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Eco-friendly management of rugose spiralling whitefly, *Aleurodicus rugioperculatus* Martin on coconut under coastal ecosystem of Maharashtra

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ABSTRACT: An experiment on eco-friendly approaches for the management of coconut Rugose spiralling whitefly (RSW), *Aleurodicus rugioperculatus* Martin under coastal ecosystem of Maharashtra was conducted during 2018-21 at Regional Coconut Research Station, Dapoli, Maharashtra, India. The data indicated that the IPM package consisting of neem oil application followed by water spray coupled with yellow sticky traps was found effective in reducing RSW incidence. It recorded lowest incidence (31.5%), intensity (20.0%), grade index (0.6) and population (33.6/four leaflet) of RSW) compared to natural control. The RSW per cent reduction over pre-count was noticed incidence (33.3%), intensity (37.1%) and live colony (37 nos.) in neem oil alone spray. The maximum *Encarsia* emergence from parasitized pupae of RSW was observed in T_8-Control treatment (96.6%) was at par with T_4-Neem oil @ 5 ml/litre of water (83.3 %).

Keywords: Coconut, rugose spiralling whitefly, biological suppression, neem oil, *Encarsia*, IPM

INTRODUCTION

The Coconut palm (*Cocos nucifera* Linn.) has great socio-economic significance as it is the source of livelihood for more than 20 million people globally, especially small and marginal farmers. It provides people basic needs such as food, drink, shelter, fuel, furniture, medicine, decorative materials and much more (Punchihewa and Arancon, 1999). They are a necessity and a luxury. It is the most intensively grown and used nut in 80 countries of the world. The rugose spiralling whitefly, *Aleurodicus rugioperculatus* Martin (Hemiptera:Aleyrodidae), has been recently reported from Tamil Nadu, India (Sundararaj *et al.,* 2017). It is an invasive pest that attacks a wide range of host plants including palms, woody ornamentals and fruits. Coconut and banana are among the most preferred host plants. *Aleurodicus rugioperculatus* Martin was originally described from Belize (Martin, 2004) and it is mainly infesting coconut palms and other broad-leaved hosts in its native range and naturally distributed in Belize, Guatemala, Mexico (Martin, 2008) and subsequently, it has spread to 22 other countries in Central and South America, including Florida, USA. India is the only country in the Oriental region where the whitefly has been introduced. Mandal (2011) listed 116 exotic insect species in India. Among the insect pests, exotic whiteflies have invaded several countries causing direct losses in agriculture, horticulture and forestry. Currently, there are 442 species of whiteflies belonging to 63 genera known from India; of these, a few are economically important. Two invasive whiteflies *viz*., the spiraling whitefly, *Aleurodicus dispersus* Russell (David and Regu, 1995) and the solanum whitefly, *Aleurothrixus trachoides* Back (Dubey and Sundararaj, 2015). Karthik *et al.,* 2018 was detected rugose spiralling whitefly from coastal areas of Karnataka, Kerala and Andhra Pradesh. It has become an escalating problem for coconut farmers. The RSW was distributed unevenly along national highways, isolated garden near water bodies, restricted garden etc. This was observed on coconut seedlings at Regional Coconut Research Station, Bhatye, Ratnagiri during August, 2017 in Maharashtra, attended pest status in coconut garden after May, 2018 and was noticed on banana, custard apple, mango, cashew nut, almond, areca palm and bush pepper everywhere in Konkan region of Maharashtra. The maximum temperature had positive impact on the incidence and intensity of RSW. However, intensity of RSW was negatively correlated with rainfall and evening humidity (Wankhede *et al*., 2021). The immature and adult whitefly by their sucking feeding habit, siphon out coconut sap by selective feeding from the abaxial of the coconut leaflets. De-sapping by RSW would induce stress on the palms due to removal of water and nutrients, but neither colour change nor necrosis has been reported. The whitish mat of flies on lower side and black shooty mould on upper side was noticed. Considering the fast-growing status of this pest and its impact on coconut, the present study was conducted on the integrated management of rugose spiralling whitefly in coconut under coastal ecosystem of Maharashtra State.

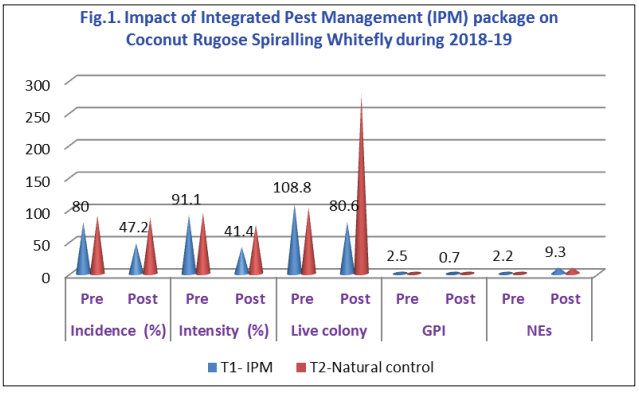

Fig. 1. Impact of IPM package on rugose spiralling whitefly (2018-19)

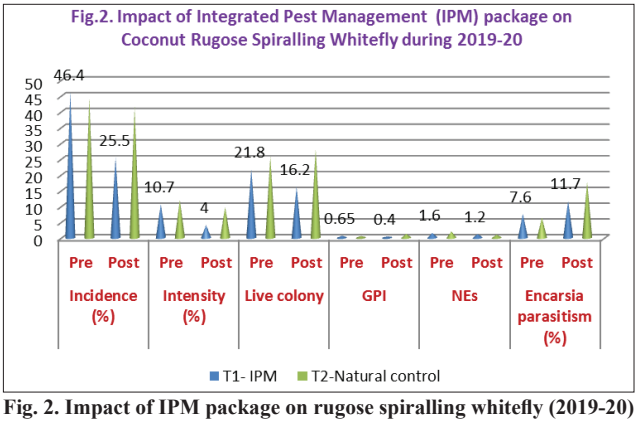

Fig. 2. Impact of IPM package on rugose spiralling whitefly (2019-20)

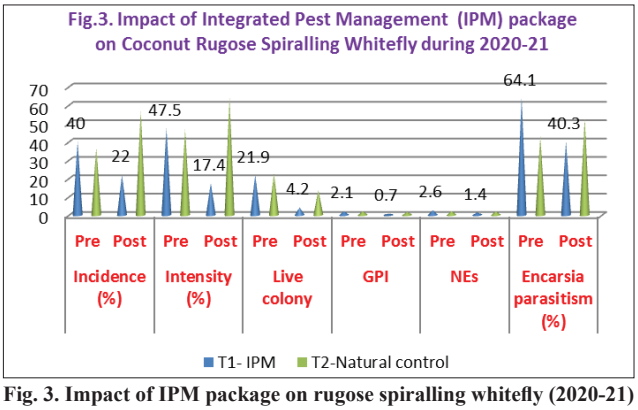

Fig. 3. Impact of IPM package on rugose spiralling whitefly (2020-21)

MATERIALS AND METHODS

An experiment on eco-friendly approaches for the management of coconut Rugose Spiralling Whitefly (*Aleurodicus rugioperculatus* Martin) under coastal ecosystem of Maharashtra State was conducted at AICRP (Palms), Regional Coconut Research Station, Bhatye Dist. Ratnagiri (M.S.) during 2018-19 to 2020-21. It consists of four sub experiments a) Evaluation of IPM package against coconut rugose spiralling whitefly (CRSW) b) Impact of yellow sticky traps at different heights against CRSW c) Individual effect of neem oil and water for the management of CRSW and d) Effect of different concentrations of neem oil on emergence of *Encarsia* from parasitized pupae of CRSW.

a) Evaluation of IPM package against coconut rugose spiralling whitefly (CRSW)

The experiment was initiated in every year during November with 25 palms of Gangabondam Green Dwarf coconut variety was selected for assessment of the efficacy of IPM strategies including three sprays of neem oil 0.5 per cent @ 5 ml/litre of water at fifteen days intervals in synergy with bands of yellow sticky traps followed by three rounds of water sprays at fifteen days intervals. The observations of per cent incidence (no. of leaves infested by RSW/total leaf per palm x100), intensity (no. of leaflets infested by RSW/total leaflets per leaf), grade pest intensity, RSW populations, natural enemies and *Encarsia* parasitism (%) per four leaflets were recorded one day prior as pre-treatment observations and post treatments observations were recorded after three months of superimposition of treatments.

b) Impact of yellow sticky trap at different height against coconut rugose spiralling whitefly

The said experiment was carried out for assessment of yellow sticky traps (YST) impact against RSW at different height. The six treatments *viz*., T_1-YST @ 1 feet from ground, T_2-YST @ 2 feet from ground, T_3-YST @ 3 feet from ground, T_4-YST @ 4 feet from ground, T_5-YST @ 5 feet from ground and T_6-Closed to crown region trap were tested with three replications in randomized block design. No. of whiteflies trapped on YST were recorded at 5 days interval and generated data was subjected for statistical analysis.

c) Individual effect of neem oil and water for the management of rugose spiralling whitefly

The present experiment was conducted for study the impact of neem oil and water spray alone on RSW. The pre-treatment observations were taken at 24 hours before imposition of treatments. Three sprays of neem oil @0.5% and water sprays three round were taken separately on coconut palms at 15 days interval and post treatment observations was recorded after 1.5 months after spraying. The per cent reduction over control of RSW incidence, intensity and populations were calculated over pre-count observations.

d) Effect of different concentrations of neem oil on emergence of *Encarsia* from parasitized pupae of coconut rugose spiralling whitefly

The set of laboratory experiment on safety of neem oil for *Encarsia* parasitism was conducted in Entomology laboratory, RCRS, Bhatye with eight treatment and three replications in completely randomized block design. The twenty *Encarsia* parasitized pupae of RSW on coconut

Table 1. Cumulative effect of integrated pest management package against rugose spiraling whitefly during three year 2018-21

Treatments	Pre-treatment observations						Post treatment observations					
	Incidence of RSW (%)	Intensity of RSW (%)	RSW live colony /four leaflet	Grade pest index	Natural enemies (predators/ spiders)	*Encarsia* parasitism (%)	Incidence of RSW (%)	Intensity of RSW (%)	RSW live colony / four leaflet	Grade pest index	Natural enemies (predators/ spiders)	*Encarsia* parasitism (%)
T_1- IPM	55.4 ± 1.9	49.7 ± 1.8	50.8 ± 5.0	1.75 ± 0.7	2.13 ± 0.4	35.8 ± 2.6	31.5 ± 1.3	20.9 ± 1.3	33.6 ± 1.1	0.60 ± 0.3	3.9 ± 0.3	26.0 ± 3.8
T_2- Natural control	57.0 ± 1.5	51.0 ± 1.8	50.4 ± 4.4	1.6 ± 0.6	2.13 ± 0.3	24.6 ± 0.1	61.7 ± 1.7	49.7 ± 3.3	106 ± 4.8	1.63 ± 0.6	4.0 ± 0.3	35.1 ± 3.5
Sig. (P=0.05)	N.S.	N.S.	N. S	Low - < 1, Median - 1-2, High - 2-3	N.S.	N.S.	Sig.	Sig.	Sig.	Low - < 1, Median - 1-2, High - 2-3	N.S.	N.S.
't' value	0.48	0.41	0.55		0.75	0.29	6.17	2.78	3.36		1.04	0.38

(mean ± standard error)

leaflets were kept in each petri dish and applied different treatments *viz*., T_1- neem oil @ 0.1%, T_2- neem oil @ 0.3%, T_3- neem oil @ 0.4%, T_4- neem oil @ 0.5%, T_5- neem oil @ 0.6%, T_6- neem oil @0.7%, T_7- neem oil @ 1% and T_{10}-control. The *Encarsia* emergences from parasitized pupae of RSW were recorded at 15 days after imposition of treatments. The generated data were subjected for statistical analysis.

RESULTS AND DISCUSSION

The T1-IPM treatment was reduced the incidence, intensity, GPI and RSW population over T2-Natural control during 2018 (Fig.1). The grade pest intensity was recorded 0.70 (low) in T1-IPM as compared to pre-treatment count 2.5 (high). The T1-IPM treatment recorded minimum rugose spiralling whitefly population (80.6 nos.) which was significantly superior over T2-Natural control (278 nos.). The T2- natural control registered incidence, intensity and grade pest intensity of RSW which recorded 86.8, 75.7 per cent and 1.9 (medium) as compared to pre-count observation was noticed 90.0, 94.5 per cent and 2.10 (high), respectively. The non significant result was noticed about natural enemies (predators/spiders).

The incidence (25.5%) and intensity (4%) of RSW was recorded minimum in T1-IPM over pre-count (46.4% incidence and 10.7% intensity). The incidence was found significantly superior over the natural control (Fig.2). The T1-IPM treatment was found minimum rugose spiralling whitefly population (16.2 nos.) and *Encarsia* (11.7%) which was significantly superior over natural control (28.2 and 17.8 %, respectively).

The non significant results registered in pre-count observations. The T1-IPM treatment was recorded minimum incidence (22%) and intensity (17.4%) of rugose spiralling whitefly over pre-count (40 and 47.5%, respectively). The IPM treatment was found significantly superior over the natural control. The grade pest intensity was reduced in IPM 0.70 as over to pre-treatment count 2.1 (Fig.3). Moreover, the T1-IPM treatment was found minimum no. of RSW live colonies (4.2) which was significantly superior over T2-Natural control (13.4/ leaflet).

The non significant results were observed in natural enemies (predators/other) and *Encarsia* parasitism associated with RSW. The T2-Natural control registered the increased of incidence and intensity of RSW were recorded 56.9 and 63.9 as compared to pre-count observations were noticed 36.7 and 46.7 per cent, respectively.

Table 2. Impact of yellow sticky traps (YST) at different heights against rugose spiralling whitefly

Treatments Details		Mean no. of rugose spiralling whitefly trapped on YST per Sqft²			
		5th day	10th day	15th day	Mean
T_1	YST @1 feet from ground	4.75 (2.34) *	10.75 (3.42)	4.75 (2.32)	6.75 (2.69)
T_2	YST @ 2 feet from ground	9.25 (3.26)	12.25 (3.56)	10.75 (3.31)	10.75 (3.37)
T_3	YST @ 3 feet from ground	28.75 (5.36)	22.75 (4.61)	36.25 (6.27)	29.25 (5.41)
T_4	YST @ 4 feet from ground	40.50 (5.68)	31.50 (4.84)	39.75 (5.84)	37.25 (5.45)
T_5	YST @ 5 feet from ground	23.25 (4.33)	22.25 (4.45)	19.50 (3.99)	21.66 (4.25)
T_6	Closed to crown region trap	12.25 (3.69)	16.00 (3.44)	17.0 (4.02)	15.08 (3.71)
S.Em. ±		**0.42**	**0.54**	**0.45**	**0.47**
C.D. @ 5%		**1.55**	**1.99**	**1.66**	**1.73**
C.V.		**3.00**	**3.90**	**3.08**	**3.32**

(Figures in parenthesis are square root transformed values)*

Table 3. Efficacy of neem oil spray alone on rugose spiralling whitefly in coconut

Treatments		Incidence of RSW (%)	Intensity of RSW (%)	RSW live colony /four leaflet	Grade pest index	Natural enemies (predators/ spiders)	*Encarsia* parasitism (%)
Neem oil @ 0.5%	**Pre-count**	17.4 ± 1.8	28.3 ± 3.6	23.2 ± 0.4	1.67	0.4 ± 0.2	79.0 ± 3.2
	Post-count	11.6 ± 1.7	17.8 ± 2.2	14.6 ± 0.7	0.31	0.8 ± 0.0	83.0 ± 2.0
Sig. (P=0.05)		N.S.	Sig.	Sig.	Low - < 1, Median - 1-2, High - 2-3	N.S.	N.S.
't' value		2.92	4.41	3.98		1.00	0.01
(%) reduction over control		33.3	37.1	37.0	-	-	-

(Average mean ± standard error)

Table 4. Efficacy of water spray alone on rugose spiralling whitefly in coconut

Treatments		Incidence of RSW (%)	Intensity of RSW (%)	RSW live colony /four leaflet	Grade pest index	Natural Enemies (Predators/ spiders)	*Encarsia* parasitism (%)
Water spray	**Pre-count**	18.1 ± 2.4	29.5 ± 3.5	33.8 ± 5.3	1.3	1.0 ± 0.4	78.0 ± 2.3
	Post-count	16.0 ± 3.1	23.4 ± 2.0	26.4 ± 1.4	1.0	1.2 ± 0.6	82.0 ± 2.0
Sig. (P=0.05)		N.S.	N.S.	N.S.	Low - < 1, Median - 1-2, High - 2-3	N.S.	N.S.
't' value		0.49	0.18	0.65		0.77	0.31
(%) reduction over control		11.6	20.6	21.8	-	-	-

Average mean ± standard error

The non significant results were observed in natural enemies (predators/other) and *Encarsia* parasitism associated with RSW. The T2-Natural control registered the increased of incidence and intensity of RSW were recorded 56.9 and 63.9 as compared to pre-count observations were noticed 36.7 and 46.7 per cent, respectively.

The data presented in table 2 indicated that the maximum whiteflies was recorded on T_4-YST @ 4 feet from ground (37.25 nos.) found significantly superior over T_6- YST closed with crown region (15.08 nos.), T_2-YST @ 2 feet from ground (10.75 nos.) and T_1-YST @ 1 feet from ground (6.75 nos.). It was on par with T_3-YST @ 3 feet from ground (29.25 nos.) and T5-YST @ 5 feet from ground (21.66 nos.). The yellow coloured sticky traps, made with sheets (100x50cm) and smeared with white grease recorded the maximum catch of rugose spiralling whiteflies (18.3 nos.) by Wankhede *et al.* (2022). Atakan and Canhilal (2004) assessed the sticky yellow traps at 60, 80, 100, and 120 cm above ground level in various developmental stages of cotton for their relative efficiency in capturing the leafhoppers, whitefly and thrips. Dewangan *et al.* (2019) assessment of variability of yellow sticky trap heights in soybean whitefly taking into consideration of six trap heights and it is found that the lower trap height three feet differs significantly with all the trap heights. Idris *et al*. (2012) found that the yellow was the most attractive colour to alate whitefly. Elango *et al*., 2017 found that the yellow was most attractive for white fly (22.1 whiteflies/per trap/per week) followed by pale yellow (13.8 whiteflies/per trap/per week) and green (13.1 whiteflies/per trap/per week). Generated results of field trials confirmed that yellow sticky trap attracted a greater number of whiteflies as compared to the others, may be used in methods of insect population monitoring (Khuhro *et al*., 2020). These results agree with Premalatha and Rajangam (2011) who reported that maximum number of whiteflies *Trialeurodes vaporariorum* (Westwood) attracted towards yellow sticky trap in gerbera. Likewise, Lu *et al.* (2012) reported that yellow sticky traps can be used as an effective method for the control of whiteflies, *Bemisia tabaci* in the greenhouse.

The data depicted in table 3 revealed that the neem oil @ 5 per cent found effective against RSW which recorded minimum incidence (11.6 %), intensity (17.8 %) and live colony of RSW (14.6 nos.) over pre-count observations *viz.,* 17.4, 28.3 and 23.2 nos., respectively. The per cent reduction over pre-count was noticed incidence (33.3%), intensity (37.1%) and live colony (37.1 nos.).

Table 5. Effect of different concentrations of neem oil on emergence of *Encarsia* from parasitized pupae of rugose spiralling whitefly

Treatments Details		*Encarsia* Emergence (%) from parasitized pupae of RSW		
		First application	Second application	Mean
T_1	Neem oil 0.1% @ 1ml/litre of water	91.0 (72.8)	93.3 (74.9)	92.1 (73.8)
T_2	Neem oil 0.3% @ 3ml/litre of water	88.8 (70.6)	88.8 (70.6)	88.8 (70.6)
T_3	Neem oil 0.4 @ 4ml/litre of water	84.4 (67.2)	86.6 (68.9)	85.6 (68.0)
T_4	Neem oil 0.5% @ 5ml/litre of water	82.2 (65.1)	84.4 (66.8)	83.3 (65.9)
T_5	Neem oil 0.6% @ 6ml/litre of water	79.9 (63.6)	79.9 (63.6)	79.9 (63.6)
T_6	Neem oil 0.7% @ 7ml/litre of water	75.5 (60.4)	77.7 (61.9)	76.6 (61.1)
T_7	Neem oil 1% @ 10ml/litre of water	66.6 (54.6)	68.8 (56.0)	67.7 (55.3)
T_8	Control	95.5 (79.9)	97.7 (84.9)	96.6 (82.4)
S.Em. ±		2.97	2.72	2.84
C.D. @ 5%		9.01	8.26	8.63

(Figures in parenthesis are Arc sign transformed values)

Ghosh *et al.* (2013) found the satisfactory control (>60% population suppression) was achieved with neem oil. Sridhar *et al.* (2017) found that the (75%) mortality of *B. tabaci* with neem/pongamia/fish oils were used together @3ml/l each. Oils alone gave upto (48.75%) mortality of *B. tabaci* and highest synergism was recorded with neem oil followed by fish oil and pongamia oil.

The forcibly application of water sprays was observed incidence (16%), intensity (23.4%) and 26.4 nos. of live colony of RSW which found better results than pre-treatment observations (18.1, 29.5 and 33.8 nos., respectively). The water sprays were reduced RSW incidence (11.6%), intensity (20.6%) and 21.8 live colony of RSW over pre-count (Table 4).

The data presented in table 5 revealed that the maximum *Encarsia* emergence from parasitized pupae of RSW was noticed in T_8-control treatment (96.6%). The next effective treatment was T1-neem oil @ 1 ml/litre of water (92.1 %) which found significantly superior over T_5-neem oil @ 6 ml /litre of water (79.9 %), T_6-neem oil @ 7 ml /litre (76.6 %) and T_7-neem oil @ 10 ml /litre of water (67.7 %) emergence of *Encarsia* from parasitized pupae of RSW and was noticed at par with T_2-neem oil @ 3ml/litre (88.8 %), T_3-neem oil @ 4 ml/litre of water (85.6 %) and T_4-neem oil @ 5 ml/litre of water (83.3 %). Aziz *et al.* (2019) found that the population of predators was not affected significantly by application of 2 per cent of neem seed extract because of predators are not phytophagous like other pests. Neem oil of biological origin (bio-pesticides) have less or no hazardous effects on human health and the environment, therefore, it can be incorporated in IPM programmes and organic farming in vegetable cultivation by Ghosh *et al.* (2013).

CONCLUSION

The T_1- IPM treatment (neem oil @ 0.5 % with yellow sticky traps 1 ft sized wrapped around the palm @ 4 feet height from ground level) was found effective for the management of rugose spiralling whitefly infesting coconut palms when applied at three sprays at 15 days intervals followed three rounds of forcibly water sprays at fortnightly interval which are safety to the natural enemies.

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