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Efficacy of different newer insecticides against mango leafhopper fauna

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Abstract
An experiment was conducted to manage the mango leafhoppers with certain newer insecticides *viz*., Spinetoram 11.7 SC @ 0.4 ml l^{-1}, Cyantraniliprole 10.26 EC @ 2 ml l^{-1}, Pymetrozine 50 WG @ 0.6 gm l^{-1}, Triflumezopyrim 10 SC @ 0.5 ml l^{-1} (at panicle initiation, at peanut stage and marble stage) Spinetoram 11.7 SC @ 0.4 ml l^{-1}, followed by *Beauveria bassiana* @ 5 gm l^{-1}, Cyantraniliprole 10.26 EC @ 2 ml l^{-1}, followed by Thiamethoxam 25WG @ 0.3 gm l^{-1}, Pymetrozine 50 WG @ 0.6 gm l^{-1}, followed by Neem oil 10000 ppm 3 ml l^{-1}, Triflumezopyrim 10 SC @ 0.5 ml l^{-1}, followed by Spinosad 45 SC @ 0.4 ml l^{-1} followed by Triflumezopyrim 10 SC @ 0.5 ml l^{-1}, Diafenthiuron 50 WP @ 0.5 – 1 gm l^{-1}, followed by Acephate 75 SP @ 1.5 gm l^{-1}, followed by Imidacloprid 17.8 SL @ 0.5 ml l^{-1} (Check), along with untreated control. Efficacies of these treatments revealed that Triflumezopyrim 10 SC @ 0.5 ml l^{-1} followed by Spinosad 45 SC @ 0.4 ml l^{-1} Triflumezopyrim 10 SC @ 0.5 ml l^{-1} have resulted in 96.57 per cent reduction of leafhopper population over control (ROC) were proved to be most effective treatment. The least per cent reduction of leafhoppers (58.13 % ROC) over control was recorded with Cyantraniliprole 10.26 EC @ 2 ml l^{-1}.

Keywords: Mango leafhoppers, insecticides, reduction over control (ROC)

1. Introduction

Approximately, 492 insect species, 17 mite species, and 26 nematode species attack crops worldwide. Among them, reports of 188 bug species originate from India. Various pests like leaf hoppers, mealybugs, gall midges, fruit flies, thrips, stone weevils, bark-eating caterpillars, stem borers, scale insects, leaf webbers, and leaf miners are most common insect pests that occurs in mango orchards. Among the various insect pests attacking mangoes, leafhoppers occur widely and cause serious damage. Hopper is a monophagous pest with a short life cycle, strong mobility towards the development of pesticide resistance and can infest a wide range of host plants (Global Pest and Disease Database, 2011; Kumar *et al*., 2020) [6]. They belong to the family Cicadellidae of the order Hemiptera. Hopper species such as *Amritodus atkinsoni* (Lethierry), *Idioscopus clypealis* (Lethierry), and *Idioscopus nitidulus* (Walker) are highly active causing losses up to 100% starting from appearance of new flush to fruit setting. Both adults and nymphs suck sap from the tender parts such as young shoots and panicles causing decreased fruit set and premature fruit fall. They also inflict physical injury to the flower buds by oviposition. They excrete honey dew on which sooty mold develops which interferes with the photosynthetic activity of the tree.

The fluctuation in the pest population and distribution appears to be mostly influenced by the environmental factors. This is because the pest has a tendency to reproduce rapidly during favourable weather, which can lead to population outbreaks. Natural enemy populations, including parasitoids and predators, are also impacted by environmental variables, either directly or indirectly. In order to create an early warning weather-based system for any pest in a particular agro-ecosystem, a fundamental understanding of pest population dynamics and seasonal occurrence in connection to common meteorological factors are required. To determine the optimal times for intervention and apply effective pest management techniques, it is crucial to address the rising pest population and the resulting yield losses caused by hoppers. Using newer insecticides is essential for managing these pests effectively.

2. Material and methods

2.1 Experimental details

The experiment was conducted in mango orchard at Anantharajupeta, Railway Koduru, Annamayya district, Andhra Pradesh, during the year 2023-24 to evaluate the efficacy of newer insecticides against mango leafhoppers. The experiment was laid in a randomised block design with ten treatments including a check and an untreated control (Table 1). All the treatments were replicated three times at three intervals (at panicle initiation stage, at the peanut stage and marble stage) with the widely cultivated variety, Bangalora. Three trees were randomly selected from each line having 8-10 trees for the application of insecticides and the observations were made.

The data was recorded one day before spraying as well as 1, 7 and 15 days after each spraying. The first spray was given at panicle initiation stage and the second spray was at pea nut stage and the third spraying was done at the marble stage of mango. Four panicles of the tree were selected randomly from each direction (east, west, north and south) for taking the pre and post-spray observations on the leafhopper population. The leafhoppers were sampled by using the polythene bag trap collection method described by Kannan and Rao (2006). After tapping the inflorescence gently, the adults and nymphs collected in the bag were counted. The post-treatment counts of leafhoppers were used to calculate the percentage reduction in pest population compared to control using the formula below.

$$\text{PROC} = \frac{\text{Population in untreated control} - \text{Population in treatment}}{\text{Population in untreated control}} \times 100$$

Table 1: Details of insecticides evaluated against mango leafhopper during 2023-24.

Treatment	Name of the Insecticide	Dose
T_1	Spinetoram 11.7 SC (3 sprays at panicle initiation, peanut and marble stages)	0.4 ml l^{-1}
T_2	Cyantraniliprole 10.26 EC (3 sprays at panicle initiation, peanut and marble stages)	2 ml l^{-1}
T_3	Pymetrozine 50 WG (3 sprays at panicle initiation, peanut and marble stages)	0.6 g l^{-1}
T_4	Triflumezopyrim 10 SC (3 sprays at panicle initiation, peanut and marble stages)	0.5 ml l^{-1}
T_5	Spinetoram 11.7 SC followed by *Beauveria bassiana* followed by Spinetoram 11.7 SC	0.4 g l^{-1} 5 g l^{-1}
T_6	Cyantraniliprole 10.26 EC followed by Thiamethoxam 25WG followed by Cyantraniliprole 10.26 EC	2 ml l^{-1} 0.3 g l^{-1}
T_7	Pymetrozine 50 WG followed by Neem oil 10000 ppm followed by Pymetrozine 50 WG	0.6 g l^{-1} 3 ml l^{-1}
T_8	Triflumezopyrim 10 SC followed by Spinosad 45 SC followed by Triflumezopyrim 10 SC	0.5 ml l^{-1} 0.4 ml l^{-1}
T_9	Diafenthiuron 50 WP, followed by Acephate 75 SP, followed by Imidacloprid 17.8 SL. (Check)	1 g l^{-1} 1.5 g l^{-1} 0.5 ml l^{-1}
T_{10}	Untreated control	

2.2 Statistical analysis

The values then obtained were subjected to arc sine transformation and significant differences among the efficacies of various treatments were subjected to analysis of variance (ANOVA). In contrast, treatment means were compared based on Duncan's Multiple Range Test (DMRT).

3. Results and Discussion

The number of leafhoppers on the inflorescence of mango before the imposition of treatments suggests a homogenous distribution of the leafhoppers. However, significant differences among the populations of leafhoppers were observed at 1, 7 and 15 days after spraying.

Efficacy of different insecticides against mango leafhoppers

Observations made regarding the average number of leafhoppers and the percentage reduction in leafhoppers compared to the control at various intervals during the experimental period after the first, second and third sprays were combined, and the total effectiveness of the insecticides used to control mango leafhoppers was displayed in Table.2 and Figure.1. Mean number of leafhoppers per panicle at first day after spraying (1 DAS) ranged from 1.78 to 22.67 whereas 69.00 leafhoppers were recorded in control. The overall efficacy of all the treatments at 1 DAS revealed that Triflumezopyrim 10 SC @ 0.5 ml l^{-1} followed by Spinosad 45 SC @ 0.4 ml l^{-1} followed by Triflumezopyrim 10 SC @ 0.5 ml l^{-1} was the most effective treatment recording 97.80 % reduction over control (ROC) and followed by, Pymetrozine 50 WG @ 0.6 g l^{-1} followed by Neem oil 10000 ppm @ 3 ml l^{-1} followed by Pymetrozine 50 WG @ 0.6 g l^{-1} with 93.44 % ROC. The least minimum effective treatment was Cyantraniliprole 10.26 EC @ 2 ml l^{-1} (3 sprays) recorded with 68.96 % ROC followed by Cyantraniliprole 10.26 EC 2 ml l^{-1} followed by Thiamethoxam 25WG @ 0.3 g l^{-1} followed by Cyantraniliprole 10.26 EC 2 ml l^{-1} with 70.64 % ROC. At seven days after spraying (7 DAS), the average number of leafhoppers among different treatments ranged from 3.00 to 30.00 per panicle, whereas 75.33 leafhoppers were recorded in control.

At 7 DAS revealed that Triflumezopyrim 10 SC @ 0.5 ml l^{-1} followed by Spinosad 45 SC @ 0.4 ml l^{-1} followed by Triflumezopyrim 10 SC @ 0.5 ml l^{-1} and Pymetrozine 50 WG @ 0.6 g l^{-1} followed by Neem oil 10000 ppm @ 3 ml l^{-1} followed by Pymetrozine 50 WG @ 0.6 g l^{-1} were the most effective treatments recording 96.17 and 90.88 % ROC respectively. The least effective treatment was Cyantraniliprole 10.26 EC @ 2 ml l^{-1} (3 sprays) with 55.88 % ROC followed by, Cyantraniliprole 10.26 EC 2 ml l^{-1} followed by Thiamethoxam 25WG @ 0.3 g l^{-1} followed by Cyantraniliprole 10.26 EC 2 ml l^{-1} with 57.92 % ROC. On fifteenth day after imposition of treatments, Triflumezopyrim 10 SC @ 0.5 ml l^{-1} followed by Spinosad 45 SC @ 0.4 ml l^{-1} followed by Triflumezopyrim 10 SC @ 0.5 ml l^{-1} recorded with 95.73 % ROC and was superior to the rest of treatments. Pymetrozine 50 WG @ 0.6 g l^{-1} followed by Neem oil 10000 ppm @ 3 ml l^{-1} followed by Pymetrozine 50 WG @ 0.6 g l^{-1} with 88.30 % ROC, was the next best treatment. Least effective treatment was Cyantraniliprole 10.26 EC @ 2 ml l^{-1} (3 sprays) recorded with 49.54 % ROC and Cyantraniliprole 10.26 EC 2 ml l^{-1} followed by Thiamethoxam 25WG @ 0.3 g l^{-1} followed by Cyantraniliprole 10.26 EC 2 ml l^{-1} with 52.58 % ROC respectively.

The overall efficacy of all the insecticides across all interval sprays revealed that Triflumezopyrim 10 SC @ 0.5 ml l^{-1} (at panicle initiation stage) followed by Spinosad 45 SC @ 0.4 ml l^{-1} (at pea nut stage) followed by Triflumezopyrim 10 SC

@ 0.5 ml l^{-1} (at marble stage) recorded with 96.57 % reduction over control and the least effective treatment was Cyantraniliprole 10.26 EC @ 2 ml l^{-1} (3 sprays at panicle initiation, peanut and marble stages) recorded 58.13 % ROC. During this present study, Triflumezopyrim 10 SC @ 0.5 ml l^{-1} followed by Spinosad 45 SC @ 0.4 ml l^{-1} followed by Triflumezopyrim 10 SC @ 0.5 ml l^{-1} was found to be most effective treatment with an 96.57 % overall ROC of leafhoppers. Combination of novel class of mesoionic insecticide (Triflumezopyrim) with spinosys class of insectides (Spinosad) with their possible diverse mode of action, mode of entry and target locations might have reduced the percentage of leafhoppers more than the single formulations sprayed. Triflumezopyrim provides excellent hopper control. Unlike neonicotinoids, nicotinic acetylcholine receptor (nAChR) inhibition is the toxicological mode of action for Triflumezopyrim. Spinosad is a fermented metabolite of the actinomycetes (*Saccharopolyspora spinosa*) a soil inhibiting microorganism and it provides most effective reduction of hoppers by disrupting binding of nAChR at the postsynaptic cell of nervous system which leads to paralysis and death of the insects. The panicles and the fresh leaf flush are the primary food sources for leafhoppers. Triflumezopyrim is highly systemic compound which can reach the apices of the young leaves and panicles, resulted in the increase of mortality of leafhoppers. Triflumezopyrim with longer periods of systemic activity in plant system, when combined with Spinosad which causes disrupting binding of acetylcholine in nicotinic acetylcholine receptors at the postsynaptic cell of nervous system might resulted in more than 90 per cent reduction of leafhoppers up to 15 days after the spraying. Furthermore, the potentiation impact of several active components presents in the insecticide formulation of above mentioned two insecticides may be the cause of the higher efficacy.

Pymetrozine 50 WG @ 0.6 g l^{-1} followed by Neem oil 10000 ppm @ 3 ml l^{-1} followed by Pymetrozine 50 WG @ 0.6 g l^{-1} was the next effective treatment recording 90.87 per cent reduction over control of leafhoppers. Pymetrozine is a systemic pyridine azomethine insecticide that is highly selective to insects that feed on plants, such as leafhoppers, aphids, whiteflies, and planthoppers. It works by blocking the stylet's penetration, causing an immediate inhibition of feeding followed by a delayed death due to starvation. Neem oil has various effects on insects, *viz*., antifeedant action, Insect growth regulators activity inhibits juvenile hormone synthesis, oviposition deterrent, repellent action, reduction of life span of adults etc., The current results are parallel with those of Ferdous and Jahan (2020), who found that after 48 hours of Pymetrozine treatment and reported the adults in the first, second, third, fourth, and fifth instars of mango leafhoppers have 100% mortality rate. The most effective pesticide for reducing planthopper populations was Pymetrozine 50 WG @ 0.5 g l^{-1}, which showed a 62.98 percent reduction over control in rice 20 SG (Deekshita and Ramarao, 2018).

In the current study, Triflumezopyrim 10 SC @ 0.5 ml l^{-1} is the next effective insecticide with 86.65 per cent reduction over control of leafhoppers which is followed by Pymetrozine 50 WG @ 0.6 g l^{-1} with 79.96 per cent reduction over control of leafhoppers. According to Suri and Singh (2020) [6], Rice treated with pymetrozine at 150 and 175 g a.i ha^{-1} resulted the least number of brown planthoppers (2.89 hoppers $hill^{-1}$). Adhikari *et al*. (2019) and Shankar *et al*. (2020) also reported on the effectiveness of pymetrozine 50% WG against sucking pests, such as brown planthoppers and white-backed planthoppers, in rice. Ferdous and Jahan (2020) who reported 90.45, 88.33, 86.34, 81.67, 79.67 and 85.35 per cent mortality of adults, first, second, third, fourth and fifth instar nymphs of mango leafhoppers, respectively by spinosad 45 SC @ 0.3 ml l^{-1} at 48 hours after treatment.

Table 2: Overall efficacy of different newer insecticides against mango leafhoppers.

		Overall efficacy of insecticides during 2023 – 2024								
S. No	Treatments	DOSE	Pre treatment count	1 DAS		7 DAS		15 DAS		OVER ALL % ROC
				Mean	% ROC	Mean	% ROC	Mean	% ROC	
T_1	Spinetoram 11.7 SC followed by Spinetoram 11.7 SC followed by Spinetoram 11.7 SC	0.4 ml l^{-1}	66.22	19.11	74.63^{e} (59.92)	24.22	65.76^{ef} (54.21)	28.37	60.11^{ef} (50.85)	66.83^{ef} (54.89)
T_2	Cyantraniliprole 10.26 EC followed by Cyantraniliprole 10.26 EC followed by Cyantraniliprole 10.26 EC	2 ml l^{-1}	65.22	22.67	68.96^{e} (56.29)	30.00	55.88^{f} (48.37)	34.11	49.54^{f} (44.73)	58.13^{f} (49.68)
T_3	Pymetrozine 50 WG followed by Pymetrozine 50 WG followed by Pymetrozine 50 WG	0.6 g l^{-1}	60.33	11.56	85.50^{cd} (67.95)	14.67	79.71^{cd} (63.30)	17.67	74.68^{cd} (59.82)	79.96^{cd} (63.50)
T_4	Triflumezopyrim 10 SC followed by Triflumezopyrim 10 SC followed by Triflumezopyrim 10 SC	0.5 ml l^{-1}	61.11	9.11	89.86^{bc} (72.55)	11.56	86.04^{bc} (68.60)	12.89	84.06^{bc} (66.91)	86.65^{bc} (69.20)
T_5	Spinetoram 11.7 SC followed by *Beauveria bassiana* followed by Spinetoram 11.7 SC	0.4 ml l^{-1}, 5 g l^{-1}	64.67	15.56	78.58^{de} (62.59)	18.78	71.73^{de} (57.89)	22.78	65.99^{de} (54.32)	72.10^{de} (58.13)
T_6	Cyantraniliprole 10.26 EC followed by Thiamethoxam 25WG followed by Cyantraniliprole 10.26 EC	2 ml l^{-1}, 0.3 g l^{-1}	65.11	20.89	70.64^{e} (57.34)	26.33	57.92^{f} (49.59)	30.19	52.58^{ef} (46.48)	60.38^{ef} (51.00)
T_7	Pymetrozine 50 WG followed by Neem oil 10000 ppm followed by Pymetrozine 50 WG	0.6 g l^{-1}, 3 ml l^{-1}	62.56	4.56	93.44^{b} (75.92)	6.44	90.88^{ab} (73.22)	8.22	88.30^{bc} (70.79)	90.87^{b} (73.20)
T_8	Triflumezopyrim 10 SC followed by Spinosad 45 SC followed by Triflumezopyrim 10 SC	0.5 ml l^{-1}, 0.4 ml l^{-1}	61.22	1.78	97.80^{a} (82.86)	3.00	96.17^{a} (80.65)	3.11	95.73^{a} (80.33)	96.57^{a} (81.19)
T_9	Diafenthiuron 50 WP followed by Acephate 75 SP followed by Imidacloprid 17.8 SL (check)	1 g l^{-1}, 1.5 g l^{-1}, 0.5 ml l^{-1}	62.78	17.33	74.60^{e} (59.78)	21.11	65.60^{ef} (54.15)	24.78	61.57^{def} (51.70)	67.26^{ef} (55.11)
T_{10}	Control		67.00	69.00		75.33		81.22		
	Sem	-	-	-	2.66	-	3.37	-	3.20	2.77
	CD (5%)	-	NS	-	7.97	-	10.09	-	9.58	8.31
	CV (%)	-	-	-	5.64	-	7.83	-	7.88	6.37

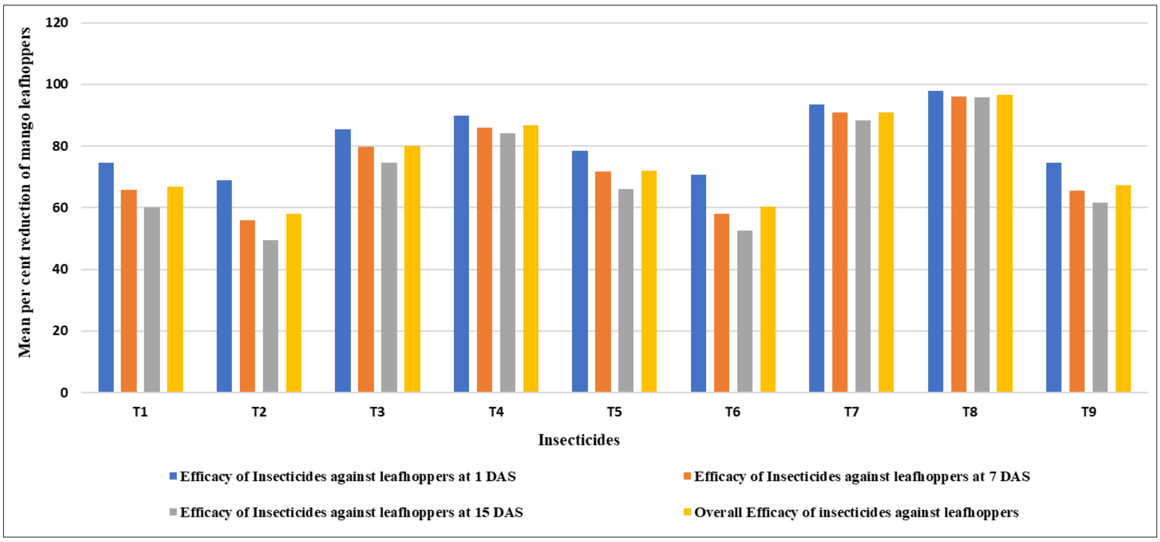

Fig 1: Overall efficacy of different newer insecticides against mango leafhoppers

4. Conclusion

Presence of multiple target locations, distinct mechanisms of action of different insecticides etc., the use of different insecticides with multiple active ingredients may increase the toxicity against insects and these insecticides, one after the other offers quick and long-lasting control of many developmental phases of insects, at the same time with various insects eating on various portions of plants both above and below ground. Therefore, the use of insecticides with different modes of action one followed by other at different sprays can successfully include in Integrated Pest Management for controlling leafhoppers in mango orchards.

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