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Impact of repeated application of different insecticides on the whiteflies of *Bt* cotton

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Abstract
An experiment was conducted during *Kharif* 2018-19 at the Experimental farm, Department of Agril. Entomology, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, inorder to study the effect of repeated use of various insecticides like 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, Profenofos 40% + Cypermethrin 4% EC on the whitefly population infesting *Bt* cotton. The highest reduction in whitefly population was recorded in Diafenthiuron 50% WP after the first, third, fourth and fifth sprayings with mean populations of 0.30, 0.93, 10.50 and 6.69 /leaf, respectively. This was found to be statistically at par with Flonicamid 50% WG after first, second, third, fourth and fifth sprayings with population means of 0.45, 1.72, 1.14, 10.97 and 7.07/leaf, respectively. Due to repeated application, the whitefly population increased drastically in Fipronil 5% SC and Lambda cyhalothrin 5% EC after the third spraying. Also, Fipronil 5%SC and Lambda cyhalothrin 5% EC recorded maximum whitefly population of 44.68/leaf and 41.01/leaf, respectively after five sprayings.

Keywords: Fipronil, *Bt* cotton, whiteflies, lambda cyhalothrin, repeated applications

1. 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 it's 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 [12]. It plays a key role in the national economy in terms of both employment generation and foreign exchange. Eventhough India has the largest acreage of cotton in the world, its productivity is low. The major reason for low productivity in cotton is damage by insect pests [1]. 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 [10]. Cotton crop has been subjected to maximum pesticide exposure than any other crop. Intense insecticide use resulted in insect resistance to insecticides, pesticide residues, and resurgence of minor pests and caused immense problems to cultivators.
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 [5].
Sucking pests, also referred to as 'sap feeders', limit the realization of potential productivity of cotton. Among all the important sucking pests of cotton, the whiteflies, *Bemisia tabaci* are deleterious to the cotton plant growth and development. The heavy infestation of nymphs and adults of whiteflies results in the yellowing and wrinkling of cotton leaves. Farmers use higher doses on account of perception, that recommended doses are not working very well in fields. Hence, there is an inclination of the farmers towards the use of higher doses of pesticides than the recommended doses for the management of sucking pests in *Bt* cotton. The spectacular success of these chemicals masked their limitations. The intensive and extensive use, misuse and abuse of the pesticides caused widespread damage to the environment. Relying more on the chemicals further intensified the consumption of pesticides resulting in the phenomenon of

the pesticide treadmill [2]. As long as the target pests were effectively controlled with the pesticide, the cultivators would not care about the effects it have on the insects other than the target. Heavy reliance and indiscriminate use of pesticides to control insect pests has led to the development of resistance to all classes of pesticides [7]. 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 [9].

2. Materials and Methods

The experiment was conducted during *Kharif* 2018-19 at the Experimental farm, Department of Agril. Entomology, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani. The experiment was laid out in Randomized Block Design with three replications in 4.8 m x 4.2 m plot. The effect of repeated use of various insecticides like 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, Profenofos 40% + Cypermethrin 4% EC were compared with the untreated control. The treatment details along with the information on dosages 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 were mixed in water inorder 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 on the whitefly population of *Bt* cotton were recorded 1 day before spraying, then 1, 3, 7 and 14 days after each spraying. The observations of whiteflies were taken from three leaves (each from bottom, middle and top canopy) on the five randomly selected plants from each plot.

2.2 Statistical analysis

The field population data was subjected to square root transformation before analyzing it in RBD (Randomized Block Design) procedure given by OPSTAT software. The significance of treatments was assessed at 5 per cent of significance.

3. Results

3.1 Effect of different insecticides on whiteflies on *Bt* cotton after first spraying

The pre-count observations regarding the whitefly population means ranged from 1.47-2.07/leaf in different treatments. The population of whitefly at initial crop growth was low in all treatments.

Significant differences in the population means were marked on one day after the first spraying in various treatments. Buprofezin 25% SC, Diafenthiuron 50% WP, Pyriproxyfen 5% + Fenpropathrin 15% EC were found to be the most effective one day after first spraying.

The records on 3 days after first spraying revealed that Diafenthiuron 50% WP and Pyriproxyfen 5% + Fenpropathrin 15% EC were most efficient in avoiding the whitefly infestation marking a zero population mean.

The trend was found to vary on 7 days after spraying where Flonicamid 50% WG was the most efficient treatment with least population mean

The observations on 14 days after spraying clearly showed that Flonicamid 50% WG, Diafenthiuron 50% WP, Buprofezin 25% SC and Pyriproxyfen 5% + Fenpropathrin 15% EC were on par with each other in terms of their efficacy in reducing the whitefly population.

The overall pooled analysis after the first spraying showed that Diafenthiuron 50% WP, Pyriproxyfen 5% + Fenpropathrin 15%EC, Flonicamid 50% WG, Buprofezin 25% EC and Acephate 75%SP were more effective against whitefly with mean populations of 0.30,0.40, 0.45, 0.54 and 0.63/leaf, respectively and were on par with each other. These were followed by Acephate 50% + Imidacloprid 1.8% SP, Profenofos 40% + Cypermethrin 4% EC, Fipronil 5% EC, Profenofos 50% EC, Acetamiprid 20% SP and Lambda cyhalothrin 5% EC. The least efficiency was marked by Spinosad 45% SC and Imidacloprid 17.8% SL with highest population mean of 1.88 and 1.82/leaf, respectively.

3.2 Effect of different insecticides on whiteflies on *Bt* cotton after second spraying

On one day after second spraying Buprofezin 25% EC and Pyriproxyfen 5% + Fenpropathrin 15% EC were devoid of whitefly infestation and were on par with Flonicamid 50% WG, and Diafenthiuron 50% WP.

A decline in the whitefly population was seen almost in every treatments on 3 days after second spraying, with the least population recorded equally in Buprofezin 25% EC, Diafenthiuron 50% WG and Pyriproxyfen 5% + Fenpropathrin 15%EC. The results also revealed that Spinosad 45% SC was the least efficienct insecticide in reducing whitefly population, with high population mean

On 7 days after spraying, Diafenthiuron 50% WG was the most effective and on par with Buprofezin 25% EC, Flonicamid 50% WG and Pyriproxyfen 5% + Fenpropathrin 15% EC.

Buprofezin 25% SC was the most effective treatment which remained efficient in reducing whitefly population even after 14 days after spraying. The highest population among insecticides was recorded in Profenofos 50% EC, followed by Acephate 75% SP, Spinosad 45% SC and Fipronil 5% SC.

The overall pooled data revealed that Buprofezin 25% SC was the best treatment after the second spraying. Diafenthiuron 50% WG, Flonicamid 50% WG and Pyriproxyfen 5% + Fenpropathrin 15% EC were on par with it, in terms of efficiency. The highest population mean was recorded in untreated control, followed by Spinosad 45% SC (4.27/leaf) and Fipronil 5% SC (4.13/leaf), proving their lack of efficiency in reducing the whiteflies.

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	____	_____

3.3 Effect of different insecticides on whiteflies on *Bt* cotton after third spraying

Diafenthiuron 50% WG, Buprofezin 25% SC, Flonicamid 50% WG and Pyriproxyfen 5% + Fenpropathrin 15% EC was found on par with each other 1 day after third spraying, with least population being marked on Diafenthiuron 50% WG

The data regarding the observations on 3 days after third spraying revealed that both Diafenthiuron 50% WG and Pyriproxyfen 5% + Fenpropathrin 15% EC were equally efficient in reducing whitefly infestation. They were seen on par with Buprofezin 25% SC and Flonicamid 50% WG

The results on 7 days after spraying followed same trend as that of 3 days after spraying, whereas the observations taken on 14 days after spraying clearly marked a change in trend with Diafenthiuron 50% WG on par with Buprofezin 25% SC, Flonicamid 50% WG, Pyriproxyfen 5% + Fenpropathrin 15% EC and Acephate 50% + Imidacloprid 1.8% SP. The maximum population was marked in Spinosad 45% SC, followed by Lambda cyhalothrin 5% EC and Fipronil 5% SC.

In case of the overall mean after third spraying, Diafenthiuron 50% WG was found to be the most effective treatment with mean population of 0.93/leaf and its efficiency on par with Buprofezin 25% SC (1.02/leaf), Pyriproxyfen 5% + Fenpropathrin 15% EC (1.07/leaf) and Flonicamid 50% WG (1.14/leaf). Among all the insecticides, the highest population mean with least efficiency was marked by Spinosad 45% SC (5.92/leaf) followed by Lambda cyhalothrin 5% EC (5.25/leaf).

3.4 Effect of different insecticides on whiteflies on *Bt* cotton after fourth spraying

Diafenthiuron 50% WG was the treatment that stood out the most effective on 1 day after fourth spraying by reducing the whitefly population to the maximum when compared with other treatments. Spinosad 45% SC recorded its least efficiency with the highest whitefly population mean and was at par with Lambda cyhalothrin 5% EC.

On 3 days after fourth spraying, Pyriproxyfen 5% + Fenpropathrin 15% EC was the most effective and was on par with Diafenthiuron 50% WG, Flonicamid 50% WG and Buprofezin 25% SC. The highest population mean was marked in Fipronil 5% SC, followed by Lambda cyhalothrin 5% EC among all insectiicides.

The trend changed on 7 days after spraying where Buprofezin 25% SC was found the best among all treatments, and was on par with Flonicamid 50% WG, Diafenthiuron 50% WP and Pyriproxyfen 5% + Fenpropathrin 15% EC.

Diafenthiuron 50% WG was the treatment that stood out the most effective even 14 days after the fourth spraying. The overall population mean after fourth spraying revealed that Diafenthiuron 50% WP, Pyriproxyfen 5% + Fenpropathrin 15% EC, Buprofezin 25% SC and Flonicamid 50% WG were most effective and were on par with each other. The highest population was recorded in Fipronil 5% SC and Lambda cyhalothrin 5% EC, among all insecticides, with mean populations of 31.50 and 28.17/leaf.

3.5 Effect of different insecticides on whiteflies on *Bt* cotton after fifth spraying

The whitefly population was increased profoundly during the fifth spraying when compared to first spraying. Spinosad 45% EC was the least efficient among all treatments on 1 day after fifth spraying, followed by Fipronil 5% EC and Lambda cyhalothrin 5% EC. Diafenthiuron 50% WG proved as the most efficient with the least whitefly population mean

On 3 days after spraying, Diafenthiuron 50% WG was the most effective in reducing whitefly population. It was on par with Flonicamid 50% WG, Pyriproxyfen 5% + Fenpropathrin 15% EC and Buprofezin 25% SC.

On 7 days of spraying, Diafenthiuron 50% WP was found equally efficient with Pyriproxyfen 5% + Fenpropathrin 15% EC in reducing the whitefly population mean. This was found on par with Flonicamid 50% WG and Buprofezin 25% SC. The same trend as that of 3 days after spraying was followed regarding the least efficiency, where Fipronil 5% SC stood first with a high population mean.

The data recorded on 14 days after fifth spraying revealed that Diafenthiuron 50% WP was the most effective treatment in reducing the whitefly population. It was on par with Flonicamid 50% WG, Buprofezin 25% EC and Pyriproxyfen 5% + Fenpropathrin 15% EC. Lambda cyhalothrin 5% EC marked least efficiency with high population mean

The observations after fifth spraying are given in the Table 2, where all treatments were found significantly superior over the untreated control. The whitefly population was increased profoundly during the fifth spraying when compared to first spraying. The overall mean data of whitefly population after fifth spraying revealed that, Diafenthiuron 50% WP, Flonicamid 50% WG, Buprofezin 25% SC and Pyriproxyfen 5% + Fenpropathrin 15% EC were found most effective against whitefly and on par with each other with mean populations of 6.69,7.07, 7.50 and 8.01/leaf, respectively. The least efficient one with highest population was recorded to be Fipronil 5% SC (44.68/leaf), followed by Lambda cyhalothrin 5% EC (41.01/leaf) and Spinosad 45% SC (39.33/leaf).

4. Discussion

The pre-treatment population of whiteflies did not vary significantly in all the plots before first spray and ranged from (1.47-2.07/leaf). The highest reduction in whitefly population was recorded in Diafenthiuron 50% WP after the first, third, fourth and fifth sprayings with mean populations of 0.30, 0.93, 10.50 and 6.69 /leaf, respectively. This was found to be statistically at par with Flonicamid 50% WG on first, second, third, fourth and fifth sprayings with population means of 0.45, 1.72, 1.14, 10.97 and 7.07/leaf, respectively. Both of them recorded the least whitefly population mean even after the fifth spraying, showing their high efficiency. Diafenthiuron is highly effective in suppressing cotton whiteflies has been supported by many others. [3, 10, 13- 15]

Fipronil 5% SC and Diafenthiuron, are statistically at par in reducing whitefly population in cotton [8]. The present findings contradicts this as Fipronil 5% SC and Lambda cyhalothrin 5% EC has recorded maximum whitefly population in the fourth and fifth sprayings. The drastic use of Fipronil 5% EC for the past 5 years along with the repeated use of synthetic pyrethroids are responsible for resurgence of whitefly. This may be the reason that in the present studies the whitefly population increased drastically in Fipronil 5% SC and Lambda cyhalothrin 5% EC after the third spraying. The resurgence in whitefly has been reported due to the repeated use of pyrethroids [4, 6, 11].

5. Conclusion

The highest reduction in whitefly population was recorded in Diafenthiuron 50% WP after the first, third, fourth and fifth sprayings and was found to be statistically at par with Flonicamid 50% WG. The drastic use of Fipronil 5% EC for the past 5 years along with the repeated use of synthetic pyrethroids are responsible for resurgence of whitefly which may be the reason for high population means in Fipronil 5% SC and Lambda cyhalothrin 5% EC.

Table 2: Effect of repeated application of different insecticides on whiteflies on *Bt* cotton during *Kharif* 2018-2019

Tr. No	Treatments	Conc. (%)	Mean no. of whiteflies / leaf					
			Pre-count	Spray I	Spray II	Spray III	Spray IV	Spray V
T_1	Imidacloprid 17.8% SL	0.0712%	1.67 (1.63)*	1.82 (1.66)	3.38 (1.99)	3.87 (2.15)	19.07 (4.28)	27.62 (5.22)
T_2	Fipronil 5% SC	0.15%	2.07 (1.75)	1.39 (1.53)	4.13 (2.15)	5.02 (2.39)	31.50 (5.43)	44.68 (6.63)
T_3	Lambda cyhalothrin 5%EC	0.03%	1.47 (1.57)	1.50 (1.55)	3.82 (2.08)	5.25 (2.44)	28.17 (5.18)	41.01 (6.36)
T_4	Spinosad 45%SC	0.18%	1.53 (1.59)	1.88 (1.69)	4.27 (2.20)	5.92 (2.59)	25.03 (4.92)	39.33 (6.30)
T_5	Acephate 75%SP	1.5%	1.80 (1.67)	0.63 (1.27)	3.93 (2.10)	3.70 (2.11)	19.53 (4.31)	30.06 (5.51)
T_6	Buprofezin 25% SC	0.5%	2.07 (1.75)	0.54 (1.24)	1.42 (1.48)	1.02 (1.39)	10.88 (3.19)	7.50 (2.79)
T_7	Flonicamid 50% WG	0.1%	1.93 (1.71)	0.45 (1.20)	1.72 (1.57)	1.14 (1.44)	10.97 (3.21)	7.07 (2.71)
T_8	Acetamiprid 20% SP	0.04%	1.73 (1.65)	1.47 (1.56)	3.09 (1.93)	3.42 (2.04)	17.32 (4.08)	23.95 (4.87)
T_9	Profenofos 50% EC	1.5%	1.87 (1.69)	1.48 (1.56)	4.05 (2.12)	4.03 (2.19)	19.97 (4.38)	34.74 (5.90)
T_{10}	Diafenthiuron 50% WP	0.6%	2.07 (1.75)	0.30 (1.14)	1.52 (1.51)	0.93 (1.37)	10.50 (3.13)	6.69 (2.65)
T_{11}	Acephate 50% + Imidacloprid 1.8%SP	1% + 0.036%	1.93 (1.71)	1.03 (1.40)	3.13 (1.94)	3.45 (2.06)	15.80 (3.90)	23.84 (4.84)
T_{12}	Pyriproxyfen 5%+ Fenpropathrin 15%EC	0.05%+0.15%	1.73 (1.65)	0.40 (1.18)	1.78 (1.56)	1.07 (1.41)	10.70 (3.16)	8.01 (2.82)
T_{13}	Profenofos 40% + Cypermethrin 4% EC	0.8% + 0.08%	2.07 (1.75)	1.27 (1.49)	3.32 (1.98)	3.92 (2.15)	17.06 (4.05)	31.40 (5.53)
T_{14}	Untreated control	____	1.73 (1.65)	2.38 (1.83)	4.87 (2.33)	6.99 (2.79)	44.57 (6.48)	65.49 (8.10)
SE ±			0.02	0.06	0.06	0.08	0.15	0.21
CD@ 5%			0.06	0.18	0.16	0.23	0.44	0.61
CV			2.02	8.86	5.91	8.01	7.10	8.47

*Figure in parenthesis are √(X+1) transformed values

Picture credit: Ms. BINU.V

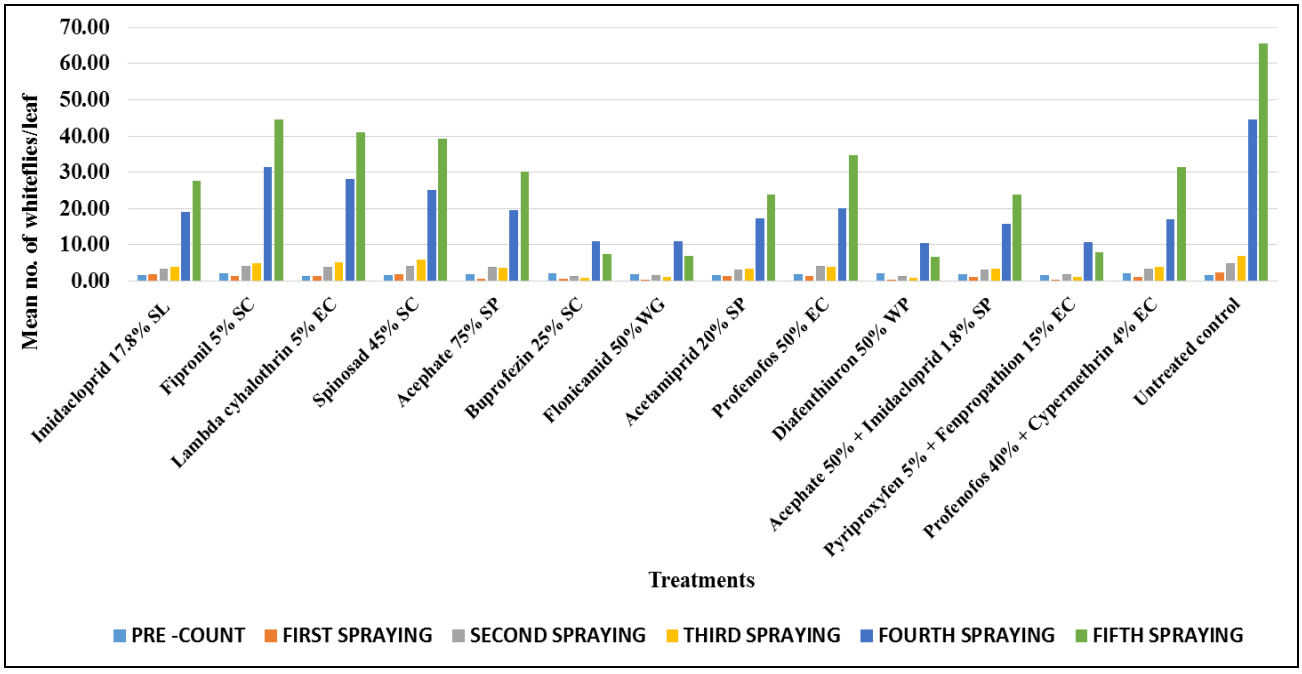

Fig 1: Effect of repeated application of synthetic insecticides on whiteflies of *Bt* cotton of *Kharif* 2018-19

5. Conclusion

The highest reduction in whitefly population was recorded in Diafenthiuron 50% WP after the first, third, fourth and fifth sprayings and was found to be statistically at par with Flonicamid 50% WG. The highest population mean was marked in Fipronil 5% SC even after the fifth spraying, followed by Lambda cyhalothrin 5% EC showing their inefficiency in reducing the whitefly population. The drastic increase in use of Fipronil 5% EC for the past 5 years along with the repeated use of synthetic pyrethroids are responsible for resurgence of whitefly. This may be the reason that in the present studies, Fipronil 5% SC and Lambda cyhalothrin 5% EC has recorded maximum whitefly population in the fourth and fifth sprayings.

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