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Management of rugose spiraling whitefly (RSW), *Aleurodicus rugioperculetus* Martin with biopesticides on coconut with a note on its natural enemies

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ABSTRACT: Studies on the evaluation of biopesticides *viz., Beauveria bassiana, Isaria fumosorosea* NBAIR *pfu*-5*,Metarhizium anisopliae, Lecanicillium lecanii,* Azadirachtin 10000 ppm, soapnut along with jet water spraywere undertakenat SKPP Horticultural Polytechnic College, Ramachandrapuram and Horticultural Research Station (HRS), Ambajipeta, Andhra Pradesh during 2020-21 and 2021-22 with an objective of examining their impact onthe management of rugose spiraling whitefly (RSW), *Aleurodicus rugioperculetus* Martin in coconut (*Cocos nucifera* L.) palms variety East Coast Tall (ECT).The overall and pooled results during the seasons 2020-21 and 2021-22, revealed that, Azadirachtin 10000 ppm @ 1 ml/l had recorded with lowest number of RSW nymphs per leaflet and *I. fumosorosea* NBAIR pfu-5 @ 5 g/l (T_2) recorded with lowest number of adults, incidence and intensity under high incidence (> 20 spirals per leaflet) of RSW. The natural enemies mainly predators *viz.,* spiderswere documented during the study.

Keywords: Coconut, RSW incidence, bio pesticides, spraying, management, East Coast Tall (ECT)

INTRODUCTION

Coconut palm (*Cocos nucifera*) is often described as "Kalpavriksha" due to its multifarious use and play important role in world coconut export trade (Ahuja *et al.,* 2014). It is cultivated for oil, tender water and raw materials used in the coir industry.India stands first in world coconut trade with 31.46 per cent production. Bulk of coconut production, in India comes from Kerala, Karnataka, Tamil Nadu, Maharashtra followed by Andhra Pradesh sharing 90 per cent of area about 1.15 lakh ha with a production of 1,377.53 m nuts. However, the production and productivity of coconut is often limited by incidence of several pests and diseases (Chowdappa *et al.,* 2018 and Neeraja *et al.,* 2020). Recently, invasive rugose spiraling whitefly (RSW), *Aleurodicus rugioperculetus* Martin (Aleyrodidae: Hemiptera) was reported on coconut palm for the first time during August-September, 2016 at Pollachitaluk, Coimbatore district in Tamil Nadu (Chandrika *et al.,* 2017) and Palakad taluk in Kerala. In Andhra Pradesh, it was first reported at Kadiyapulanka nursery gardens, East Godavari district during late December 2016 (Chalapathi Rao *et al.,* 2018). Very recently, studies of Raghuteja *et al.* (2023) for the first time reported that East Coast Tall (ECT) variety of coconut palms infested with low, medium and high incidence of invasive *A. Rugioperculetus* resulted in nut dropping of 4.06, 22.33 and 28.51% at Ambajipeta, while it was 4.68, 23.49 and 30.58% at Kalavalapalli coconut plantations. It was reported that infestation of RSWreflects nut yield loss up to 6.61% and 22.45% in ECT palms withlow and medium RSW incidence, while comparativelygreater yield loss of 27.59% inECT palms with high incidence respectively (Raghuteja *et al.,* 2023).

The study on incidence of RSW is required to understand the behaviour of the pest and find its peak infestation period, so that the farmers could adopt eco-friendly techniques for managing this insect pest at the farm level. Effective management of RSW is critical in maximizing coconut yield. Over reliance on pesticides and its indiscriminate use over last four decades has resulted in many negative consequences, *viz.,* Resurgence, Resistance and Residual aspects (Raghuteja *et al.,* 2020). Botanical pesticides which are non-toxic to man and also environmentally friendly can be used as alternatives to the synthetic pesticides. Insecticides and neem oil have been found effective against the pest in several countries. In India, tobacco extract, neem oil, pongamia oil, rosin soap and detergent solution in addition to various entomopathogenic fungal isolates are effective (Gundappa *et al.,* 2013; Boopathi *et al.,* 2015; Srinivasan *et al.,* 2017). Hence, keeping in view the

present investigation was designed with an objective of evaluation of various biopesticides against RSW under high incidence (> 20 spirals per leaflet) infesting coconut palms along with documentation of natural enemies.

MATERIALS AND METHODS

The efficacy of different bio-pesticides was evaluated against RSW in East Coast Tall (ECT) variety of 7 years age-old palms with high RSW incidence as per the damage rating scale during 2020-21 and 2021-22 at SKPP Polytechnic college, Ramachandrapuram (16°83'72"NL and 82°03'25" EL) and HRS, Ambajipeta (16°59'38"NL and 81°95'36" EL). Evaluation of bio pesticides was carried out at Ramachandrapuram, horticultural polytechnic college working under the aegis of Dr. YSR Horticultural University as the plantations were found suitable for carrying out the experimentation with the desired pest load during 2020-21. The documentation of different predatory spiders was also carried out in the study.

The numbers of treatments of biopesticides were eight replicated thrice and statistically analysed by simple randomised block design (RBD). The observations on RSW incidence were made at weekly intervals starting from 7 days after imposing the treatments and continued up to 28 days. The data pertaining to number of RSW nymphs and adults wererecorded on four randomly selected pest infested leaflets per leaf per palm from the top, middle and lower whorl representing four directions (total of 4 leaves/palm) was worked out and expressed as mean number of leaflet/leaf/palm (total of 4 leaflets/ leaf) (16 leaflets/palm) at 1 day before spraying (DBS), 7, 14, 21 and 28 days after spraying (DAS). Estimation of RSW incidence and intensity (%) were also calculated using the following formulae

$$\textbf{RSW Incidence (\%)} = \frac{\textit{Number of leaves infested by RSW}}{\textit{Total number of leaves per palm}} \times 100$$

$$\textbf{RSW Intensity (\%)} = \frac{\textit{Number of leaflets infested by RSW}}{\textit{Total number of leaflets per leaf}} \times 100$$

The randomly selected four leaflets/ leaf/ palm for each treatment were marked carefully, sealed in a polythene cover and immediately brought to the laboratory. The data was collected on population of RSW nymphs under Nikon SMZ18 13.5 x stereomicroscope and adults on visual basis.

Statistical Analysis

The statistical analysis of data was done by using OPSTAT software. The data was transformed by arc sine and square root transformations before the data subjecting for analysis. After the analysis the data was tabulated for interpretation of results.

RESULTS AND DISCUSSION

Spraying of bio pesticides *viz., B. bassiana*, *I. Fumosorosea* NBAIR pfu-5**,** *M. anisopliae, L. lecanii*, Azadirachtin 10000 ppm, soapnut powder and Jet water spray were undertaken to evaluate efficacy against RSW infested coconut palms with high (> 20 spirals per leaflet) incidence as per the damage rating scale developed by Srinivasan *et al.,* (2016) during 2020-21 and 2021-22.

The pooled analysis (2020-21 and 2021-22) of data indicated that, significant difference was observed among different treatments of bio pesticides against RSW incidence from 7th day and continued till 28th day. *I. fumosorosea* NBAIR pfu-5 @ 5 g/l (T_2) recorded least incidence with 82.98, 78.37, 76.47 and 71.89 per cent throughout the experimental period and found to be promising followed by Azadirachtin 10,000 ppm @ 1 ml/l (T_5) with 83.80, 78.87, 77.12 and 72.82 per cent followed by soap nut powder @ 3 g/l (T_6) with 85.18, 80.25, 77.62 and 73.79 per cent. The highest incidence of 90.49, 91.71, 93.34 and 95.57 per cent was recorded in control (Table 1).

The pooled analysis (2020-21 and 2021-22) of data showed that, significant difference was observed among different treatments of bio pesticides against RSW intensity from 7th day and continued till 28th day. *I. fumosorosea* NBAIR pfu-5 @ 5 g/l (T_2) recorded least intensity with 88.81, 84.44, 81.79 and 76.83 per cent throughout the experimental period and found to be promising followed by Azadirachtin 10,000 ppm @ 1 ml/l (T_5) with 88.81, 84.44, 81.79 and 76.83 per cent.

The pooled analysis of data (2020-21 and 2021-22) indicated that, significant difference was observed among different treatments against RSW nymphs from 7th day and continued till 28th day after spraying. Treatment (T_5) Azadirachtin 10000 ppm @ 1 ml/l recorded least number (42.63, 37.04, 33.11 and 24.00 nymphs) with 30.18 per cent reduction after spraying, 44.82 per cent reduction over control and proved to be superior over remaining treatments followed by *I. fumosorosea* NBAIR pfu-5 @ 5 g/l (T_2) (43.68, 36.98, 34.51 and 26.89 nymphs) with 27.53 per cent reduction and 42.67 per cent reduction over control followed by soapnut powder treatment (T_6) with 45.90, 39.46, 37.72 and 28.36 nymphs (24.46 per cent reduction and 38.89 per cent reduction over control). The highest population of 50.75, 57.29, 61.32 and 64.31 nymphs per leaflet was recorded in control plots (Table 2).

The pooled analysis of data (2020-21 and 2021-22) indicated that, significant difference was observed among different treatments against RSW adults. *I. fumosorosea* NBAIR pfu-5 @ 5 g/l (T_2) recorded lowest number (36.42, 35.25, 33.59 and 29.11 adults) with 12.55 per cent reduction after spraying, 15.52 per cent reduction over control and proved to be superior followed by Azadirachtin 10,000 ppm @ 1 ml/l (T_5) with 36.46, 35.14, 33.10 and 30.90 adults (11.16 per cent reduction and 16.63 per cent reduction over control) followed by soapnut powder @ 3 g/l with 36.99, 35.72, 35.01 and 33.21 adults (8.28 per cent reduction and 13.35 per cent reduction over control). *L. lecanii*@ 5 g/l (T_4) recorded with 7.77 per cent reduction and 12.74 per cent reduction over control (37.10, 35.91, 34.78 and 34.14 adults).

Table 1. Efficacy of bio pesticides against incidence and intensity of RSW, *A. rugioperculetus* under high incidence palms (>20 spirals per leaflet) (Pooled data of 2 years)

Tr. No.	Treatments	Before Spraying (B.S)		7 Days after Spraying (7 DAS)		14 Days after Spraying (14 DAS)		21 Days after Spraying (21 DAS)		28 Days after Spraying (28 DAS)	
		Incidence (%)	Intensity (%)	Incidence (%)	Intensity (%)	Incidence (%)	Intensity (%)	Incidence (%)	Intensity (%)	Incidence (%)	Intensity (%)
T_1	*B. bassiana*	85.71 (68.01)	91.02 (73.13)	85.12 (67.28)	90.58 (72.09)	82.05 (64.91)	87.37 (69.16)	80.12 (63.49)	85.39 (67.50)	77.98 (61.99)	82.44 (65.19)
T_2	*I. fumosorosea* NBAIR pfu-5	86.42 (69.12)	91.74 (73.26)	82.98 (65.61)	88.81 (70.43)	78.37 (62.26)	84.44 (66.74)	76.47 (60.96)	81.79 (64.71)	71.89 (57.96)	76.83 (61.19)
T_3	*M. anisopliae*	89.00 (70.75)	94.33 (76.61)	87.15 (68.96)	92.42 (73.99)	84.87 (67.08)	90.19 (71.72)	82.97 (65.60)	88.28 (69.97)	81.39 (64.42)	85.38 (67.49)
T_4	*L. lecanii*	87.34 (71.07)	92.05 (73.68)	84.29 (66.62)	89.79 (71.33)	81.07 (64.18)	86.39 (68.32)	78.85 (62.59)	84.17 (66.53)	76.90 (61.26)	82.41 (65.17)
T_5	Azadirachtin 10000 ppm	86.11 (68.24)	91.27 (72.86)	83.80 (66.24)	89.39 (70.96)	78.87 (62.61)	84.14 (66.50)	77.12 (61.39)	82.39 (65.17)	72.82 (58.55)	77.76 (61.83)
T_6	Soapnut powder	88.59 (70.64)	93.91 (76.98)	85.18 (67.33)	90.49 (72.02)	80.25 (63.59)	85.57 (67.45)	77.62 (61.74)	82.94 (65.58)	73.79 (59.18)	79.23 (62.86)
T_7	Jet water spray	89.58 (71.27)	94.90 (77.37)	86.67 (68.56)	91.98 (73.53)	83.97 (66.37)	89.29 (70.87)	81.64 (64.60)	86.96 (68.80)	79.48 (63.04)	84.79 (67.03)
T_8	Control	88.53 (70.29)	93.53 (75.52)	90.49 (72.02)	94.49 (76.40)	91.71 (73.23)	95.71 (78.01)	93.34 (75.01)	97.34 (80.57)	95.57 (77.82)	98.41 (83.15)
	S.E (m)	3.41	2.65	0.004	0.15	0.002	0.08	0.24	0.28	0.15	0.62
	C.D at 5 %	N.S	N.S	0.01	0.46	0.006	0.25	0.73	0.85	0.46	1.89
	C.V	8.43	6.12	0.009	0.21	0.005	0.20	0.64	0.70	0.42	1.60

Table 2. Efficacy of bio pesticides against nymphs of RSW, *A. Rugioperculetus* under high incidence palms (>20 spirals per leaflet) (Pooled results of 2 years)

Tr. No.	Treatments	Before Spraying (B.S)	7 Days after Spraying (7 DAS)	14 Days after Spraying (14 DAS)	21 Days after Spraying (21 DAS)	28 Days after Spraying (28 DAS)	Per cent Reduction	Per cent Reduction over control
T_1	*B. bassiana* commercial	53.22 (7.36)	50.68 (7.19)	43.74 (6.69)	41.56 (6.52)	34.56 (5.96)	19.88	31.18
T_2	*I. fumosorosea* NBAIR pfu-5	49.01 (7.07)	43.68 (6.68)	36.98 (6.16)	34.51 (5.96)	26.89 (5.28)	27.53	42.67
T_3	*M. anisopliae* commercial	51.15 (7.22)	49.67 (7.12)	42.73 (6.61)	41.07 (6.49)	33.53 (5.88)	18.38	32.62
T_4	*L. lecanii* commercial	52.60 (7.32)	48.29 (7.02)	41.49 (6.52)	38.77 (6.31)	32.58 (5.79)	23.42	34.99

T_5	**Azadirachtin 10000 ppm**	**48.97 (7.07)**	**42.63 (6.60)**	**37.04 (6.16)**	**33.11 (5.83)**	**24.00 (4.99)**	30.18	44.82
T_6	Soapnut powder	50.12 (7.15)	45.90 (6.85)	39.46 (6.36)	37.72 (6.22)	28.36 (5.42)	24.46	38.89
T_7	Jet water spray	52.92 (7.34)	49.27 (7.09)	43.17 (6.65)	40.87 (6.47)	33.74 (5.89)	21.09	32.60
T_8	Control (No sprayings)	49.46 (7.10)	50.75 (7.19)	57.29 (7.83)	61.32 (7.89)	64.31 (8.08)	-	-
	S.E (m)	0.09	0.11	0.10	0.11	0.12	-	-
	C.D at 5 %	N.S	0.35	0.31	0.33	0.36	-	-
	C.V	2.25	2.82	2.67	2.86	3.44	-	-

Table 3. Efficacy of bio pesticides against adults of RSW, *A. Rugioperculetus* under high incidence palms (>20 spirals per leaflet) (Pooled Results of 2 years)

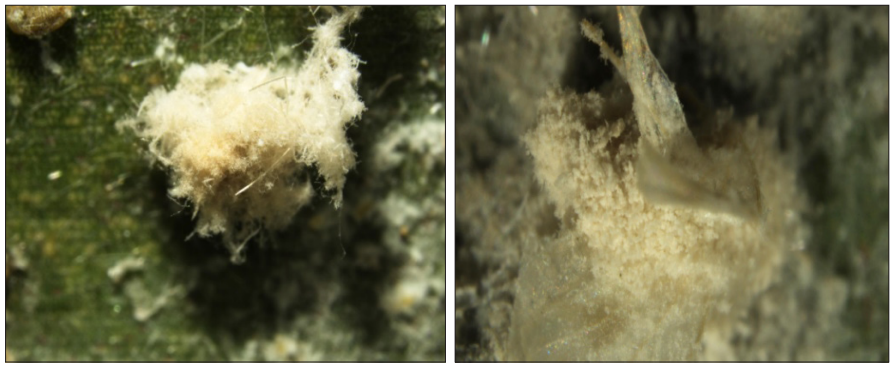
Tr. No.	Treatments	Before Spraying (B.S)	7 Days after Spraying (7 DAS)	14 Days after Spraying (14 DAS)	21 Days after Spraying (21 DAS)	28 Days after Spraying (28 DAS)	Per cent Reduction	Per cent Reduction over control
T_1	*B. bassiana* commercial	38.41 (6.28)	36.99 (6.16)	36.22 (6.10)	35.51 (6.04)	34.71 (5.98)	6.64	11.81
T_2	*I. fumosorosea* NBAIR pfu-5	**39.28 (6.35)**	**36.42 (6.12)**	**35.25 (6.02)**	**33.59 (5.88)**	**29.11 (5.75)**	12.55	15.52
T_3	*M. anisopliae* commercial	39.13 (6.33)	38.44 (6.28)	37.58 (6.21)	37.19 (6.18)	35.82 (6.07)	4.78	8.36
T_4	*L. lecanii* commercial	38.47 (6.28)	37.10 (6.17)	35.91 (6.08)	34.78 (5.98)	34.14 (5.93)	7.77	12.74
T_5	**Azadirachtin 10000 ppm**	38.16 (6.25)	36.46 (6.12)	35.14 (6.01)	33.10 (5.84)	30.90 (5.65)	11.16	16.63
T_6	Soapnut powder	38.41 (6.28)	36.99 (6.16)	35.72 (6.06)	35.01 (6.00)	33.21 (5.85)	8.28	13.35
T_7	Jet water spray	39.35 (6.35)	37.89 (6.24)	37.31 (6.19)	36.65 (6.14)	35.88 (6.07)	6.15	9.17
T_8	Control (No sprayings)	38.20 (6.26)	38.72 (6.30)	40.98 (6.48)	41.15 (6.49)	41.79 (6.54)	-	-
	S.E (m)	0.07	0.03	0.05	0.02	0.03	-	-
	C.D at 5 %	N.S	0.08	0.16	0.06	0.09	-	-
	C.V	1.92	0.74	1.45	0.59	0.88	-	-

*Mean of three replicates; DAS: Days after spraying, Figures in the parenthesis are $\sqrt{x} + 0.5$ transformed values

The findings imply that *I. fumosorosea* was more effective in the field than *B. bassiana*, *M. anisopliae* or *L. lecanii* in controlling the exotic*A. rugioperculetus*. To physically infiltrate the host and suppress its regulatory system, *I. fumosorosea* releases chitinase, chitosanase and lipase (Ali *et al.,* 2010). These results are in line with those of Boopathi *et al.* (2013), Boopathi *et al.* (2015) and Chalapathi Rao *et al.* (2020). *I. fumosorosea* NBAIR Pfu-5 reduced the early nymphal instars of RSW by 52-68 per cent and 35-40 per cent in Godavari Ganga hybrid and Gauthami Ganga variety of coconut, according to Chalapathi Rao *et al.* (2020). Selvaraj *et al.*(2020) identified *I. Fumosorosea* NBAIR Pfu-5 as promising strain and observed overall reduction of 72.20-73.83 per cent and 74.26-75.83 per cent in RSW population in Karnataka and Andhra Pradesh with two sprays at 15 days interval in coconut and oil palm.

Dipcolonic acid, hydroxy carboxylic acid and cyclosporine are released by *L. lecanii* and elevate the pH of the haemolymph, causing clotting and ending the haemolymph's circulation in the insect. Similar findings were obtained against *A. dispersus* by Boopathi *et al.* (2013). Elango and Nelson (2020) discovered that 1 x 10^8 conidia/ml of *L. lecanii* (NBAIR VL-15 strain) caused up to 50 per cent RSW mortality.

The current investigation indicated that Azadirachtin 10,000 ppm was efficient at massacring and preventing the growth of invasive RSW nymphal stages at high incidence. Azadirachtin, a major active element isolated from *Azadirachtaindica* seeds, works as a growth regulator, anti feedant and insect repellant against insects of various genera, including those that feed on plant fluids (Copping and Duke, 2007) by inhibiting the activity of ecdysone-20-monooxygenase in the haemolymph, which converts ecdysone to 20-hydroxyecdysone (active form of moulting hormone). The findings are supported with those of Elango and Nelson (2020), Alagar *et al*. (2021) and Krishnarao and Chalapathi Rao (2019) who found that Azadirachtin 10,000 ppm was effective against RSW nymphs. In the current study, the powdered soapnut, which contains active components such as triterpenoid saponins (I) and sesquiterpene glucoside (II), was found to have stronger larvicidal and pupicidal effects, resulting in the death of all *A. rugioperculetus* developmental stages. Koodalingam *et al.* (2009). Who explained the superiority of soapnut powder against stages of the *A. aegypti* mosquito, confirmed the findings.



***I. fumosorosea* NBAIR, *pfu*-5 infested nymph and adult**

Plate 1. Mycosis of Entomo pathogenic fungi against RSW nymphs and adults

Gasteracantha geminata
Family: Araneidae

***Oxyopes* spp.**
Family: Oxyopidae

***Plexippus* spp.**
Family: Salticidae

***Tetragnatha* spp.**
Family: Tetragnathidae

Carrhotusviduus
Family: Salticidae

Brettuscingulatus
Family: Salticidae

***Peucetia* spp.**
Family: Oxyopidae

***Phintelloides* spp.**
Family: Salticidae

Telamoniadimidiata
Family: Salticidae

Argiopeanasuja
Family: Araneidae

***Gasteracantha* spp.**
Family: Araneidae

Hyllus semicupreus
Family: Salticidae

Plate 2. Documentation of natural enemies (Spiders)

Thus, considering all aspects in the present study azadirachtin 10,000 ppm or *I. Fumosorosea* are recommended but in view of low cost of *I. Fumosorosea* and possibility of natural epizootics during favourable conditions provides us the best option for the management of RSW.

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