Indian Journal of Entomology 84(3): 562-566 (2022) DoI No.: 10.55446/IJE.2021.317

ECOFRIENDLY MANAGEMENT OF RUGOSE SPIRALLING WHITEFLY *ALEURODICUS RUGIOPERCULATUS* MARTIN INFESTING COCONUT

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ABSTRACT

Studies were conducted on the incidence, intensity of infestation, infestation grade index and natural enemy complex of rugose spiralling whitefly (RSW) *Aleurodicus rugioperculatus* Martin infesting coconut palms so as to evolve ecofriendly IPM. RSW incidence was at peak in June 2018 (38.3%), subsequently declined in December 2018 (20.5%), but later attained peak again in March 2019 (47.5%). The pest intensity also showed increasing trend from January 2018 to June 2019. The mean intensity of infestation and infestation grade index were 29.5% and 1.5 (medium), respectively in 2018-2019. The incidence and intensity significantly reduced from 75.5 to 37.7% and 85.7 to 42.9%, respectively on palms treated with ecofriendly IPM practices in 2018-19. Nut yield and net return were also found more in synergy with maximum parasitism (78.5%) by the aphelinid parasitoid *Encarsia guadeloupae* Viggiani observed on palms treated with ecofriendly IPM practices.

Key words: Coconut, *Aleurodicus rugioperculatus*, seasonal incidence, intensity, infestation grade index, IPM, biological pest suppression, *Encarsia guadeloupae*, parasitism, ecofriendly IPM

Rugose Spiralling Whitefly (RSW) *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae), first described from Belize (Martin, 2004) is a polyphagous, small, sap sucking, phloem feeder belonging to the order Hemiptera. The nymphs and adult whiteflies feed from the under surface of the palm leaflets by inserting the pointed stylets. This pest is considered serious by its extensive feeding habit that led to the excretion of abundant honey dew which subsequently gets deposited on the upper surface of the leaves down beneath and also on other under storey crops. In case of severe attack, egg spirals could be located on leaf, petiole as well as on tender coconuts. Honey dew excrement, being sweet and watery, attracts ants and develop sooty mould rapidly, which disrupts the normal leaf physiology and exacerbates its invasive potential. This exotic whitefly pest was reported from Miami-Dade County, Florida, in March 2009 (Stocks and Hodges, 2012). In India, this pest was reported from different locations of Coimbatore district, Tamil Nadu and Palakkad district, Kerala during July-August 2016 on coconut (Sundararaj and Selvaraj, 2017; Srinivasan et al., 2016; Selvaraj et al., 2016) and also from other parts of the country (Chalapathi Rao et al., 2018; Chandrika Mohan et al, 2016; 2017). RSW feeds on a broad range of host plants including palms, woody ornamentals and fruit trees (Mannion, 2010; Elango and Jeyarajan Nelson, 2019; Alagar et al., 2020). The present study focuses on evolving measures for its ecofriendly IPM through assessment of pest intensity, infestation grade index and natural enemy complex.

MATERIALS AND METHODS

The study was done during 2018-19 and 2019-20 at the Coconut Research Station, Aliyarnagar (10.49201^{0}N, 76.9033^{0}E), Tamil Nadu Agricultural University, Tamil Nadu, India. The observations were made at monthly intervals in the three gardens having 15 years old Chowghat Orange Dwarf (COD) and Kenthali Dwarf (KTD) palms. Five palms were randomly selected in each garden and incidence and intensity of damage were assessed through counts of eggs, nymphs and adults; infestation grade index; and occurrence of predators and parasitism by *Encarsia guadeloupae* Viggiani (Hymenoptera: Aphelinidae). The infestation was observed as % of leaves infested, and the intensity

assessed from four infested leaves/ fronds/ palm from outer/ middle whorl representing four directions (No. of leaflets infested/ fronds/ total leaflets/ frond x 100). Five leaflets from the observed leaf samples were brought to laboratory for the assessment of life stages of pest and natural enemies (20 leaflets/ palm and total of 100 leaflets/ plot). The infestation grade index was recorded with grading index methodology developed by Srinivasan et al. (2016) as follows: Adults nil, no sooty mould - Grade 0, Category Nil, Infestation grade index (IGI) 0.0; < 10 adults/ leaflet with sooty mould in 5- 6 lowermost fronds- Grade 1, Category low, IGI -0.01 to 1.0; 10-20 adults/ leaflet with sooty mould in 10-12 fronds- Grade 1, Category medium, IGI-1.01 to 2.0; >20 adults/ leaflet; sooty mould encrustation in >12 fronds- Grade 3, Category- high, IGI- 2.01 to 3.0. A minimum of 20 palms were randomly selected in a garden in diagonal fashion and categorized. Infestation grade index was arrived as given below to categorize the gardens as low/ medium/ highly infested.

$$IGI = \frac{\text{(No. of palms under Scale 0 x 0) + (No. of palms under Scale 1 x 1) +…. + (No. of palms under Scale 3 x 3)}}{\text{Total no. of palms observed}}$$

Surveys were conducted to assess the natural enemies complex and IGI at the Coconut Research Station, Aliyarnagar and nearby 20 villages viz., Kottur, Malayandipattinam, Angalakurichi, Puliyankandi, Pongaliyur, Kaliayapuram Sangampalayam, Aval Chinnampalayam, Pil Chinnampalayam, Somandurai chittur, Thenchittur, Ramanamuthali pudur, Manchanayaganur, Duraiyurmedu, Kammalapatti, Sungam, Pethanayanur, Sethumadai, Odaiyakulam and Devipattinam. The collected coconut leaf samples were observed under the microscope and the parasitized nymphs and exit holes on the pupae were counted. Infested leaflets collected were kept in the laboratory for the emergence of the parasitoid. The circular exit holes of parasitoid emergence were counted under stereozoom microscope to assess the rate of parasitism. The parasitised nymphs were black whereas, the unparasitised nymphs were pale yellow, and % parasitism was worked out.

Ecofriendly IPM practices formulated under AICRP (Palm) cell, ICAR- Central Plantation Crops Research Institute (CPCRI), Kasaragod, Kerala were evaluated on selected 50 palms of 15 years old COD variety which is relatively more susceptible to RSW. Fifty palms were maintained as untreated control. The treatments include: installation of light traps @ 5/ ha, fixing yellow sticky trap sheets @ 25/ ha, spraying three rounds of 0.5% neem oil at 15 days interval on the under surface of leaves, three rounds of jet water spray at 10 days interval about 15 days after spraying of neem oil and stapling of leaflets containing, *E. guadeloupae* parasitised puparia on palm leaflets. In control palms, all cultural operations were followed except for imposition of treatments. The RSW incidence (%), intensity, IGI, number of eggs, nymphs, adult, predators, parasitism by *E. guadeloupae* before and after IPM measures were recorded. Student't' test was used for analyzing the data.

RESULTS AND DISCUSSION

The results showed that the RSW incidence declined after the receipt of south west monsoon showers and it was at its least (20.5%) in December 2018; however it reached a peak (47.5%) during March 2019; intensity of infestation and the IGI also decreased after the onset of monsoon. Maximum parasitism by *E. guadeloupae* was observed in December 2018 (70.5%); between April 2019 and March 2020, incidence was at its peak (60.2%) in June 2019, and after initiation of monsoon, it declined (20.3%) in November 2019, and reached a peak (45.5%) during June 2019, which subsequently declined to 22.7% in December 2019. Maximum parasitism by *E. guadeloupae* (84.6%) was observed in December 2019 (Table 1).

Surveys on the natural enemy complex in the infested coconut gardens at Pollachi, Tamil Nadu revealed the occurrence of predators *Jauravia pallidula* Motschulsky (Coccinellidae: Coleoptera) and *Pseudomallada astur* (Banks) (Chrysopidae: Neuroptera) and the aphelinid parasitoid *E. guadeloupae* as well established ones. Parasitism by *E. guadeloupae* ranged from 40.4 to 82.5%, with a maximum (82.5%) at the Coconut Research Station, Aliyarnagar. Predators like *Chrysoperla zastrowi sillemi* (Esben- Petersen), *Mallada boninensis* (Navas), *Chilocorus nigrita* (F.), *Coccinella transversalis* (F.), *Menochilus sexmaculatus* (F.), *Propylea dissecta* (Mulsant), *Scymnus nubilis* (Mulsant), *Scymnus saciformis* (Mots.) and *Oecophylla smaragdina,* (F.) were also observed in the infested gardens at Pollachi North, and South and Anaimalai taluks of Coimbatore district. Similar results were reported from Kerala and Andhra Pradesh (Josephrajkumar et al., 2016; Shanas et al., 2016; Krishnarao and Chalapathi Rao, 2019). The aphelinid parasitoid *E. guadeloupae* and the chrysopid predator *P. astur* were the predominant natural enemies. The

Table 1. Seasonal incidence of RSW and its natural enemies in coconut (2018-19 & 2019-20)

Months	Incidence of RSW (%)	Intensity of RSW (%)	Infestation grade index	Live colony/ four leaflets/ palm			Predators/ four leaflets/ palm	Parasitisation by *E. guadeloupae* (%)
				Eggs	Nymphs	Adult		
2018-19								
June 2018	38.3	50.7	1.3	50.2	26.5	12.2	0.2	25.7
July 2018	32.2	40.7	0.9	42.5	38.7	10.5	0.5	35.5
August 2018	29.2	28.5	0.8	27.2	52.5	7.2	0.5	23.5
September 2018	25.7	24.8	0.8	8.3	3.4	4.5	0.7	50.8
October 2018	24.4	23.5	1.0	40.5	32.5	6.5	0.9	60.3
November 2018	21.5	25.3	1.2	27.2	52.5	7.2	0.5	52.8
December 2018	20.5	20.8	1.3	42.5	38.7	10.5	-	70.5
January 2019	32.5	20.7	2.4	50.2	26.5	12.2	0.5	48.8
February 2019	41.8	25.5	2.5	42.5	54.5	15.8	0.7	69.5
March 2019	47.5	34.9	2.7	37.8	48.5	20.5	0.4	60.5
Mean ± SE	31.3± 2.7	29.5± 2.9	1.5± 0.2	36.9± 3.8	37.4± 4.8	10.7±1.4	0.5± 0.1	49.9± 5.0
2019-20								
April, 2019	50.5	35.8	1.2	40.2	21.2	9.8	0.2	30.8
May, 2019	55.7	40.5	1.5	34.0	31.0	8.4	0.6	42.6
June, 2019	60.2	45.5	1.4	21.8	42.0	5.8	0.6	28.2
July, 2019	50.8	40.2	1.0	6.6	2.7	3.6	0.8	61.0
August, 2019	48.3	37.4	0.8	32.4	26.0	5.2	1.1	72.4
September, 2019	32.5	33.2	0.8	21.8	42.0	5.8	0.6	63.4
October, 2019	25.2	28.5	1.0	34.0	31.0	8.4	0.8	42.6
November, 2019	20.3	25.2	0.8	21.8	42.0	5.8	0.2	30.8
December, 2019	21.4	22.7	0.5	34.0	31.0	8.4	0.6	84.6
January 2020	22.5	25.2	0.7	34.0	38.5	18.5	0.8	70.5
February 2020	28.7	30.2	1.5	35.2	48.7	25.7	0.5	65.2
March 2020	35.3	33.4	2.0	35.2	60.7	38.4	0.6	42.5
Mean± SE	37.6±4.0	33.2± 1.9	1.1± 0.1	29.3± 2.6	34.7± 4.1	12.0± 2.9	0.6± 0.1	52.9± 5.2

*Mean of three trials, Mean ± standard error

ecofriendly IPM measures adopted during 2018-19 revealed that the RSW incidence significantly reduced from 75.5 to 37.7%, with intensity reducing from 85.7 to 42.9% on treated palms; in the untreated control palms, it increased from 64.2 to 80.2% and 80.5 to 95.5%, respectively. Similarly, the live colonies of eggs, nymphs and adults also significantly reduced. All the parameters except IGI and occurrence of predators significantly differed as compared to natural control in the post treatment observations.

Similar decreasing trend of incidence and intensity was observed during 2019-20 as well, and with IPM practices it was significantly reduced from 56.6 to 28.3%, with intensity of 64.3 to 32.2% and the IGI also significantly reduced from 1.7 (medium) to 0.8 (low). The IGI was observed to be subdued in control plots owing to the reduced treatmental disturbances, which subsequently enhanced the parasitic potential of *E. guadeloupae* marginally up to 56.6% (Table 2). The natural control as exhibited in control plots led to declining incidence, intensity and IGI even in comparison to the IPM practiced plots. Comparison between intensity of infestation and parasitism by *E. guadeloupae* revealed that the intensity reduced from 85.7 to 42.9% in treated palms compared to control palms (in which it increased from 80.5 to 95.5%. The parasitism by *E. guadeloupae* also increased from 43.2 to 70.2% in the IPM practiced plots, whereas it increased marginally from 50.5 to 61.5% in control plots. During 2019-20, the intensity of infestation reduced from 64.3 to 32.3% in the IPM practiced plots compared to control plots, and parasitism by *E. guadeloupae* increased from 32.4 to 78.5% (IPM plots) and 37.9 to 56.6% (control plots). This indicated faster reduction in intensity of infestation also coupled with enhancement in parasitic potential by *E, guadeloupae* when IPM is practiced. These results indicate that the palms that received ecofriendly IPM practices along with parasitism by *E. guadeloupae* suppressed the RSW infestation to a significant level. These results are in accordance with the research outcome emerged from Kerala and

Table 2. Efficacy of ecofriendly IPM against RSW and yield/ economics in in coconut (2018-19 & 2019-20)

Treatments	2018-19															
	Pre-treatment								Post-treatment							
	Incidence (%)	Intensity (%)	Live colony			Infestation Grade Index	Predators (No./ Palm)	Parasitisation (%)	Incidence (%)	Intensity (%)	Live colony			Infestation Grade Index	Predators (No./ Palm)	Parasitisation (%)
			Egg	Nymph	Adult						Egg	Nymph	Adult			
T1-Eco friendly pest management	75.5	85.7	22.5	30.2	12.4	2.2	0.8	43.2	37.7	42.9	11.3	15.1	6.2	1.1	0.4	70.2
T2-Natural control	64.2	80.5	25.5	32.5	10.1	2.5	0.5	50.5	80.2	95.5	31.9	40.6	12.7	2.5	0.6	61.5
Significance (p= 0.1)	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	*	*	*	*	*	*	N.S.	N.S	*
't' value	0.6	0.1	0.7	0.2	0.004	0.2	0.3	6.2	6.2	4.5	0.001	2.3	0.1	1.3	0..5	6.5
2019-20																
T1-Eco friendly pest management	56.6	64.3	16.9	22.7	9.3	1.7	0.6	32.4	28.3	32.2	8.5	11.3	4.7	0.8	0.3	78.5
T2-Natural control	48.2	60.4	19.1	24.4	7.6	1.9	0.4	37.9	60.2	71.6	23.9	30.5	9.5	1.0	0.5	56.6
Significance (p= 0.1)	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	*	*	*	*	*	*	N.S.	N.S	*
't' value	0.6	0.1	0.7	0.2	0.004	0.2	0.3	6.2	6.2	4.5	0.001	2.3	0.1	1.3	0..5	6.5

Treatments/ year	Pretreatment					Post-treatment				
	Yield (No. of nuts/ha)	Cost of Cultivation (Rs/ ha)	Gross return (Rs/ ha)	Net return (Rs/ ha)	BC ratio	Yield (No. of nuts/ha)	Cost of Cultivation (Rs/ ha)	Gross return (Rs/ ha)	Net return (Rs/ ha)	BC ratio
2018-19										
Ecofriendly IPM	10,726	65,245	1,44,801	79,556	1:2.2	12,975	71,245	1,75,163	1,03,918	1: 2.5
Natural control	11,245	67,152	1,51,808	84,656	1:2.3	10,726	67,542	1,44,801	77,259	1:2.1
2019-20										
Ecofriendly IPM	12,975	71,245	1,75,163	1,03,918	1: 2.5	15,916	71,245	2,14,866	1,43,621	1:3.0
Natural control	10,726	67,542	1,44,801	77,259	1:2.1	10,726	65,124	1,44,801	79,677	1:2.2

Andhra Pradesh (Josephrajkumar et al., 2016; Shanas et al., 2016; Krishnarao and Chalapathi Rao, 2019). Enhancement in nut yield and better economics was realized from ecofriendly IPM, and the benefit cost ratio was 1:2.2 before treatment increased to 1:2.5 and 1:3.0 after the treatment during 2018-19 and 2019-20, respectively. In control plots it was 1:2.3 at the start of the experiment, which got slightly reduced to 1:2.1 during 2018-19 and 1:2.2 during 2019-20 (Table 2).

ACKNOWLEDGEMENTS

The authors acknowledge the ICAR- All India Coordinated Research Project (AICRP) on Palms for the funding. Scientists in the Department of Entomology and Centre for Plant Protection Studies, Tamil Nadu Agricultural University, Coimbatore are acknowledged for the help in identifying the predators and parasitoids.

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(Manuscript Received: November, 2020; Revised: March, 2021;
Accepted: March, 2021; Online Published: July, 2021)
Online published (Preview) in www.entosocindia.org Ref. No. e20390