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Effect of different ready-mix insecticidal formulations on ladybird beetle (*Cheilomenes sexmaculata* F.) in *Bt* cotton

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Abstract
The present study entitled "Effect of different ready-mix insecticidal formulations on ladybird beetle (*Cheilomenes sexmaculata* F.) in *Bt* cotton" was undertaken at Agricultural farm of Krishi Vigyan Kendra, Dhule (Maharashtra)- 424004 during *Kharif* 2024. The experiment was designed using a Randomized Block Design, incorporating eight treatments and three replications. The variety selected for this study was "Ankur Kirti BG II". A total of eight treatments were used in the current investigation, which included insecticides such as Bifenthrin 8% + Clothianidin 10% SC @ 500 ml/ha, Profenofos 40% + Cypermethrin 4% EC @ 1000 ml/ha, Clothianidin 3.5% + Pyriproxyfen 8% SE @ 1500 ml/ha, Pyriproxyfen 8% + Dinotefuran 5% + Diafenthiuron 18% SC @ 600 ml/ha, Propargite 50% + Bifenthrin 5% SE @ 1100 ml/ha, Fipronil 40% + Imidacloprid 40% WG @ 125 g/ha, Lambda-cyhalothrin 4.6% + Chlorantraniliprole 9.3% ZC @ 250 ml/ha, and untreated Control. Regarding the effectiveness of the various ready-mix insecticidal formulations, all of them demonstrated significantly greater efficacy compared to the untreated plot in managing pest populations in the *Bt* cotton. Furthermore, while controlling pests, there is a potential risk of harming the natural enemies present in the *Bt* cotton ecosystem.

Keywords: Ladybird beetle, *Bt* cotton, ready-mix insecticidal formulations

Introduction
Cotton (*Gossypium spp.)* often referred to as India's "White Gold" belongs to the Malvaceae family and the *Gossypium* genus. There are approximately 40 species of cotton, but only four are cultivated that is *Gossypium arboreum*, *G. herbaceum*, *G. hirsutum* and *G. barbadense*. As a key fiber and cash crop in India, cotton significantly impacts both the industrial and agricultural economies globally. It serves as the primary raw material for the cotton textile industry and generates income for over 250 million people worldwide, employing nearly 7 per cent of the labour force in developing nations. About half of all textiles produced are made from cotton. In India, apart from providing 60 per cent of the fiber used in textile industries, the crop is also a source for 11.5 lakh tonnes of oil, 90 lakh tonnes of animal feed and about 200 lakh tonnes of cotton stalk that is used for fuel and value addition as particle boards. The area and production of *Bt* cotton in India in 2024-25 is 113.6 lakh ha and 299.26 lakh bales and in Maharashtra it is 40.84 lakh ha and 84.80 lakh bales, respectively (Anonymous, 2025) [1]. In Maharashtra, 80 per cent of the cotton is cultivated in the regions of Khandesh, Vidarbha, and Marathwada. Key districts involved in cotton cultivation include Jalgaon, Akola, Yavatmal, Dhule, Osmanabad, Nanded, Chhatrapati Sambhajinagar, Wardha, and Nagpur, among others. The cultivation of cotton has thrived due to the region's black soil, favorable climate, and the high demand for cotton within the state.

Cotton plant with its green leaves, many large open flowers, nectarines on every leaf and flowers and large number of fruits seems to specially attract the insect pests under natural condition. Approximately 162 species of insect and mites have been documented as pests affecting cotton in India which causes 50-60 per cent yield loss (Jayaswal and Sundaramurthy, 1992) [4]. It is attacked by several sucking pests right from germination to picking. Among these sucking pests, the aphid is a significant one that is naturally controlled by the ladybird beetle (Saner *et al*., 2014) [6]. The ladybird beetle, *Cheilomenes sexmaculata* F. (Coleoptera-Coccinellidae), is recognized as the most effective and promising predator of

cotton pests. Both the grub and adult stages of the ladybird beetles feed voraciously on cotton pests such as aphids, jassids, and whiteflies, significantly reducing their populations. Therefore, it is necessary to manage the pests effectively. Whereas there are many methods of pest control like cultural, physical, mechanical, chemical, biological, and legal method, chemical one is the best, which gives quick results. But harmful to natural enemies in somewhat level. With the increasing use of ready-mix insecticidal formulations, which combine multiple active ingredients into a single product for enhanced pest control, there is a need to assess their impact on non-target organisms. Such formulations, while effective against pest populations, may pose risks to beneficial insects like ladybird beetles, whose survival and population dynamics are vital for integrated pest management strategies.

Material and Methods

The field experiment was conducted during *Kharif* season of 2024 at Agricultural farm of Krishi Vigyan Kendra, Dhule (Maharashtra)- 424004. Eight treatments including untreated control were replicated thrice in randomized block design. *Bt* cotton hybrid "Ankur Kirti BG II" variety was sown in 3.60 m x 3.30 m plots at row and plant spacing of 90 x 30cm. Pre-treatment counts (PTC) were recorded one day before the spray, and observations for ladybird beetles on *Bt* cotton were made on the 5^{th}, 10^{th}, and 15^{th} days after treatment. Five plants from each net plot were selected randomly and tied with tags, while plants located at border were avoided for recording observations. Ladybird beetle population counted on per plant basis from 5 selected and tagged plants.

Treatment details

Treatments	Name of Insecticides	Dosage (gm or ml/lit)
T_1	Bifenthrin 8% + Clothianidin 10% SC	1ml/lit
T_2	Profenofos 40% + Cypermethrin 4% EC	2 ml/lit
T_3	Clothianidin 3.5% + Pyriproxyfen 8% SE	3 ml/lit
T_4	Pyriproxyfen 8% + Dinotefuran 5% + Diafenthiuron 18% SC	1.2 ml/lit
T_5	Propargite 50% + Bifenthrin 5% SE	2.2 ml/lit
T_6	Fipronil 40% + Imidacloprid 40% WG	0.30gm/lit
T_7	Lambda- cyhalothrin 4.6% + Chlorantraniliprole 9.3% ZC	0.5 ml/lit
T_8	Untreated Control	--

Result and Discussion

Effect of different ready-mix insecticidal formulations on ladybird beetle (*Cheilomenes sexmaculata* F.)

The data regarding effect of different ready-mix insecticidal formulations on ladybird beetle are presented in Table 1. The population of ladybird beetle recorded a day prior to spraying ranged from 2.31 to 2.67 ladybird beetles/plant and was found to be statistically non-significant.

After first spray

Data on survival population of ladybird beetle revealed that at five days after first spraying (DAS), the highest population of ladybird beetles was observed in the untreated control, with a count of 2.51 ladybird beetles/plant. The application of Fipronil 40% + Imidacloprid 40% WG @ 125 g/ha and Pyriproxyfen 8% + Dinotefuran 5% + Diafenthiuron 18% SC @ 600 ml/ha was found to be safe, as it resulted in the highest population of ladybird beetle (2.38 ladybird beetles/plant) among the evaluated ready-mix insecticidal formulations; however, the differences among the treatments were found to be statistically non-significant. At 10 days after first spraying, Fipronil 40% + Imidacloprid 40% WG @ 125 g/ha was found to be safe, as it recorded the highest population of ladybird beetle (2.34 ladybird beetles/ plant) compared to other ready-mix insecticidal formulations, with the maximum population of ladybird beetle noted in the untreated control (2.71 ladybird beetles/plant) in the experimental field, although the differences among treatments remained statistically non-significant. At 15 days after first spraying, Fipronil 40% + Imidacloprid 40% WG @ 125 g/ha was found to be safe, as it recorded the highest population of ladybird beetle (2.64 ladybird beetles/plant) compared to other ready-mix insecticidal formulations, with the maximum population of ladybird beetle noted in the untreated control (2.81 ladybird beetles/plant) in the experimental field, although the differences among treatments remained statistically non-significant.

After second spray

Data on survival population of ladybird beetle revealed that at five days after second spraying (DAS), the lowest population of ladybird beetle was recorded in Propargite 50% + Bifenthrin 5% @ 1100 ml/ha (2.17 ladybird beetles/plant), whereas the untreated control exhibited a significantly highest population (2.96 ladybird beetles/plant) compared to the other treatments. The variation among the ready-mix insecticidal formulations were found to be statistically non-significant. At ten days after second spraying (DAS), the highest population of ladybird beetle was recorded in the untreated control with 3.05 ladybird beetles/plant and was significantly superior over all insecticidal treatments. Treatment with Fipronil 40% + Imidacloprid 40% WG @ 125 g/ha (2.48 ladybird beetles/ plant) was found to be safe, as it recorded the highest population of ladybird beetle compared to other ready-mix insecticidal formulations, this was statistically at par with treatments Pyriproxyfen 8% + Dinotefuran 5% + Diafenthiuron 18% SC @ 600 ml/ha(2.45 ladybird beetles plant), Lambda-cyhalothrin 4.6% + Chlorantraniliprole 9.3% ZC @ 250 ml/ha (2.38 ladybird beetles/plant), Profenofos 40% + Cypermethrin 4% EC @ 1000 ml/ha (2.34 ladybird beetles/plant), Clothianidin 3.5% + Pyriproxyfen 8% SE @ 1500 ml/ha (2.28 ladybird beetles/plant), and Bifenthrin 8% + Clothianidin 10% SC @ 500 ml/ha (2.24 ladybird beetles/plant). The lowest population of ladybird beetle was recorded in Propargite 50% + Bifenthrin 5% @ 1100 ml/ha which resulted in 1.95 ladybird beetles/plant. There was a slight increase in ladybird population at fifteen days after second spraying, the maximum population of ladybird beetle was observed in untreated control (3.31 ladybird beetle/plant) and was

significantly superior over all insecticidal treatments. Treatment with Propargite 50% + Bifenthrin 5% @ 1100 ml/ha (2.11 ladybird beetles/plant) was observed least population of ladybird beetle considered as most toxic to the ladybird beetle. The treatments that found to be safe for ladybird beetle was Fipronil 40% + Imidacloprid 40% WG @ 125 g/ha (2.54 ladybird beetles/plant) which was statistically at par with Pyriproxyfen 8% + Dinotefuran 5% + Diafenthiuron 18% SC @ 600 ml/ha (2.51 ladybird beetles/plant), Lambda-cyhalothrin 4.6% + Chlorantraniliprole 9.3% ZC @ 250 ml/ha (2.45 beetles plant), Profenofos 40% + Cypermethrin 4% EC @ 1000 ml/ha (2.38 ladybird beetles/plant), Clothianidin 3.5% + Pyriproxyfen 8% SE @ 1500 ml/ha (2.34 ladybird beetles/plant), and Bifenthrin 8% + Clothianidin 10% SC @ 500 ml/ha (2.24 ladybird beetles/plant).

After third spray

Data on survival population of ladybird beetle revealed at five days after third spraying (DAS), the treatment with Propargite 50% + Bifenthrin 5% @ 1100 ml/ha (1.95 ladybird beetles/plant) resulted in the lowest population of ladybird beetle among all insecticidal treatments. The highest population of ladybird beetle in the experimental plot was recorded in the untreated control, with 3.45 ladybird beetles/plant at five days after third spraying and was significantly superior over rest of the treatments. The treatment with Fipronil 40% + Imidacloprid 40% WG @ 125 g/ha (2.45 ladybird beetles/plant) was found to be safe, as it recorded highest population of coccinellid compared to the other ready-mix insecticidal formulations, and was statistically at par with Pyriproxyfen 8% + Dinotefuran 5% + Diafenthiuron 18% SC @ 600 ml/ha (2.38 ladybird beetles/plant), Lambda-cyhalothrin 4.6% + Chlorantraniliprole 9.3% ZC @ 250 ml/ha (2.31 ladybird beetles/plant), Profenofos 40% + Cypermethrin 4% EC @ 1000 ml/ha (2.18 ladybird beetles/plant), Clothianidin 3.5% + Pyriproxyfen SE @ 1500 ml/ha (2.11 ladybird beetles/ plant), and Bifenthrin 8% + Clothianidin 10% SC @ 500 ml/ha (1.98 ladybird beetles/plant). At ten days after third spraying (DAS), Fipronil 40% + Imidacloprid 40% WG @ 125 g/ha (2.32 ladybird beetles/plant) was found to be safe, as it recorded the highest population of ladybird beetle compared to other ready-mix insecticidal formulations and this was statistically at par with treatments Pyriproxyfen 8% + Dinotefuran 5% + Diafenthiuron 18% SC @ 600 ml/ha(2.24 ladybird/beetles plant), Lambda-cyhalothrin 4.6% + Chlorantraniliprole 9.3% ZC @ 250 ml/ha (2.18 ladybird beetles/plant), Profenofos 40% + Cypermethrin 4% EC @ 1000 ml/ha (1.97 ladybird beetles/plant), Clothianidin 3.5% + Pyriproxyfen 8% SE @ 1500 ml/ha (1.85 ladybird beetles/plant), and Bifenthrin 8% + Clothianidin 10% SC @ 500 ml/ha (1.74 ladybird beetles plant). The next effective treatment was Propargite 50% + Bifenthrin 5% @ 1100 ml/ha which resulted in 2.11 ladybird beetles/plant. The highest population of ladybird beetle was recorded in the untreated control with 3.51 ladybird beetles/ plant. At fifteen days after third spraying (DAS), the highest number of ladybird beetle was recorded in the untreated control (3.85 ladybird beetles/plant) and was significantly superior over rest of the treatments. The treatment Fipronil 40% + Imidacloprid 40% WG @ 125 g/ha was found to be safe because it recorded the highest number of ladybird beetle, with 2.65 ladybird beetles/plant compared to other insecticides. This was statistically at par with Pyriproxyfen 8% + Dinotefuran 5% + Diafenthiuron 18% SC @ 600 ml/ha (2.54 ladybird beetles/plant), Lambda-cyhalothrin 4.6% + Chlorantraniliprole 9.3% ZC @ 250 ml/ha (2.44 ladybird beetles/plant), Profenofos 40% + Cypermethrin 4% EC @ 1000 ml/ha (2.31 ladybird beetles/plant), Clothianidin 3.5% + Pyriproxyfen 8% SE @ 1500 ml ha (2.21 ladybird beetles/plant), and Bifenthrin 8% + Clothianidin 10% SC @ 500 ml/ha (2.11 ladybird beetles/plant). Propargite 50% + Bifenthrin 5% @ 1100 ml/ha (1.95 ladybird beetle/plant) recorded the lowest population of ladybird beetles.

Table 1: Effect of different ready-mix insecticidal formulations on ladybird beetle ((*Cheilomenes sexmaculata* F.) under field condition during *Kharif* -2024

Tr. No.	Treatment details	Dose gm or ml /lit	Number of ladybird beetle/ plant										Mean
			First spray				Second spray			Third spray			
			PTC	5 DAS	10 DAS	15 DAS	5 DAS	10 DAS	15 DAS	5 DAS	10 DAS	15 DAS	
T_1	Bifenthrin 8% + Clothianidin 10% SC	1 ml	2.38 (1.69)	2.25 (1.66)	2.05 (1.60)	2.38 (1.70)	2.24 (1.66)	2.24 (1.66)	2.24 (1.66)	1.98 (1.57)	1.74 (1.50)	2.11 (1.62)	1.60 (1.45)
T_2	Profenofos 40% + Cypermethrin 4% EC	2 ml	2.31 (1.67)	2.31 (1.68)	2.18 (1.64)	2.51 (1.73)	2.35 (1.69)	2.34 (1.69)	2.38 (1.70)	2.18 (1.64)	1.97 (1.57)	2.31 (1.68)	1.71 (1.49)
T_3	Clothianidin 3.5% + Pyriproxyfen 8% SE	3 ml	2.51 (1.73)	2.28 (1.67)	2.11 (1.62)	2.45 (1.72)	2.28 (1.67)	2.28 (1.67)	2.34 (1.69)	2.11 (1.62)	1.85 (1.53)	2.21 (1.65)	1.66 (1.47)
T_4	Pyriproxyfen 8%+ Dinotefuran 5% + Diafenthiuron 18% SC	1.2 ml	2.31 (1.67)	2.38 (1.70)	2.30 (1.67)	2.58 (1.75)	2.48 (1.73)	2.45 (1.72)	2.51 (1.73)	2.38 (1.70)	2.24 (1.66)	2.54 (1.74)	1.82 (1.52)
T_5	Propargite 50% + Bifenthrin 5% SE	2.2 ml	2.67 (1.78)	2.21 (1.65)	1.95 (1.57)	2.31 (1.68)	2.17 (1.63)	1.95 (1.57)	2.11 (1.62)	1.95 (1.57)	1.65 (1.47)	1.95 (1.57)	1.52 (1.42)
T_6	Fipronil 40% + Imidacloprid 40% WG	0.30 gm	2.45 (1.71)	2.38 (1.70)	2.34 (1.69)	2.64 (1.77)	2.51 (1.73)	2.48 (1.73)	2.54 (1.74)	2.45 (1.72)	2.32 (1.68)	2.65 (1.77)	1.86 (1.54)
T_7	Lambda-cyhalothrin 4.6% + Chlorantraniliprole 9.3% ZC	0.5 ml	2.45 (1.71)	2.33 (1.68)	2.27 (1.66)	2.54 (1.74)	2.45 (1.72)	2.38 (1.70)	2.45 (1.72)	2.31 (1.68)	2.18 (1.64)	2.44 (1.71)	1.77 (1.51)
T_8	Untreated control	–	2.45 (1.71)	2.51 (1.73)	2.71 (1.79)	2.81 (1.82)	2.96 (1.86)	3.05 (1.88)	3.31 (1.95)	3.45 (1.99)	3.51 (2.00)	3.85 (2.09)	2.35 (1.69)
	S.E.±		0.047	0.046	0.044	0.048	0.047	0.046	0.047	0.045	0.043	0.043	0.032
	CD at 5%		NS	NS	NS	NS	NS	0.141	0.143	0.137	0.131	0.131	0.097

Figures in the parentheses are square root transformed values, NS: Non-significant, PTC: Pre-treatment count, DAS: Days after spraying.

Overall mean effect of three sprays

The data on the effect of various ready-mix insecticidal formulations on the typical population of ladybird beetle on *Bt* cotton following three sprayings separated by 15 days presented in the table 1. The data revealed that the, untreated control exhibited the highest population of ladybird beetle (2.35 ladybird beetles/plant). Among the ready-mix insecticidal treatments Fipronil 40% + Imidacloprid 40%

WG @ 125 g/ha (1.86 ladybird beetles/plant) was found to be most safest treatment for ladybird beetles which was statistically at par with Pyriproxyfen 8% + Dinotefuran 5% + Diafenthiuron 18% SC @ 600 ml/ha (1.82 ladybird beetles/plant), Lambda-cyhalothrin 4.6% + Chlorantraniliprole 9.3% ZC @ 250 ml/ha (1.77 ladybird beetles/plant), Profenofos 40% + Cypermethrin 4% EC @ 1000 ml/ha (1.71 ladybird beetles/plant), Clothianidin 3.5% + Pyriproxyfen 8% SE @ 1500 ml ha (1.66 ladybird beetles/plant), and Bifenthrin 8% + Clothianidin 10% SC @ 500 ml/ha (1.60 ladybird beetles/plant). Propargite 50% + Bifenthrin 5% @ 1100 ml/ha (1.52 ladybird beetles/plant) recorded the lowest population of ladybird beetles.

The current findings are similar with Bharpoda *et al*. (2014) [2] reported that plot treated with Imidacloprid 17.8 SL and Diafenthiuron 50 WP found maximum population of ladybird beetles in *Bt* cotton. Highest predatory activity of coccinellid in untreated control, followed by Imidacloprid 70 WS@ 4.9 g a.i./ha at 15 days after spraying was noticed by Patil *et al*. (2008) [5]. Hugar *et al*. (2020) [3] also observed that Diafenthiuron 30% + Pyriproxyfen 8% SE was safe for ladybird beetle. Saner *et al*. (2014) [6] also found maximum population of ladybird beetles per plant was observed in untreated control. Among different insecticide treatments Lambda- cyhalothrin 5 SC and imidacloprid 17.80 SL were found ecofriendly.

Conclusion

In the untreated control plot the number of ladybird beetle was more than treated plot. Among the ready-mix insecticides, Fipronil 40% + Imidacloprid 40% WG @ 125 g/ha found safe to ladybird beetle which was statistically at par with Pyriproxyfen 8% + Dinotefuran 5% + Diafenthiuron 18% SC @ 600 ml/ha, Lambda-cyhalothrin 4.6% + Chlorantraniliprole 9.3% ZC @ 250 ml/ha, Profenofos 40% + Cypermethrin 4% EC @ 1000 ml/ha, Clothianidin 3.5% + Pyriproxyfen 8% SE @ 1500 ml/ha and Bifenthrin 8% + Clothianidin 10% SC @ 500 ml/ha. Propargite 50% + Bifenthrin 5% @ 1100 ml/ha found toxic to ladybird beetle as the percent mortality by these insecticides found highest.

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