

Field efficacy of newer insecticides against Coconut Rugose Spiralling Whitefly *Aleurodicus rugioperculatus* (Linnaeus) (Hemiptera: Aleyrodidae) and their safety to beneficial insects

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Abstract

The present study was aimed to investigate the efficacy of newer insecticides against the coconut rugose spiralling whitefly *Aleurodicus rugioperculatus*. Field experiments were conducted during April–July 2022 and August–November 2022 at the Eastern and Western farms of PAJANCOA and RI, Karaikal, U.T. of Puducherry, India. Among the treatments, thiamethoxam 25 WG at 100 g/ha was the most effective, recording the lowest nymphal populations (5.36 and 4.89 nymphs per leaflet) and adult populations (2.24 and 2.43 adults per leaflet), with reductions over control of 85.08 and 84.74% for nymphs and 83.81 and 84.06% for adults, respectively. Higher populations of natural enemies, including coccinellids, spiders, and lacewings, were observed in the untreated control, followed by azadirachtin 1000 ppm at 700 ml/ha, thiamethoxam 25 WG at 100 g/ha, and pymetrozine 50 WG at 300 ml/ha in both experiments. Based on these data, it was stated that among the newer insecticides, thiamethoxam 25 WG at 100g/ha was most effective and harmless to natural enemies over the other treatments and should be included in pest management techniques used to combat the coconut rugose spiralling whitefly.

Keywords: Coconut, rugose spiralling whitefly, newer insecticides, coccinellids, spiders, lacewings

Introduction

Coconut, *Cocos nucifera* (Palmaceae) is an important oil seed crop mainly in the tropical and subtropical regions of the world (Kumara *et al.*, 2015) [16] and usually referred as ‘tree of heaven’ or ‘kalpavriksha’, since it gives more valuable and diverse products to the people (Elango *et al.*, 2020) [9]. India is the third largest producer of coconut in the world by producing 13283.11 tonnes from an area 2159.62 ha with an average productivity of 6.15 MT/ ha. Coconut palm is assaulted by more than 900 species of insect pests, among those rhinoceros beetle, red palm weevil, coconut mite and coconut black headed caterpillar are the four major insect pests which cause huge economic loss of coconut crop (Tzecz-sima *et al.*, 2022) [32].

In the contemporary period, economic reforms paved way for globalization which drove to the introduction of certain plant, insect and pathogen species to new localities. Such non-native insect species are referred to as Alien species. So distant, more than 118 exotic insect species had been detailed from India, of which, whiteflies and mealybugs constitute a major portion of the intrusion (Elango *et al.*, 2021 and Selvaraj *et al.*, 2017) [25]. During August 2016, invasive rugose spiralling whitefly (RSW), *Aleurodicus rugioperculatus* Martin (Aleyrodidae: Hemiptera) was found heavily infesting coconut palm at Pollachi, Tamil Nadu for the first time from India (Selvaraj *et al.*, 2016; 2017) [25, 26].

It is an introduced pest, endemic to Central America and it was first described by Martin in 2004. RSW is profoundly polyphagous with 118 hosts belonging to 43 plant families including economically important crops in the United States (Francis *et al.*, 2016) [10]. In India, the RSW was detailed to nourish on more than 30 host plants and about 120 plant species including several economically important horticultural and ornamental crops. Both nymphs and adults

excrete a sticky liquid substance (Honey dew) which promotes sooty mould growth on leaves as a result it affects photosynthetic activity driving to physiological disorders of plants (Selvaraj *et al.*, 2019) [27].

So, the RSW drastically reduces the yield and vigour of coconut trees. Hence, suitable management strategies could be identified to enhance the yield by protecting the coconut trees from the dreaded RSW.

Materials and Methods

a. Study site

Two field experiments I and II were conducted during April to July 2022 and August to November 2022, respectively, in the Eastern and Western farm of PAJANCOA and RI, Karaikal, UT of Puducherry. The experiment was laid out in a randomized block design (RBD) having eight treatments replicated thrice with variety east coast tall (ECT) (Table 1). In between the trees about 4 meters were maintained. Based on economic threshold level, the insecticides were sprayed to the under surface of coconut leaves with a double motor pump battery sprayer (TURBO). About 5 litres of spray fluid were used per tree. The tree received three foliar applications at 14 days intervals and Tween 80 at 0.5 ml was used as surfactant.

Table 1: Treatments of the experiment

Sl.no	Treatments	Dose (ml/g/ha)
1	Thiamethoxam 25 WG	100
2	Bifenthrin 10 EC	800
3	Pymetrozine 50 WG	300
4	Fipronil 5 SC	1000
5	Diafenthiuron 47.80 SC	500
6	Azadirachtin 10000 PPM	700
7	Monocrotophos 36 SL	1000
8	Untreated check	-

b. Pest assessment

Observation of total number of nymphs and adults of whitefly was recorded on 3 leaflets (top, middle, and bottom) per frond per tree. First count was taken one day before first spray and post treatment counts were recorded on 1, 3, 5, 7, 9, 12 and 14 days after application (Bebitha, 2009) [6].

Reduction over control was calculated by using the following formula.

$$\text{Percentage reduction} = \frac{\text{Untreated palm} - \text{treated palm}}{\text{Untreated palm}} \times 100$$

(Bhatt *et al.*, 2018)

c. Assessment of natural enemies

The populations of natural enemies namely predatory coccinellids, spiders, and lacewings were recorded in the field experiment I and II on selected leaflets per plant prior to treatment and at 1, 3, 5, 7, 9, 12 and 14 days after each treatment. The total number of natural enemies were counted and expressed as numbers per plant (Bhatt *et al.*, 2018) [7].

d. Statistical analysis

In order to do a statistical analysis, the data on number of whiteflies and natural enemies were transformed by using the formula $\sqrt{X + 0.5}$ and used for statistical analysis. The data obtained from the field were analysed in a simple randomized block design by “F” test for significance as described by Panse and Sukhatme (1985) [18]. Critical difference values of the experiments were computed using Duncan’s Multiple Range Test (DMRT) (Gomez and Gomez, 1984) [11].

Results and Discussion

1. Management of the nymphs of rugose spiralling whitefly, *A. rugioperculatus*

The field experiments I results, which are presented in Table 2, showed that the thiamethoxam 25 WG at 100 g/ ha recorded the lowest nymphal population of 5.36 nymphs/ leaflet, followed by bifenthrin 10 EC at 800 ml/ ha (6.18 nymphs/ leaflet) and diafenthiuron 47.80 SC at 500 ml/ ha (7.00 nymphs/ leaflet) compared to untreated check (35.92 nymphs/ leaflet). Similar results were found in the field experiment II, with thiamethoxam 25 WG at 100 g/ ha reducing the nymphal population of 4.89 nymphs/ leaflet, followed by bifenthrin 10 EC at 800 ml/ ha reducing the second least nymphal population 5.77 nymphs/ leaflet compared to untreated check (32.06 nymphs/ leaflet). In both field experiments, thiamethoxam 25 WG at 100 g/ ha was found to be superior among the treatments than the untreated check (Table 2).

The order of efficacy was thiamethoxam 25 WG at 100 g/ ha > bifenthrin 10 EC at 800 ml/ ha > diafenthiuron 47.80 SC at 500 ml/ ha > fipronil 5 SC at 1000 ml/ ha > azadirachtin 10000 ppm at 700 ml/ ha > pymetrozine 50 WG at 300 g/ ha > monocrotophos 36 SL at 1000 ml/ ha. Mohammadali *et al.* (2019) [17] reported that the foliar spraying of actara 25 WG at 40g/ 100 litre and calypso 480 SC at 35 ml/100 litre were most efficient against nymphal stages at one day after application and the foliar treatment of actara 25 WG gave the highest efficacy after 14 days, so

actara was recommended in IPM program which greatly reduced the population density of cotton whiteflies. Shalini *et al.* (2019) [28] reported that among treatments evaluated for management of whitefly, diafenthiuron 50 SC at 0.75 ml/ l, fipronil 5 SC at 1ml/ l and thiamethoxam 25 WG at 0.25 g/ litre of water proved to be best treatments in reducing whitefly population. Whereas thiamethoxam 25 WG at 0.25g/ l and bufrofezin 25 SC at 0.5 ml/ l were more effective in reducing nymphal stage of whitefly. Pradhan *et al.* (2020a) [22] reported that thiamethoxam 25 WG (0.84 g) recorded lowest nymphal population of RSW (99.32 %) at 8 DAT in the field condition. These findings are in consonance with the present findings (Fig 1).

2. Management of the adults of rugose spiralling whitefly, *A. rugioperculatus*

The results of the field experiment I as given in table 3 reveal that the thiamethoxam 25 WG at 100 g/ ha recorded the low adult population of 2.42 adults/ leaflet followed by bifenthrin 10 EC at 800 ml/ ha (3.22 adults/ leaflet) and diafenthiuron 47.80 SC at 500 ml/ ha (4.13 adults/ leaflet) compared to untreated check (14.95 adults/ leaflet). Similar findings were confirmed in the field experiment II, lowest adult population was recorded in thiamethoxam 25 WG at 100 g/ ha (2.43 adults/ leaflet), followed by bifenthrin 10 EC at 800 ml/ ha (3.25 adults/ leaflet) and diafenthiuron 47.80 SC at 500 ml/ ha (4.02 adults/ leaflet) compared to untreated check (14.68 adults/ leaflet)(Table 3).

The order of efficacy was thiamethoxam 25 WG at 100 g/ ha > bifenthrin 10 EC at 800 ml/ ha > diafenthiuron 47.80 SC at 500 ml/ ha > fipronil 5 SC at 1000 ml/ ha > azadirachtin 10000 ppm at 700 ml/ ha > pymetrozine 50 WG at 300 g/ ha > monocrotophos 36 SL at 1000 ml/ ha. The present findings are in agreement with the earlier research work of Aslam *et al.* (2004) [4] who reported that the most effective insecticides for whitefly upto seven days were mospilan 20 SP at 150 g (acetamiprid) and actara 25 WG at 24 g (thiamethoxam). Al-Kherb (2011) [1] stated that thiamethoxam 25 WG proved to be the most effective insecticides with a reduction of 82.0 per cent of whitefly, *B. tabaci* on tomato crop. Patnaik *et al.* (2011) [19] reported that thiamethoxam 25 WG at 0.015 per cent reduced the incidence of whitefly population on mulberry plant (99.82%). Gopaldaswamy *et al.* (2012) [12] reported the less whitefly population in diafenthiuron 50 WP at 600 g/ha, imidacloprid 70 WG at 75 g/ ha and thiamethoxam 25 WG at 100 g/ ha compared to dimethoate 30 EC on green gram. Kumar *et al.* (2017a) [12] reported that thiamethoxam 25 WG at 100g/ ha was found most effective insecticide in reducing the population of whitefly on brinjal followed by imidacloprid 17.8 SL at 100 ml/ha. Sachin and Kumari (2018) [24] expressed that thiamethoxam 25 WG proved to be effective in reducing the adult whitefly population at 1, 5, 7 and 10 DAT. Pavithran *et al.* (2021) [20] reported that spraying of azadirachtin 10000 ppm (1.7ml) and thiamethoxam 25 WG (0.84 g) effectively suppressed the pest population of RSW on coconut plant. The present findings are also in accordance with Balakrishnan *et al.* (2009) [5] who revealed that the higher dose of bifenthrin 10 EC (1000 ml/ ha) recorded 81.56 per cent control of whitefly and it was on par with bifenthrin 10 EC (800 ml/ ha) that 79.01 per cent reduction (Fig 2).

Table 3: Bioefficacy of newer insecticides against the coconut rugose spiralling whitefly, *Aleurodicus rugioperculatus*(Martin) on the basis of adult population in the coconut variety ECT (Field experiment I and II)

Sl. No.	Treatments	Conc ml/g per ha	Mean adult population / leaflet April to July2022					Mean adult population / leaflet August to November2022				
			I Foliar application	II Foliar application	III Foliar application	Overall mean	Per cent reduction over Control	I Foliar application	II Foliar application	III Foliar application	Overall mean	Per cent reduction over control
1	Thiamethoxam 25 WG	100	3.66	2.17	1.44	2.42	83.81	3.45	2.46	1.38	2.43	84.06
2	Bifenthrin 10 EC	800	4.44	2.98	2.25	3.22	78.46	4.28	3.27	2.19	3.25	77.86
3	Pymetrozine 50 WG	300	8.01	6.62	5.86	6.83	54.31	8.94	8.15	7.07	8.05	45.16
4	Fipronil 5 SC	1000	6.20	4.60	3.87	4.89	67.29	6.06	4.91	3.83	4.93	66.42
5	Diafenthiuron 47.80 SC	500	5.20	3.79	3.41	4.13	72.37	5.09	4.09	3.01	4.06	72.34
6	Azadirachtin 10000 PPM	700	7.16	5.41	4.68	5.75	61.54	7.59	6.53	5.45	6.52	55.59
7	Monocrotophos 36 SL	1000	9.07	8.00	6.30	7.79	47.89	10.34	9.76	8.56	9.55	34.95
8	Untreated check	--	13.89	14.97	15.98	14.95		13.22	14.79	16.04	14.68	

Table 4: Effect of newer insecticides on the population of predatory coccinellids in the coconut variety ECT (Field experiment I and II)

Sl.No.	Treatments	Conc. ml/g per ha	Mean number of predatory coccinellids/ leaflet April to July2022				Mean number of predatory coccinellids/ leaflet August to November2022			
			I Foliar application	II Foliar application	III Foliar application	Overall mean	I Foliar application	II Foliar application	III Foliar Application	Overall mean
1	Thiamethoxam 25 WG	100	1.65	1.70	1.82	1.72	1.25	1.46	1.63	1.45
2	Bifenthrin 10 EC	800	1.24	1.30	1.41	1.32	0.95	1.15	1.20	1.10
3	Pymetrozine 50 WG	300	1.45	1.50	1.61	1.52	1.10	1.26	1.42	1.26
4	Fipronil 5 SC	1000	0.83	0.89	0.99	0.90	0.65	0.77	0.81	0.74
5	Diafenthiuron 47.80 SC	500	1.03	1.09	1.20	1.11	0.80	0.94	1.02	0.92
6	Azadirachtin 10000 PPM	700	1.86	1.90	2.03	1.93	1.40	1.64	1.83	1.62
7	Monocrotophos 36 SL	1000	0.63	0.68	0.79	0.70	0.50	0.59	0.61	0.57
8	Untreated check	--	2.29	2.79	3.34	2.81	1.80	2.55	3.22	2.52

Table 5: Effect of newer insecticides on the population of predatory spiders in the coconut variety ECT (Field experiment I and II)

Sl.No.	Treatments	Conc. ml/g per ha	Mean number of predatory spiders/ leaflet April to July2022				Mean number of predatory spiders/ leaflet August to November2022			
			I Foliar application	II Foliar application	III Foliar application	Overall mean	I Foliar application	II Foliar application	III Foliar application	Overall mean
1	Thiamethoxam 25 WG	100	2.07	2.19	2.49	2.25	1.44	1.51	1.49	1.48
2	Bifenthrin 10 EC	800	1.79	1.92	2.2	1.97	1.16	1.23	1.19	1.19
3	Pymetrozine 50 WG	300	1.92	2.05	2.34	2.10	1.31	1.37	1.34	1.34
4	Fipronil 5 SC	1000	1.51	1.63	1.90	1.68	0.88	0.95	0.89	0.91
5	Diafenthiuron 47.80 SC	500	1.64	1.77	2.05	1.82	1.02	1.09	1.04	1.05
6	Azadirachtin 10000 PPM	700	2.20	2.33	2.64	2.39	1.58	1.65	1.63	1.62
7	Monocrotophos 36 SL	1000	1.36	1.49	1.69	1.51	0.75	0.80	0.77	0.77
8	Untreated check	--	2.77	3.45	4.23	3.48	2.23	2.75	3.10	2.69

Table 6: Effect of newer insecticides on the population of predatory lacewings in the coconut variety ECT (Field experiment I and II)

Sl.No.	Treatments	Conc. ml/g per ha	Mean number of predatory lacewings/ leaflet April to July2022				Mean number of predatory lacewings/ leaflet August to November2022			
			I Foliar application	II Foliar application	III Foliar application	Overall mean	I Foliar application	II Foliar application	III Foliar application	Overall mean
1	Thiamethoxam 25 WG	100	1.22	1.32	1.42	1.32	1.12	1.18	1.36	1.22
2	Bifenthrin 10 EC	800	0.93	1.04	1.14	1.04	0.85	0.91	1.08	0.95
3	Pymetrozine 50 WG	300	1.07	1.18	1.28	1.18	0.99	1.05	1.22	1.09
4	Fipronil 5 SC	1000	0.64	0.75	0.85	0.75	0.57	0.64	0.79	0.67

5	Diafenthiuron 47.80 SC	500	0.79	0.89	1.00	0.89	0.72	0.77	0.93	0.81
6	Azadirachtin 10000 PPM	700	1.37	1.47	1.56	1.47	1.26	1.34	1.50	1.37
7	Monocrotophos 36 SL	1000	0.51	0.61	0.72	0.61	0.43	0.51	0.66	0.53
8	Untreated check	--	1.87	2.47	3.15	2.50	1.75	2.45	3.08	2.43

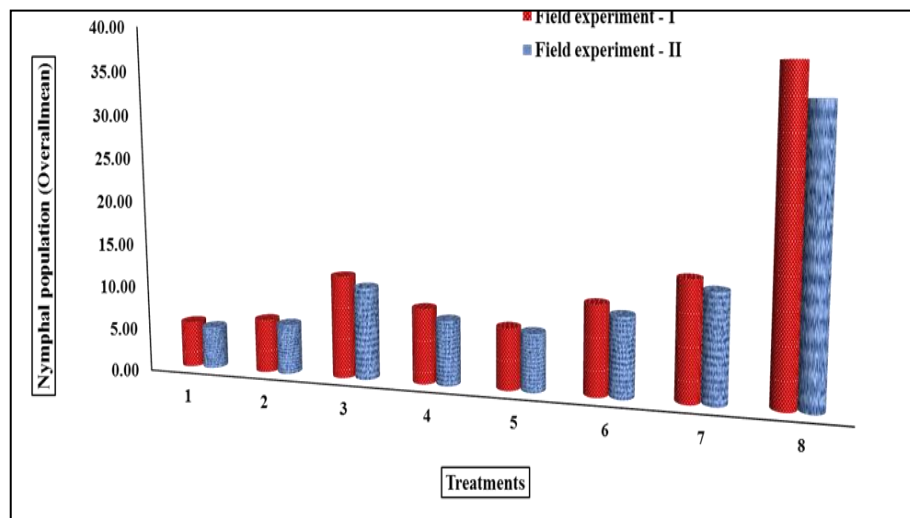


Fig 1: Bioefficacy of newer insecticides against the coconut rugose spiralling whitefly, *Aleurodicus rugioperculatus*(Martin) on the basis of nymphal population in the coconut variety ECT (Field experiment I and II)

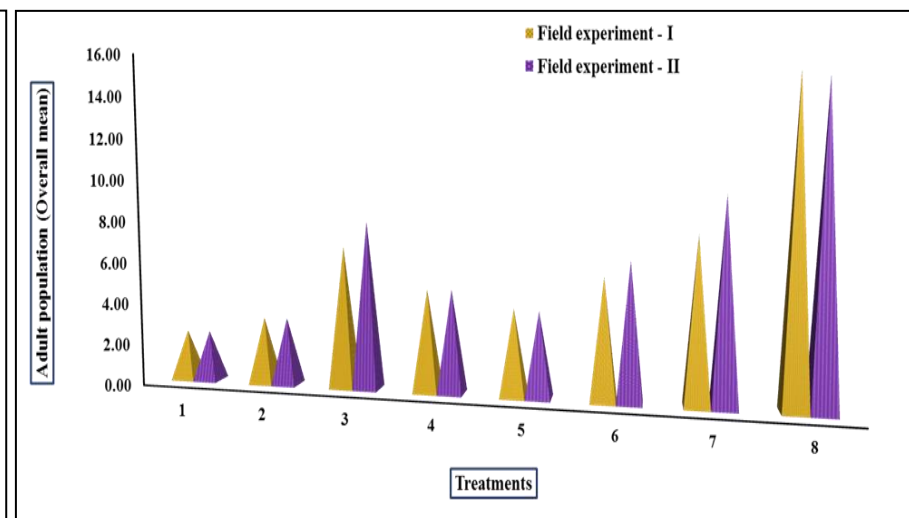


Fig 2: Bioefficacy of newer insecticides against the coconut rugose spiralling whitefly, *Aleurodicus rugioperculatus*(Martin) on the basis of adult population in the coconut variety ECT (Field experiment I and II)

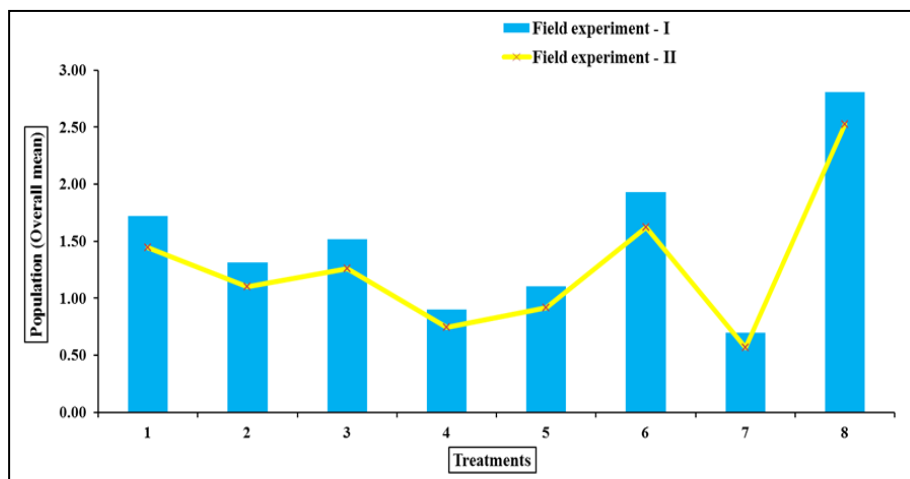


Fig 3: Effect of newer insecticides on the population of predatory coccinellids in the coconut variety ECT (Field experiment I and II)

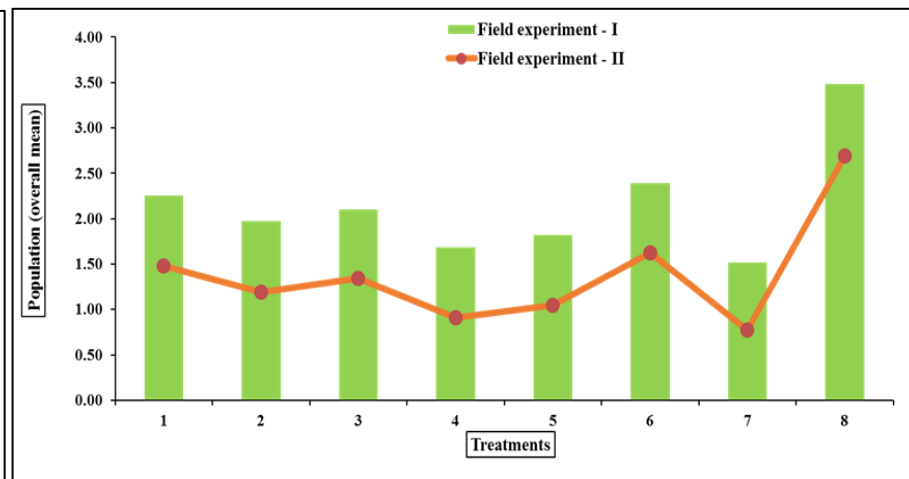


Fig 4: Effect of newer insecticides on the population of predatory spiders in the coconut variety ECT (Field experiment I and II)

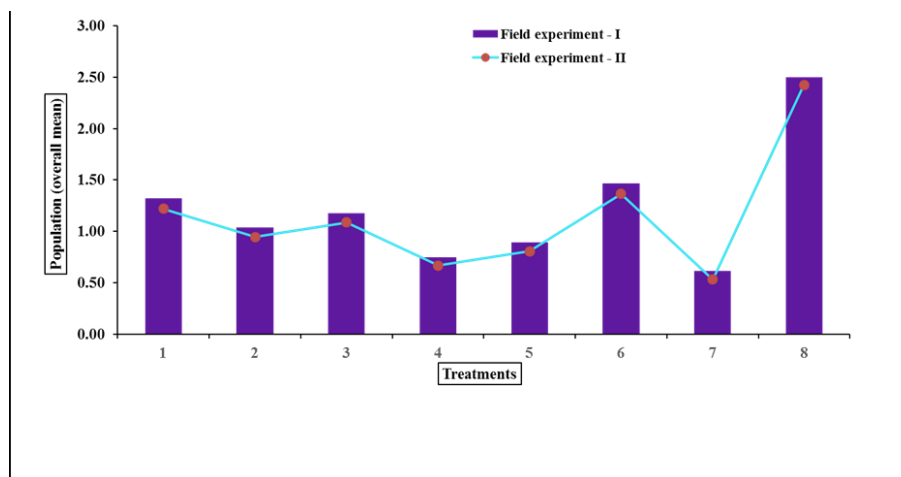


Fig 5: Effect of newer insecticides on the population of predatory lacewings in the coconut variety ECT (Field experiment I and II)

3. Safety to natural enemies

The Population density of predatory coccinellids was high in the untreated check (2.81/ leaflet), followed by azadirachtin 10000 ppm at 700 ml/ ha, thiamethoxam 25 WG at 100 g/ ha and pymetrozine 50 WG at 300 g/ ha (1.93,1.72 and 1.52/ leaflet) in the field trail I (Table 4 & Fig 3). The highest population of predatory spiders was recorded in untreated check (3.48/ leaflet), followed by azadirachtin 10000 ppm at 700 ml/ ha (2.39/ leaflet), thiamethoxam 25 WG at 100 g/ ha (2.25/ leaflet) and pymetrozine 50 WG at 300 ml/ ha (2.10/ leaflet) (Table 5 & Fig 4). Maximum occurrence of lacewings were observed in untreated check (2.50/ leaflet), followed by azadirachtin 10000 ppm at 700 ml/ ha (1.47/ leaflet), thiamethoxam 25 WG at 100 g/ ha (1.32/ leaflet) and pymetrozine 50 WG at 300 ml/ ha (1.18/ leaflet) (Table 6 & Fig 5). Similar results were also observed in the field experiment II.

The present findings are in accordance with the findings of Arshad *et al.* (2019) [3] who reported that plant extract of *A. indica* was effective synthetic insecticides and safer for natural enemies in the field. Kumar *et al.* (2022) [15] stated that the benefits of botanical formulation are safer for beneficial organisms and environment, followed by Elakkiya *et al.* (2021) [1] expressed that the IPM modules with azadirachtin 10000 ppm conserved more number of natural enemies *viz.*, predatory coccinellid beetle.

Amirzade *et al.* (2014) [2] reported that thiamethoxam (296.62 mg a.i./ ha) was less toxic to predatory ladybird beetles as compared to other neonicotinoids *viz.*, acetamaprid and imidacloprid. Zala *et al.* (2015) [33] reported that the application of thiamethoxam 25 WG at 0.0125 (%) was relatively safer to the activity of these two predators *viz.*, spider and coccinellids with highest population in okra ecosystem. Karthik *et al.* (2020) [13] reported that thiamethoxam 25 WG at 25, 50 and 75 g a.i./ ha recorded the maximum population of *Coccinellaspp* recorded after first and second spray. The present study exhibited that thiamethoxam 25 WG at 100 g/ ha had a little inhibitory effect on the population of predatory coccinellids, spider and lacewingfly, because it had toxic effect on the population of native natural enemies associated with the coconut RSW, *A. rugipercolatus*. Sreedhar (2020) [29] reported that among the effective insecticides against whitefly, pymetrozine 50 WG, flonicamid 50 WG, spiromesifen 240 SC and thiamethoxam 25 WG were found to be relatively safe to the native insect predators, *C.*

repanda and *N. tenuis*. Torres *et al.* (2003) [31] reported predators released on pymetrozine treated leaves experienced mortality from 0 to 20 per cent. It does not affect *A. gossypii* nor the whitefly predator *Delphastus pusillus*. These reports are in conformity with the present findings.

Conclusion

Based on the overall results, among the insecticides evaluated thiamethoxam 25 WG at 100 g/ha was found effective in controlling the population of both nymphs and adults of coconut rugose spiralling whitefly as foliar application. It was followed by bifenthrin 10 EC at 800 ml/ha which gave good control against the nymphs of RSW due to contact and stomach action. Hence, thiamethoxam 25 WG at 100 g/ha can be used by farmers to control the RSW on coconut in field level.

Author's Contribution

Conception and design, data collection and interpretation of results of the manuscript (M.K., S.T.); Draft preparation (S.T.); All authors read and approved the final manuscript.

Declaration

The authors declare that they have no conflict of interests.

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