18)	2.37 (1.77)	12.72 (3.51)	29.60 (5.33)	19.25 (4.47)
T ₆	Buprofezin 25% SC	0.5%	2.20 (1.79)	0.15 (1.07)	0.55 (1.23)	8.78 (2.83)	15.85 (4.04)	7.33 (2.82)
T ₇	Flonicamid 50% WG	0.1%	2.53 (1.88)	0.18 (1.08)	0.50 (1.21)	6.80 (2.59)	11.50 (3.49)	4.80 (2.36)
T ₈	Acetamiprid 20 % SP	0.04%	2.40 (1.84)	0.32 (1.14)	0.83 (1.33)	11.52 (3.18)	30.67 (5.50)	20.68 (4.59)
T ₉	Profenofos 50 % EC	1.5%	2.60 (1.89)	0.02 (1.01)	1.09 (1.42)	13.48 (3.46)	32.38 (5.57)	18.35 (4.32)
T ₁₀	Diafenthiuron 50 % WP	0.6%	2.67 (1.91)	0.29 (1.13)	0.77 (1.31)	9.37 (2.94)	25.12 (5.00)	13.93 (3.77)
T ₁₁	Acephate 50% + Imidacloprid 1.8 %SP	1% + 0.036%	2.93 (1.98)	0.37 (1.16)	1.97 (1.67)	12.83 (3.44)	43.20 (6.45)	36.88 (6.13)
T ₁₂	Pyriproxyfen 5%+ Fenpropathrin15%E C	0.05% +0.15%	2.13 (1.77)	0.28 (1.13)	2.38 (1.78)	15.75 (3.74)	29.17 (5.34)	14.70 (3.91)
T ₁₃	Profenofos 40 % + Cypermethrin 4% EC	0.8% + 0.08%	2.53 (1.88)	0.32 (1.14)	1.79 (1.62)	13.07 (3.44)	30.03 (5.36)	16.92 (4.17)
T ₁₄	Untreated control	—	2.60 (1.90)	1.10 (1.41)	3.58 (2.10)	18.62 (4.43)	75.30 (8.43)	76.27 (8.67)
SE ±			0.10	0.05	0.08	0.13	0.32	0.24
CD@ 5%			NS	0.15	0.24	0.39	0.91	0.69
CV			9.41	9.48	10.96	8.26	11.83	10.61

*Figures in parenthesis are $\sqrt{(X+1)}$ transformed values

Table.3 Effect of repeated application of different insecticides on ladybird beetles on *Bt* cotton on *Kharif* 2018-2019

Tr. No	Treatments	Conc.(%)	Mean no. of ladybird beetles/plant					
			Pre-count	Spra y I	Spra y II	Spra y III	Spray IV	Spra y V
T ₁	Imidacloprid 17.8 % SL	0.0712%	0.20 (1.09) *	0.25 (1.11)	0.15 (1.07)	0.08 (1.04)	0.12 (1.05)	0.07 (1.03)
T ₂	Fipronil 5% SC	0.15%	0.20 (1.09)	0.22 (1.10)	0.07 (1.03)	0.05 (1.02)	0.02 (1.00)	0.03 (1.01)
T ₃	Lambda cyhalothrin 5 %EC	0.03%	0.13 (1.06)	0.10 (1.05)	0.18 (1.08)	0.15 (1.07)	0.09 (1.04)	0.12 (1.05)
T ₄	Spinosad 45 %SC	0.18%	0.20 (1.08)	0.55 (1.23)	0.77 (1.32)	1.00 (1.41)	0.62 (1.26)	0.17 (1.07)
T ₅	Acephate 75 %SP	1.5%	0.13 (1.06)	0.40 (1.18)	0.30 (1.13)	0.37 (1.16)	0.18 (1.08)	0.07 (1.03)
T ₆	Buprofezin 25% SC	0.5%	0.20 (1.08)	0.39 (1.16)	0.82 (1.34)	0.68 (1.29)	0.43 (1.19)	0.12 (1.05)
T ₇	Fonicamid 50% WG	0.1%	0.20 (1.08)	0.57 (1.23)	0.90 (1.37)	0.80 (1.34)	0.57 (1.25)	0.17 (1.07)
T ₈	Acetamiprid 20 % SP	0.04%	0.13 (1.06)	0.20 (1.09)	0.20 (1.09)	0.22 (1.10)	0.17 (1.07)	0.08 (1.04)
T ₉	Profenofos 50 % EC	1.5%	0.20 (1.09)	0.20 (1.09)	0.27 (1.12)	0.20 (1.09)	0.10 (1.05)	0.08 (1.04)
T ₁₀	Diafenthiuron 50 % WP	0.6%	0.07 (1.03)	0.22 (1.09)	0.50 (1.21)	0.53 (1.23)	0.20 (1.09)	0.12 (1.05)
T ₁₁	Acephate 50% + Imidacloprid 1.8 %SP	1% + 0.036%	0.13 (1.06)	0.20 (1.09)	0.15 (1.07)	0.25 (1.11)	0.10 (1.04)	0.08 (1.04)
T ₁₂	Pyriproxyfen 5%+ Fenpropathrin15%EC	0.05%+0. 15%	0.20 (1.09)	0.38 (1.17)	0.48 (1.21)	0.40 (1.18)	0.17 (1.08)	0.10 (1.04)
T ₁₃	Profenofos 40 % + Cypermethrin 4% EC	0.8% + 0.08%	0.20 (1.08)	0.30 (1.13)	0.27 (1.12)	0.25 (1.11)	0.15 (1.07)	0.07 (1.03)
T ₁₄	Untreated control	—	0.13 (1.06)	0.53 (1.22)	1.18 (1.47)	1.05 (1.42)	0.73 (1.31)	0.25 (1.11)
SE ±			0.07	0.03	0.02	0.03	0.02	0.01
CD@ 5%			NS	0.09	0.07	0.08	0.07	NS
CV			10.67	6.04	4.05	4.77	4.30	2.01

*Figures in parenthesis are $\sqrt{(X+1)}$ transformed values

Table.4 Effect of repeated application of different insecticides on predatory spiders on *Bt* cotton during *Kharif* 2018-2019

Tr. No	Treatments	Conc. (%)	Mean No. of predatory spiders/ plant					
			Pre-count	Spra y I	Spra y II	Spra y III	Spra y IV	Spray V
T ₁	Imidacloprid 17.8 % SL	0.0712%	0.00 (1.00)*	0.07 (1.03)	0.13 (1.06)	0.40 (1.18)	0.52 (1.23)	0.52 (1.23)
T ₂	Fipronil 5% SC	0.15%	0.00 (1.00)	0.07 (1.03)	0.15 (1.07)	0.27 (1.12)	0.28 (1.13)	0.24 (1.11)
T ₃	Lambda cyhalothrin 5 %EC	0.03%	0.00 (1.00)	0.05 (1.03)	0.05 (1.02)	0.25 (1.11)	0.30 (1.14)	0.22 (1.10)
T ₄	Spinosad 45 %SC	0.18%	0.00 (1.00)	0.28 (1.12)	0.44 (1.19)	1.28 (1.50)	1.40 (1.55)	1.22 (1.49)
T ₅	Acephate 75 %SP	1.5%	0.00 (1.00)	0.13 (1.06)	0.37 (1.16)	0.78 (1.33)	0.68 (1.29)	0.67 (1.28)
T ₆	Buprofezin 25% SC	0.5%	0.00 (1.00)	0.23 (1.10)	0.58 (1.24)	1.32 (1.51)	1.24 (1.49)	1.12 (1.45)
T ₇	Fonicamid 50% WG	0.1%	0.00 (1.00)	0.21 (1.09)	0.55 (1.23)	1.28 (1.51)	1.27 (1.50)	1.18 (1.47)
T ₈	Acetamiprid 20 % SP	0.04%	0.00 (1.00)	0.11 (1.05)	0.17 (1.08)	0.67 (1.28)	0.54 (1.23)	0.58 (1.26)
T ₉	Profenofos 50 % EC	1.5%	0.00 (1.00)	0.07 (1.03)	0.12 (1.05)	0.32 (1.14)	0.23 (1.10)	0.30 (1.14)
T ₁₀	Diafenthiuron 50 % WP	0.6%	0.00 (1.00)	0.15 (1.07)	0.47 (1.21)	0.96 (1.39)	0.97 (1.40)	0.85 (1.36)
T ₁₁	Acephate 50% + Imidacloprid 1.8 %SP	1% + 0.036%	0.00 (1.00)	0.08 (1.04)	0.17 (1.07)	0.47 (1.20)	0.63 (1.27)	0.63 (1.28)
T ₁₂	Pyriproxyfen 5%+ Fenpropathrin15%EC	0.05% +0.15%	0.00 (1.00)	0.13 (1.06)	0.28 (1.13)	0.72 (1.30)	0.82 (1.34)	0.82 (1.35)
T ₁₃	Profenofos 40 % + Cypermethrin 4% EC	0.8% + 0.08%	0.00 (1.00)	0.19 (1.08)	0.08 (1.04)	0.35 (1.15)	0.43 (1.19)	0.43 (1.19)
T ₁₄	Untreated control	—	0.00 (1.00)	0.31 (1.13)	0.88 (1.36)	1.58 (1.60)	1.52 (1.59)	1.37 (1.54)
SE ±			0.00	0.03	0.03	0.03	0.03	0.03
CD@ 5%			0.00	0.07	0.10	0.08	0.10	0.09
CV			0.00	5.23	6.45	4.47	5.00	4.54

*Figures in parenthesis are $\sqrt{(X+1)}$ transformed values

Fig.1 Effect of repeated application of different insecticides on thrips on *Bt* cotton during *Kharif* 2018-2019

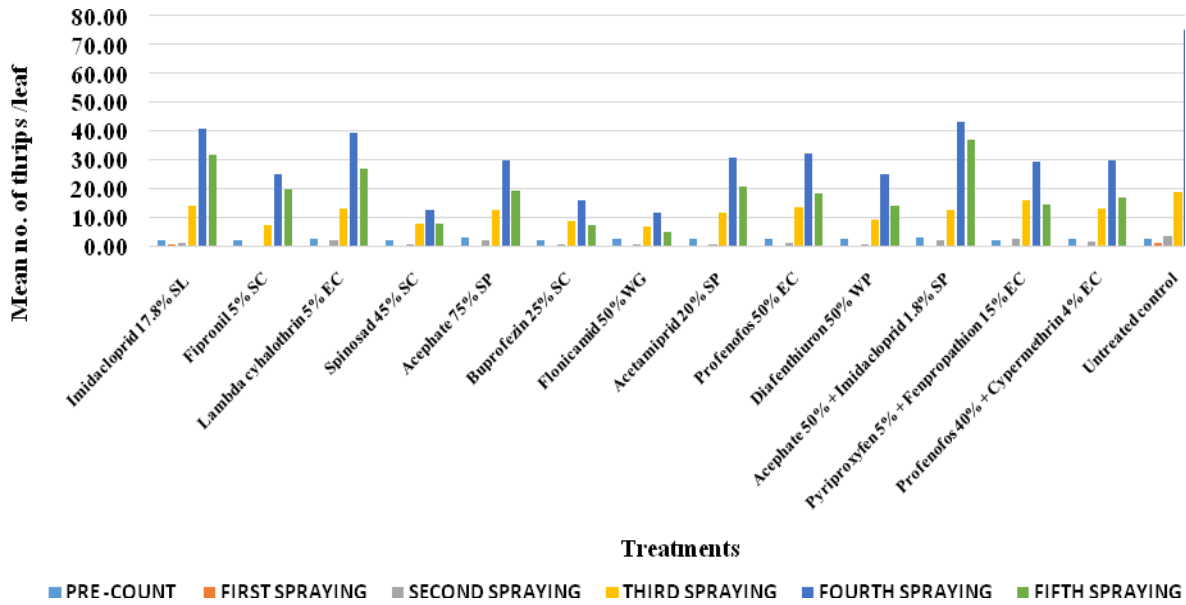


Fig.2 Effect of repeated application of different insecticides on Ladybird beetles on *Bt* cotton during *Kharif* 2018-2019

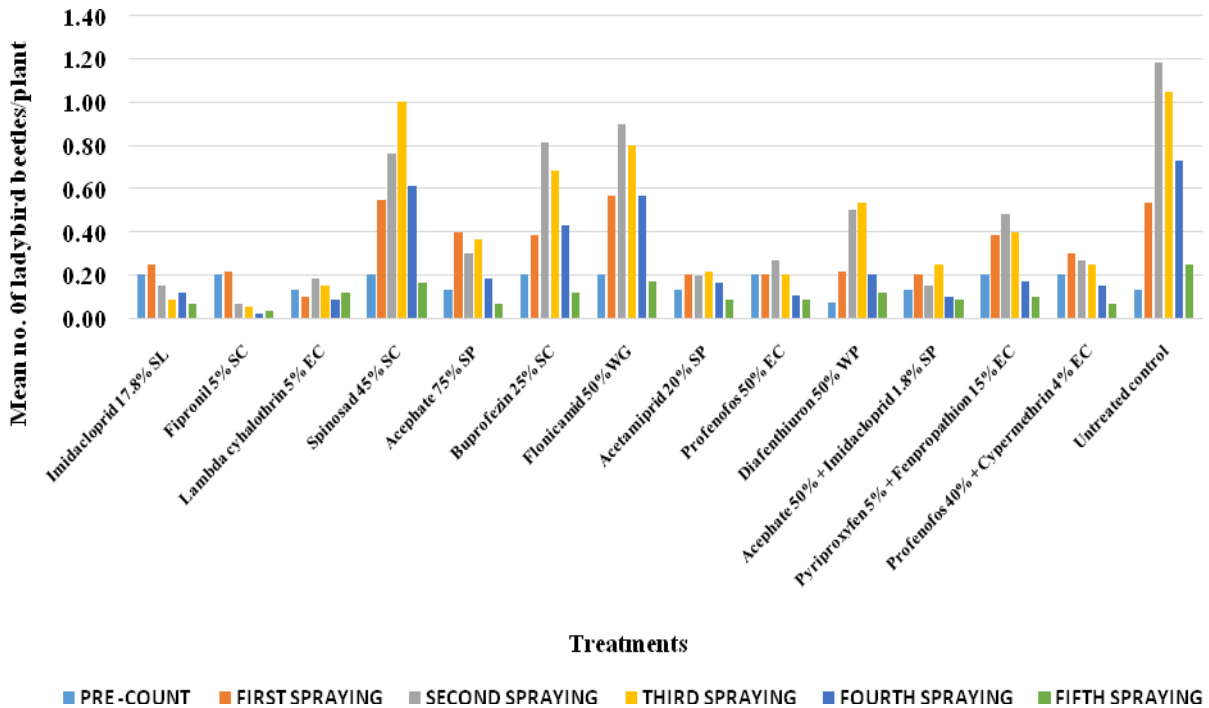
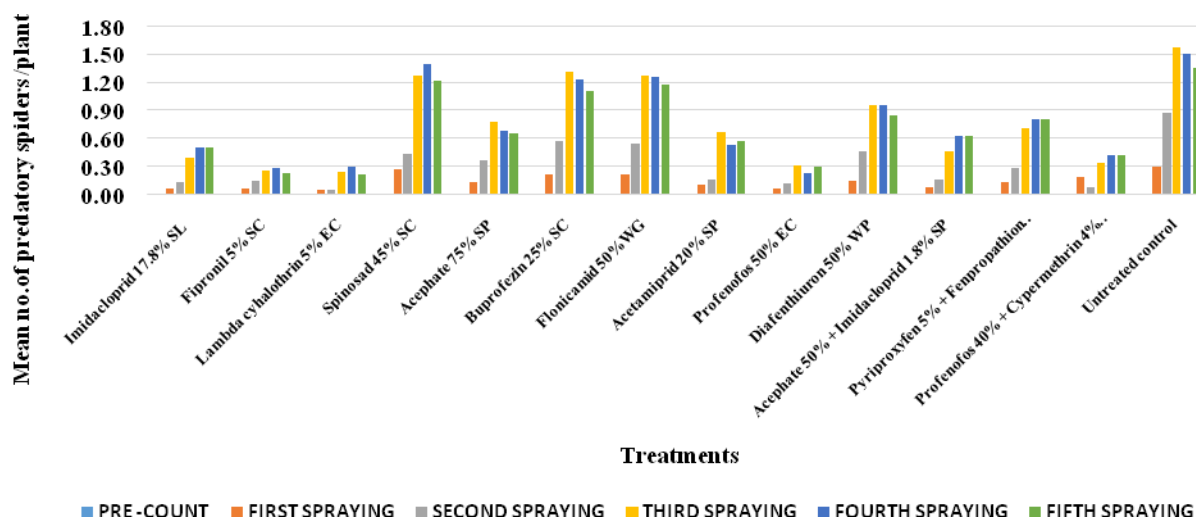


Fig.3 Effect of repeated application of different insecticides on predatory spiders on *Bt* cotton during *Kharif* 2018-2019



The population was very high after fifth spraying. Spinosad 45% SC marked same population mean as that of Flonicamid 50% WG (0.17/plant) and was on par with Buprofezin 25% SC (0.12/plant). The most toxic treatment with least population was Imidacloprid 17.8% SL (0.07/plant) which was equally efficient with Fipronil 5% SC, Acetamiprid 20% SP, Pyriproxyfen 5% + Fenpropathrin 15% EC and Profenofos 40% + Cypermethrin 4% EC.

Effect of repeated spraying of different insecticides on ladybird beetles on *Bt* cotton during *Kharif* 2018-19.

The pooled analysis of all sprayings on ladybird beetles are presented in the Table 3 and Figure 2, where no significant difference in the population was observed 1 day before the first spraying. But, after the first spray, some of the treatments were on par with the untreated control.

The overall recordings emphasized that the effect of Imidacloprid 17.8% SL was toxic and reduced the ladybird population after

each sprayings. Its effect was seen on par with Fipronil 5% SC and Lambda cyhalothrin 5% EC. The population was observed to steadily keep in pace with the untreated control in case of Flonicamid 50% WG.

The present findings are in tune with Nemade *et al.*, (2017) who reported that Flonicamid is the promising insecticide for aphid control in term of selectivity for aphid antagonist, the ladybird beetle. The findings of Chandi *et al.*, (2016) also supports this observations, where they reported the mortality of coccinellids on the sucking pests of *Bt* cotton to be significantly less in Flonicamid 50% WG and more in Imidacloprid 17.8% SL.

Effect of application of different synthetic insecticides on Predatory spiders on *Bt* cotton during *Kharif* 2018-2019

The data in the Table 4 revealed that no predatory spiders were seen 1 day before spraying and 1 and 3 days after the first spraying. The overall mean after the first spraying revealed that Spinosad 45% SC was the least toxic treatment to the predatory

spiders (0.28/plant) which were on par with Buprofezin 25% SC (0.23/plant), Flonicamid 50% WG (0.21/plant), Profenofos 40% + Cypermethrin 4% EC, Acephate 75% SP and Diafenthiuron 50% WG. Lambda cyhalothrin 5% EC marked the lowest population mean of 0.05/leaf.

The pooled data after the second spraying indicated that Spinosad 45% SC was the safest insecticide for predatory spiders (0.44/plant), whose effect on the predatory spiders was on par with the untreated control (0.88/plant). The most toxic treatment was Lambda cyhalothrin 5% EC, marking lowest predatory spider population of 0.05/plant, followed by Profenofos 40% + Cypermethrin 4% EC (0.08/plant).

An increase in the population was observed after third spraying when compared to first spraying. The overall mean after the third spraying depicted that Flonicamid 50% WG (1.28/plant) and Buprofezin 25% SC (1.32/plant) was safer to the predatory spiders and were on par with the untreated control (1.58/plant). Lambda cyhalothrin 5% EC was observed as the most toxic for predatory spiders followed by Fipronil 5% SC.

The pooled data on fourth spraying reported that Spinosad 45% SC, Flonicamid 50% WG and Buprofezin 25% SC were safer to spiders. Profenofos 50% EC was observed as the most toxic towards predatory spiders, followed by Fipronil 5% SC and Lambda cyhalothrin 5% EC.

The pooled data on fifth spraying recorded maximum population of predatory spiders. The overall data on the fifth spraying indicated that Spinosad 45% SC (1.22/plant), Flonicamid 50% WG (1.18/plant) and Buprofezin 25% SC (1.12/plant) were safer and on par with the untreated control (1.37/plant). Lambda cyhalothrin 5% EC was

recorded as the most toxic insecticide for predatory spiders, followed by Fipronil 5% SC and Profenofos 50% EC.

Effect of repeated spraying of different insecticides on Predatory spiders on *Bt* cotton during *Kharif*2018-19.

The effect of repeated application of different insecticides on predatory spiders is given in the Table 4 and Figure 3. No predatory spiders were seen on 1 day before first spraying, the population increased gradually after each sprayings. The population increase was very slow in Lambda cyhalothrin 5% EC and Profenofos 50% EC up to second spraying. From third spraying onwards, a steady population increase was observed. Maximum population was observed in Spinosad 45% SC, followed by Flonicamid 50% WG and Buprofezin 25% SC. The effect of Spinosad 45% SC was no different from the untreated control. The present findings are in tune with Murray and Lloyd (1997), who reported that there were no differences in the predator spider populations between unsprayed and Spinosad treated plots and a substantial reduction in the population of predatory spiders was seen in the conventional treatments.

Thrips, *Thripstabaci*

From the first spraying onwards, Flonicamid 50% WG was found to be the best in reducing the thrips population steadily up to second spraying. But, a sudden increase in population mean was found in the third and fourth spraying. Same trend was followed in Fipronil 5% SC, Buprofezin 25% SC and Diafenthiuron 50% WP. Flonicamid, Diafenthiuron, Fipronil, Buprofezin were highly effective in reducing the thrips population when compared to all other treatments

Ladybird beetles

The overall recordings emphasizes the toxic effect of Imidacloprid 17.8% SL in reducing the Ladybird population after each sprayings. Its effect was seen on par with Fipronil 5% SC and Lambda cyhalothrin 5% EC. The population was observed to steadily keep in pace with the untreated control in case of Flonicamid 50% WG and Spinosad 45% SC.

Predatory spiders

Maximum population was observed in Spinosad 45% SC, followed by Flonicamid 50% WG and Buprofezin 25% SC. The effect of Spinosad 45% SC was no different from the untreated control.

The effect of repeated applications of synthetic insecticides on the natural enemies depicted that Spinosad 45% SC, Flonicamid 50% WG and Buprofezin 25% SC were the safest insecticides, showing maximum natural enemies population. Imidacloprid 17.8% SL, Fipronil 5% SC and Lambda cyhalothrin 5% EC recorded minimum natural enemies population marking its intense toxicity against them.

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