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RESEARCH ARTICLE

EXPLORING SELECTED CONVENTIONAL AND BIORATIONAL INSECTICIDES AGAINST RUGOSE SPIRALING WHITEFLY, *ALEURODICUS RUGIOPERCULATUS* MARTIN (HEMIPTERA: ALEYRODIDAE) INFESTING COCONUT IN BANGLADESH

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ABSTRACT

Coconut is a crop of high economic value in Bangladesh due to its versatile uses. But at present, coconut plants are found to be seriously infested by invasive Rugose Spiraling Whitefly (RSW), *Aleurodicus rugioperculatus* Martin, resulting substantial yield loss. Against this backdrop, efficacy of several conventional and biorational insecticides were evaluated during December 2019-February 2020 in two coconut growing areas of Bangladesh for developing sustainable management option(s) against this pest. Among the tested conventional and biorational insecticides, significantly the highest percent reduction of both nymph and adult whitefly population over control (77.01% nymph and 73.79% adult in Jashore; 75.78% nymph and 76.8% adult in Barishal) in both the locations was recorded from spraying Tundra 50 SP (Acetamiprid) followed by Admire 200 SL (imidacloprid) and Bio-clean (d-limonene). The effectiveness of Pegasus 500 SC (Diafenthiuron) and Fytoclean (Potassium salt of fatty acid) was not satisfactory in reducing nymph and adult population of whitefly. Parasitism activity of nymphal parasitoids was found enhanced when biopesticides were applied indicating positive role of biopesticides in pest management. The chemical insecticide Tundra 50 SP (Acetamiprid) and biopesticide, Bio-clean (d-limonene) holds promise for incorporation into a well-designed integrated pest management (IPM) program against Rugose Spiraling Whitefly in coconut.

KEYWORDS

Rugose spiraling whitefly, Coconut, Management, Biopesticide, Parasitoid

1. INTRODUCTION

Coconut is an important cash crop in Bangladesh. It provides income to the growers continuously and significantly contributes to total farm productivity. It supports livelihood to the farmers through its diversified uses. Many small holder farmers usually depend on this crop for their livelihood since it is a source of regular income (Eyzaguirre and Batugal, 1999). The southern part of Bangladesh constitutes around 80% of total coconut production. Attack of different pests and diseases in most of the coconut-growing areas in Bangladesh has seriously affected the coconut industry to a large extent. Recently, coconut plants are suffering from severe infestation of Rugose Spiraling Whitefly (RSW) (*Aleurodicus rugioperculatus* Martin). This invasive pest was first recorded in Bangladesh from Regional Agricultural Research Station, Jashore during May 2019 on coconut (Dutta et al., 2019). This invasive pest was first recorded in India on coconut plants during August, 2016 (Sundararaj and Selvaraj, 2017). RSW is highly polyphagous with more than 118 host plants belonging to 43 families which include several economically important crops (Francis et al., 2016; Kartick et al., 2018).

Rugose Spiraling Whitefly has now become a serious problem to coconut growers. The problem is quite serious in south and southwestern parts of the country and considerable damage to coconut leaves has been noticed causing economic losses affecting a lot of farmers. The nymphs and adult whitefly by their sucking feeding habit, suck coconut sap by sucking the coconut leaflets (Figure 1 A, B). Sucking of saps by RSW would induce stress on the plants due to removal of water and nutrients. The pest excretes honey dew which subsequently is deposited on the upper surface of the leaves down beneath and also on other under storey crops. In case of massive attack, egg spirals could be seen on leaf petiole as well as on tender coconuts. Honey dew excretion on leaves attracts ants, thereby encouraging growth of sooty mold fungus, which reduces the photosynthetic efficiency of the leaves.

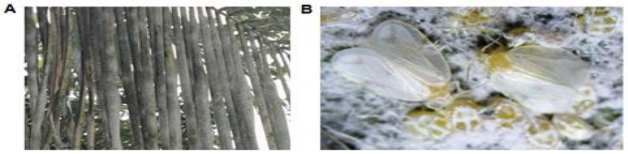

Figure 1: Infestation of RSW in coconut plant, (A) RSW infested coconut leaf and (B) RSW adult and nymph

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As the pest is new in the coconut growing areas, farmers are not aware of the control measures. Moreover, little or no information on its management approach is available in Bangladesh context. With these views in mind, an attempt was made in this study to evaluate the efficacy of some selected chemical insecticides and bio-pesticides against rugose spiraling whitefly along with their effect on activity nymphal parasitoids of RSW.

2. Materials And Methods

The present investigation was carried out in two locations viz., Regional Agricultural Research Station (RARS), BARI, Jashore (geographic coordinates 23°11' N, 89°11' E) and RARS, Rahmatpur, Barishal (geographic coordinates 22°47' N, 90°17' E) during December 2019-February 2020 to develop a suitable management option against newly introduced invasive pest Rugose Spiraling Whitefly (RSW). Same methodology was followed in both the locations. Three chemical insecticides and two bio-pesticides were tested in this study. Experiment was conducted in a randomized block design with three replicates consisting of single palm each. There were six treatments including control. Treatments (details in Table 1) were assigned as follows:

T_1: Spraying of Pegasus 500 SC (Diafenthiuron) @ 1 ml/litre of water

T_2: Spraying of Fytoclean (Potassium salt of fatty acid) @ 5 ml/litre of water

T_3: Spraying of Bioclean (D- limonene) @ 1ml/litre of water

T_4: Spraying of Tundra 50 SP (Acetamiprid) @ 1 g/litre of water

T_5: Spraying of Admire 200 SL (Imidacloprid) @ 0.5 ml/litre of water

T_6: Untreated control.

Table 1: Details of the insecticides/biopestcides used in the experiment

Trade name	Common name	Group/Class
Pegasus 500 SC	Diafenthiuron	Thiourea (Inhibits mitochondrial respiration)
Fytoclean	Potassium salt of fatty acid	Horticultural soap (causes cellular dehydration due to ingestion by larva. The formulation also disrupts the cuticle of soft-bodied insects resulting death).
Bioclean SL	d- limonene	d-Limonene (Found mostly in citrus and also other plants and is a major constituent of essential oil. It is generally used as a component of flavourings and fragrances, as a chemical intermediate and as an insect repellant)
Tundra 50 SP	Acetamiprid	Neonicotinoid (Potent agonist at the nicotinic acetylcholine receptors in insects)
Admire 200 SL	Imidacloprid	Neonicotinoid (Acts on post-synaptic nicotinic acetylcholine receptors in insect nervous system.)

Two sprays of each insecticide were done using high volume foot pump sprayer/ power sprayer at one-month interval. From each plant 20 leaflets were collected randomly, kept in polythene bags, brought to lab, and observed under stereo zoom microscope/10x hand lens for counting nymph and adult whitefly population. Nymph and adult whitefly population on coconut leaflets were counted at 1 day before spraying and 7 days after spraying. Parasitism (%) and adult emergence (%) of nymphal parasitoids were also recorded.

Natural parasitization by parasitoids was calculated using the following formula.

$$\text{Per cent parasitization} = \frac{\text{Number of parasitized whitefly nymphs}}{\text{Total number of whitefly nymphs}} \times 100$$

The number of parasitoids that emerged from the whitefly nymph was recorded based on the emergence hole in the nymph and the per cent emergence was worked out using the following formula:

$$\text{Per cent adult emergence} = \frac{\text{Number of nymphs having emergence hole}}{\text{Total number of parasitized nymphs}} \times 100$$

Recorded data subjected to proper analysis and means were separated by DMRT and Tukey test for Jashore and Barishal, respectively.

3. Results

3.1 Efficacy of Chemical Insecticides/Biopesticides in Reducing Nymph and Adult Population of RSW

Results of the present study conducted in Jashore indicated that, at 7 days after spray (DAS), the lowest mean nymph population /leaflet (4.65) was noticed in Tundra 20 SP treated plots followed by Admire 200 SL treated plots (5.47) (Table 2). The control treatment recorded the highest nymphal population /leaflet (19.30) at 7 DAS. Among the chemical insecticides/bio-pesticides tested, significantly the highest per cent reduction of whitefly nymphal population over pretreatment was recorded in Tundra 50 SP (77.01%), followed by Admire 200 SL (72.55%) and Bio-clean (62.89%). At 7 days after spray (DAS), the lowest mean adult whitefly population /leaflet (7.13) was noticed in Tundra 20 SP treated plots followed by Admire 200 SL treated plots (8.13). The control treatment recorded the highest whitefly population /leaflet (25.66) at 7 DAS. Among the chemical insecticides/bio-pesticides tested, significantly the highest per cent reduction of whitefly adult population over pretreatment was recorded in Tundra 50 SP (73.79%), followed by Admire 200 SL (69.85%) and Bio-clean (60.00%) at, Joshore. The bio-pesticide bio-clean could be used in a well designed IPM program against Rugose Spiraling Whitefly infesting coconut.

Table 2: Effect of different treatments on the population reduction of RSW nymphs and adults during December 2019- February 2020 at RARS, Jashore

Treatments	Mean RSW nymph population/ leaflet		Reduction (%) of RSW nymph population over pretreated	Mean RSW Adult population/ leaflet		Reduction (%) of RSWAdult population over pretreated
	1 DBS	7 DAS		1 DBS	7 DAS	
Pegasus 500 SC	20.56	9.09 c	55.79	26.80	13.67 b	48.99
Fytoclean	20.50	11.51 b	43.85	27.00	16.00 b	40.74
Bioclean	20.40	7.57 d	62.89	26.67	10.67 c	60.00

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Table 2 (cont): Effect of different treatments on the population reduction of RSW nymphs and adults during December 2019- February 2020 at RARS, Jashore

Tundra 50 SP	20.23	4.65 f	77.01	27.20	7.13 d	73.79
Admire 200 SL	19.93	5.47 e	72.55	26.53	8.13 cd	69.85
Untreated control (water spray only)	19.91	19.30 a	3.06	26.87	25.66 a	4.50
CV (%)	2.39	4.38	-	4.93	11.65	-

Means having same letter(s) in a column are not significantly different at P> 0.01 followed by DMRT.

On the other hand, results of the present study conducted in Barishal indicated that, at 7 days after spray (DAS), the lowest mean nymph population /leaflet (4.80) was noticed in Tundra 20 SP treated plots followed by Admire 200 SL treated plants (6.80) and Bioclean treated plants (7.57) (Table 3). The control treatment recorded the highest nymphal population /leaflet (17.96) at 7 DAS. Among the chemical insecticides/bio-pesticides tested, significantly the highest per cent reduction of whitefly nymphal population over pretreatment was recorded in Tundra 50 SP (75.78%), followed by Admire 200 SL (64.94%) and Bio-clean (60.60%). At 7 days after spray (DAS), the lowest mean adult whitefly population /leaflet (4.70) was noticed in Tundra 20 SP treated plants followed by Admire 200 SL treated plots (7.23). The control treatment recorded the highest whitefly population /leaflet (18.78) at 7 DAS. Among the chemical insecticides/ bio-pesticides tested, significantly the highest per cent reduction of whitefly adult population over pretreatment was recorded in Tundra 50 SP (76.80%), followed by Admire 200 SL (63.00%) and Bio-clean (58.74%) at Barishal.

3.2 Effect of Different Chemical Insecticides/Biopesticides on Parasitization (%) and Adult Emergence (%) of Nymphal Parasitoids of RSW

During the study, two species of parasitoids were found associated with *A. rugioperculatus* and parasitizing RSW nymph and identified as *Encarsia guadeloupae* Viggiani and *Encarsia dispersa* Polaszek (Figure 2 A, B).

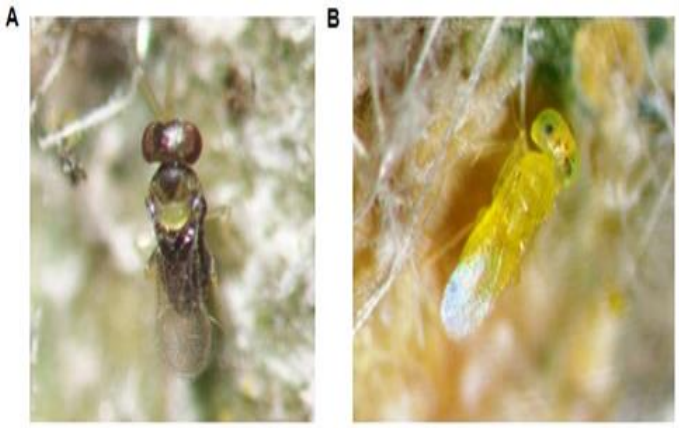

Figure 2: Parasitoids of RSW, (A) *Encarsia guadeloupae* Viggiani and (B) *Encarsia dispersa* Polaszek

Parasitism activity of these natural enemies' were found enhanced when biopesticides treatments were used (Table 4). Parasitization (%) of nymph and adult emergence (%) varied significantly among the treatments different locations. Parasitism by these parasitoids and emergence of adults parasitoids was the highest in control treatment plants followed by biopesticides treated plants and lowest in chemical treatment plants in both the locations.

Table 3: Effect of different treatments on the population reduction of RSW nymphs and adults during December 2019- February 2020 at RARS, Rahmatpur, Barishal

Treatments	Mean RSW nymph population/ leaflet		Reduction (%) of RSW nymph population over pretreated	Mean RSW Adult population/ leaflet		Reduction (%) of RSWAdult population over pretreated
	1 DBS	7 DAS		1 DBS	7 DAS	
Pegasus 500 SC	19.14	10.46 c	45.21	19.03	10.36 b	45.54
Fytoclean	19.14	13.21 b	31.02	18.05	11.76 b	34.92
Bioclean	19.28	7.57 d	60.60	18.58	7.68 c	58.74
Tundra 50 SP	19.88	4.80 e	75.78	20.26	4.70 d	76.80
Admire 200 SL	19.40	6.80 d	64.94	19.53	7.23 c	63.00
Untreated control (water spray only)	19.13	17.96 a	6.08	19.60	18.78 a	4.16
CV (%)	10.32	9.72	-	9.36	13.36	-

All means followed by same letters at each column were not significantly different among the treatments by Tukey test ($P < 0.05$).

It was observed that in Barishal, parasitization (%) in Pegasus 500 SC, Tundra 50 SP and Admire 200 SL treated plants were 6.02, 7.48 and 6.35%, respectively and these were statistically at par. Similarly, parasitization (%) in Pegasus 500 SC, Tundra 50 SP and Admire 200 SL treated plants were 7.83, 8.23 and 7.03% in Jashore, respectively, which were also statistically similar. Parasitism in case of biopesticides, Fytoclean and Bioclean treated plants offered statistically similar parasitism (15.08 and 15.24%, respectively) in Barishal. Fytoclean and Bioclean treated plants also offered statistically similar parasitism (16.52 and 17.02%, respectively) in Jashore.

Similar results were also observed in case of adult emergence. In both the locations, significantly the highest adults emergence was noticed (15.28 and 16.85% Barishal and Jashore, respectively) from untreated plants followed by biopesticide and chemical insecticide treated plants (Table 4). From the findings it is revealed that, parasitism efficiency of nymphal parasitoids enhanced when biopesticides were applied.

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Table 4: Effect of different treatments on parasitization (%) and adult emergence (%) of nymphal parasitoids of rugose spiraling whitefly in different locations during December 2019- February 2020

Treatments	RARS, Rahmatpur, Barishal		RARS, Jashore	
	*Percent parasitization	*Percent Parasitoid adult emergence	*Percent parasitization	*Percent Parasitoid adult emergence
Pegasus 500 SC	6.02 c	2.35 c	7.83 c	2.64 c
Fytoclean	15.24 b	10.24 b	17.02 b	12.01 b
Bioclean	15.08 b	11.25 b	16.52 b	11.52 b
Tundra 50 SP	7.48 c	2.01 c	8.23 c	3.34 c
Admire 200 SL	6.35 c	2.08 c	7.03 c	2.59 c
Control	20.24 a	15.28 a	22.62 a	16.85 a
CV (%)	11.31	14.36	9.2	6.42

Means having same letter(s) in a column did not differ significantly by DMRT ($P < 0.05$).

4. Discussion

Results of these two locations study clearly indicated that, although the chemical insecticide Tundra 20 SP (acetamiprid) performed best, it is not advisable to spray chemical insecticides repeatedly. To obtain sustainable management of this pest, biopesticides may be integrated with chemical control strategy. This strategy will reduce the load of hazardous chemicals, delay development of resistance of pest, and safe environment will be ensured for indigenous natural enemies of RSW. So, the best performing bio-pesticide bioclean (D-limonene) can be used in rotation with Tundra 20 SP for sustainable management of this pest.

In India, some researcher observed microbial biopestcide '*I. fumosorosea* NBAIR Pfu-5' as promising strain in reducing population of RSW in Karnataka and Andhra Pradesh with two sprays at 15 days interval in coconut plants (Selvaraj and Sundararaj, 2016). Visalakshi et al.(2021) also reported a 58.1 to 97.03 per cent reduction in RSW infestation in coconut plants when *I. fumosorosea* fungus (NBAIR- Pfu-5) @ 2 x 108 spores/ ml (5 g/l of water) was sprayed. A group researcher observed that different neem based biopesticide formulations were effective in reducing the *Aleurodicus dispersus* nymphal and adult whitefly population in guava plants (Kirubavathy et al., 1999). It is very difficult to control whitefly, *Aleurodicus disperses* with chemical insecticides since nymphs are covered by waxy flocculent materials and wax threads produced by the insects (Waterhouse and Norris, 1989; Neuenschwander, 1994).

Findings of the present study also revealed that, parasitism efficiency of nymphal parasitoids enhanced when biopesticides were applied. These results are in agreement to the findings of a group researcher who reported that the palms that received ecofriendly management practices significantly reduced the incidence and intensity of RSW along with maximum parasitism by the parasitoid *Encarsia guadeloupae* Viggiani (Alagar et al., 2022).

The management of RSW in coconut should highlight several issues. These include the exploration of eco-friendly alternatives like biorational insecticides, the development of effective strategies for resistance management, the incorporation of cultural control components to reduce insecticide sprays, and the utilization of biocontrol agents and cultural control options that can contribute to this pest control. Moreover, conducting studies on bioecology and pest population dynamics is very crucial for designing an effective pest management and, in the long run, developing an integrated pest management (IPM) strategy.

6. Conclusion

From the above study, it could be concluded that, the conventional insecticide Tundra 50 SP (Acetamiprid) and biopesticide, Bio-clean (d-limonene) holds promise for incorporation into a well designed IPM program against Rugose Spiraling Whitefly in coconut. Need based rotation spraying of the above mentioned pesticides can also be recommended to the farmers for effective management of RSW thereby reducing sole dependence on chemical pesticides. Parasitism activity of nymphal parasitoids viz. *Encarsia guadeloupae* Viggiani and *Encarsia dispersa* Polaszek were found enhanced when biopesticides were applied, which is signals the outstanding contribution of biopesticides in managing RSW in a sustainable basis.

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Competing Interest

The authors declare that the research work was carried out without any financial or commercial dealings that could be raised as a probable conflict of interest.

Authorship Contribution

Nirmal Kumar Dutta: Writing-original draft, Visualization, Validation, Software, Resources, Methodology, Investigation, Formal analysis, Conceptualization. **Md. Ishaqul Islam:** Writing-review & editing, Validation, Supervision, Resources, Methodology, Conceptualization. **Md. Mahbubur Rahman:** Writing-review & editing, Validation, Supervision, Resources, Methodology, Conceptualization. **Kohinoor Begum:** Writing-review & editing, Validation, Supervision, Resources, Methodology, Data curation, Conceptualization. **Md. Harun-Or-Rashid:** Writing-review & editing, Validation, Supervision, Formal analysis, Data curation, Conceptualization. **A. K. M. Rakibul Hasan Ferdous**: Supervision, Resources, Methodology, Conceptualization. **Md. Kafil Uddin:** Writing-review & editing, Methodology, Formal analysis, Conceptualization. **Md. Akhtaruzzaman Sarkar:** Writing-review & editing, Resources, Methodology, Conceptualization.

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