Population dynamics of invasive Rugose Spiralling Whitefly, in East Godavari, Andhra Pradesh

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Coconut palm (Cocos nucifera) is often described as "Kalpavriksha" due to its multifarious use and plays an important role in world coconut export trade (Ahuja *et al.*, 2014). The coconut crop is mainly confined to the four southern states of India, accounting for 90% of the area under coconut, among which Andhra Pradesh shares about 1.05 lakhs ha area with a production of 1,689.09 m nuts. India has witnessed invasion of 118 exotic species of insects which includes several economically important whiteflies. A new addition to the list of whitefly species, an invasive Rugose Spiralling Whitefly (RSW), *Aleurodicus rugioperculatus Martin* (Hemiptera: Sternorrhyncha: Aleyrodidae) had entered to India and was reported on coconut palm for the first time during August-September, 2016 at Pollachi taluk, Coimbatore district in Tamil Nadu (Chandrika *et al.* 2017) and Palakkad taluk in Kerala and from Andhra Pradesh it was first reported at Kadiyapulanka nursery gardens during late December 2016 (Chalapathirao et al. 2018). 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. Whereas, in the case of Godavari Ganga hybrid palms nut dropping of 4.84, 27.48 and 35.32 % and 5.50, 28.11 and 36.01% was recorded at HRS, Ambajipeta and Kalavalapalli. The pest has spread across the country particularly in the East Godavari District of Andhra Pradesh famous for coconut plantations. Hence, keeping in view of rapid spread of RSW, field surveys were undertaken to assess its incidence, intensity and infestation levels in hotspot villages of East Godavari District of Andhra Pradesh.

Assessment of population dynamics of RSW and natural enemy count in coconut plantations.

The survey was conducted from January to February 2021 to ascertain incidence, infestation levels and intensity of RSW on coconut in randomly selected 15 and 12 villages of East Godavari districts of A.P and GPS co-ordinates of coconut plantations in each selected villages were also recorded simultaneously so as to prepare pest distribution maps. The data was recorded on per cent palm infestation (%), RSW incidence (%), RSW intensity (%), Infestation Grade Index (I.G.I), RSW life stages population and its natural enemies.

Five sample palms per plantation were selected randomly in each selected village and population assessment (spirals, nymphs, pupae and adults) was made on four randomly selected pest infested leaflets per leaf per palm from top, middle and lower whorl representing four directions (four leaves per palm) and worked out and expressed as mean of leaflet /leaf /palm (80 leaflets per five palms).

Five sample palms per plantation were selected randomly in each selected village. Data was collected on *Encarsia guadeloupae* paralyzed (pupae) and emergence holes, predator *A. astur* adults and naturally established eggs on four randomly selected pest infested leaflets per leaf per palm from the top, middle and lower whorl representing four directions (four leaves per palm) and worked out and expressed as mean of leaflet / leaf / palm (80 leaflets per five palms). The natural enemies viz., spiders, coccinellids and chrysopids if any were also documented in study.

Population of RSW and natural enemy count in coconut varieties viz., Godavari Ganga hybrid and local East Coast Tall (ECT) in East Godavari districts of Andhra Pradesh

The invasive rugose spiralling whitefly (RSW), *A. rugioperculatus Martin*, has expanded across the country, including Gujarat and Assam. In Andhra Pradesh Godavari district is an important coconut growing region and occupy more than 50,000 acres under coconut. Hence, field surveys were conducted in East Godavari districts to ascertain its incidence, intensity and infestation levels, as well as the documentation of natural enemies.

Incidence and intensity of RSW on coconut palms in villages of East Godavari district

In East Godavari District of Andhra Pradesh, the population dynamics of RSW was studied in 15 villages viz., Pulletikurru, Mukkamala, Nedunuru, Vakkalanka, Ambajipeta, Dosakayala Palli, Ramachandrapuram, Samanthakuru, Allavaram, Kadiyapulanka, Kadiam, Podurupaka, Kodurupadu, Veeravaram and Munganda are the important villages for coconut cultivation (Table 1).

S. No.	Name of the village	GPS co-ordinates	Per cent palm infestation (%)	RSW incidence (%)	RSW intensity (%)	Infestation Grade Index
1.	Pulletikurru	16°63'65"NL and 81°94'94"EL	84.21	38.46	54.40	1.6
2.	Muramalla	16°67'41"NL and 82°16'73" EL	72.55	50.00	87.15	1.7
3.	Nedunuru	16°64'24"NL and 81°98'89"EL	92.50	100.00	93.90	2.3
4.	Vakkalanka	16°65'92"NL and 81°95'14"EL	14.56	63.16	70.00	0.8
5.	Ambajipeta	16°59'38"NL and 81°95'36" EL	57.14	87.50	80.43	1.9
6.	Dosakayala Palli	17°12'46"NL and 81°85'39" EL	54.55	58.33	88.57	1.6
7.	Ramachandrapuram	16°83'72"NL and 82°03'25" EL	91.67	92.31	82.51	2.2
8.	Samanthakuru	16°47'51"NL and 82°04'89"EL	30.00	34.33	36.99	0.4
9.	Allavaram	16°50'78"NL and 81°98'89" EL	61.73	34.62	32.77	0.9
10.	Kadiyapulanka	16°89'31"NL and 81°81'42" EL	90.00	85.71	82.51	2.4
11.	Kadiam	16°91'36"NL and 81°81'83" EL	93.83	68.18	84.03	2.7
12.	Podurupaka	17°30'97"NL and 82°24'10" EL	100.00	91.67	96.09	2.5
13.	Kodurupadu	16°53'90"NL and 82°00'12" EL	40.00	38.46	34.88	1.0
14.	Veeravaram	16°87'61"NL and 81°83'06" EL	41.67	37.93	48.49	1.3
15.	Munganda	16°59'80"NL and 81°91'87" EL	50.00	21.28	27.58	1.7
Mean infestation (Mean + S.E)			**64.97+6.87**	**60.13+6.71**	**66.69+6.38**	**1.67+ 0.18 (medium)**

Table 1. Incidence and intensity of RSW on coconut palms in villages of East Godavari district, Andhra Pradesh (2021)

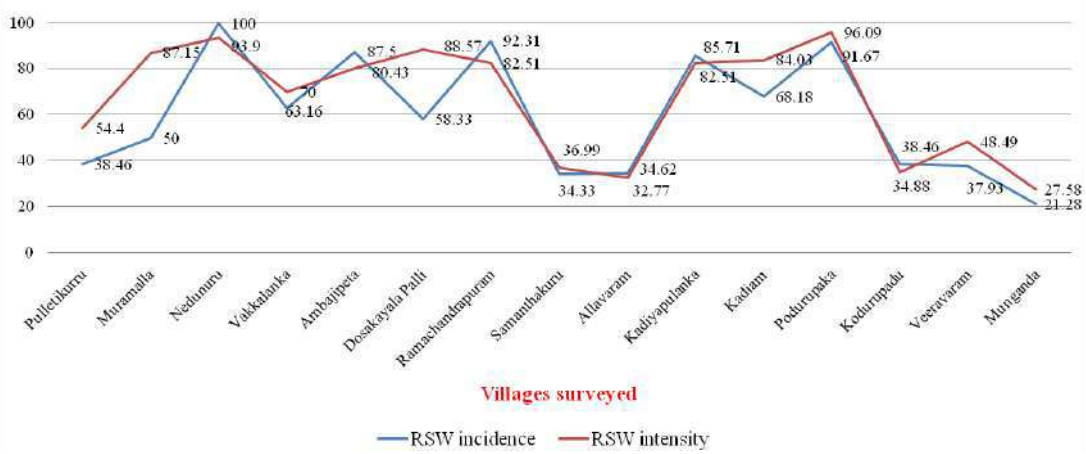

Figure 1. Incidence and intensity of RSW in villages of East Godavari District, Andhra Pradesh.

Per cent palm infestation (%)

The per cent (%) palm infestation was ranged from 14.56 to 100 per cent in which village Podurupaka recorded with highest infestation (100 per cent) followed by Kadiam (93.93 per cent). The mean per cent palm infestation was recorded as 64.97 per cent. The data from the study revealed that the severity of RSW on coconut palms was low to high in East Godavari District of Andhra Pradesh (Table 1). The per cent palm infestation (%) was found to be least in Vakkalanka village (14.56 per cent).

RSW incidence (%)

The incidence (%) of RSW in East Godavari District was in the range of 21.28 to 100 per cent. The mean RSW incidence was recorded as 60.13 per cent (Table 1 and Figure 1). Highest incidence was recorded in Nedunuru village (100 per cent) followed by Ramachandrapuram (92.31 per cent), whereas least incidence was recorded in Munganda village (21.28 per cent) (Plate 1).

RSW intensity (%)

The intensity (%) of RSW in East Godavari District was in the range of 26.58 to 96.09 per cent. Finally, the mean intensity calculated was 66.69 per cent (Table 1 and Figure 1). Highest intensity was recorded in Podurupaka village (96.09 per cent) followed by Nedunuru (93.90 per cent), while least intensity was recorded in Munganda village (27.58 per cent) (Plate 1).

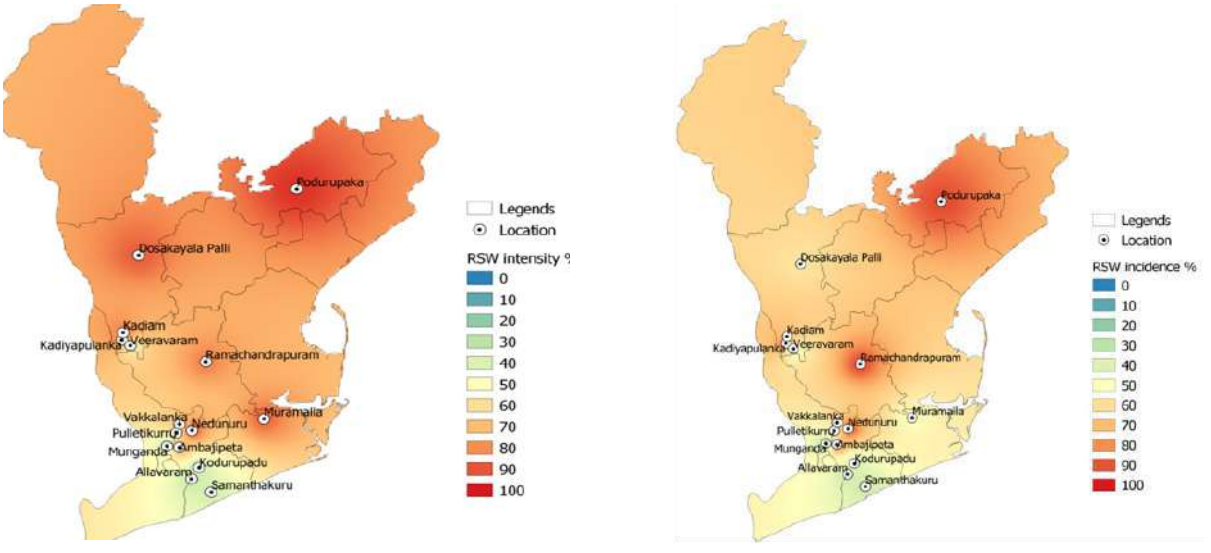

Plate 1. RSW pest distribution map in East Godavari district of A.P.

S. No.	Name of the village	RSW spirals	Nymphs	Pupae	Adults	E. guadeloupae paralyzed pupae	E. guadeloupae emergence holes	Predator A. astur	A. astur eggs	Other natural enemies observed
1.	Pulletikurru	4.56	5.53	8.50	7.34	1.55	0.25	0.20	0	Spiders
2.	Muramalla	3.23	4.27	5.67	5.15	1.68	0.55	0.40	0.22	Coccinellids
3.	Nedunuru	8.56	17.25	7.65	8.35	1.45	0.23	0	0	-
4.	Vakkalanka	7.55	11.26	8.35	9.15	0.55	0	0.35	0	Spiders and Coccinellids
5.	Ambajipeta	9.50	22.50	4.50	8.25	1.95	1.00	0.13	0	Spiders and Coccinellids
6.	Dosakayala Palli	11.25	28.65	9.00	7.74	1.90	0.95	0.45	0.20	Spiders and Coccinellids
7.	Ramachandrapuram	9.35	20.50	7.23	7.78	1.86	1.41	0.28	0.08	Spiders and Coccinellids
8.	Samanthakuru	1.89	1.88	1.86	1.55	0.23	0	0.01	0	Spiders, chrysopids
9.	Allavaram	1.69	1.91	1.15	1.66	0.21	0	0	0	Chrysopids
10.	Kadiyapulanka	8.91	21.25	10.31	8.38	1.63	0.49	0.43	0.29	Spiders
11.	Kadiam	13.63	27.26	7.96	26.14	2.21	0.71	0.38	0.55	-
12.	Podurupaka	11.50	24.65	9.50	8.68	1.85	1.23	0.25	0.10	-
13.	Kodurupadu	0.74	1.26	0.73	1.15	0.10	0	0	0	-
14.	Veeravaram	1.13	1.68	1.15	2.20	0.16	0	0.01	0	Spiders
15.	Munganda	0.40	0.95	0.66	1.10	0.10	0	0	0	Chrysopids
Mean Population (Mean + S.E)		**6.26 + 1.16**	**12.72 + 2.77**	**5.61 +0.93**	**6.97 + 1.59**	**1.16 + 0.21**	**0.45 + 0.13**	**0.17 + 0.05**	**0.08 + 0.04**	

Table 2. Population count of RSW life stages and natural enemies (per leaflet) on coconut palms in villages of East Godavari District of Andhra Pradesh.

Infestation Grade Index (I.G.I)

The Infestation Grade Index (I.G.I) was highest in Kadiam (2.7) followed by Podurupaka (2.5) village, whereas it was least in Samanthakuru (0.4) village. The mean I.G.I of RSW in East Godavari district was observed to be 1.67 (medium) with a range of 0.4 (low) to 2.7 (high) (Table 1).

RSW life stages

The data from the study revealed that the mean population of RSW life stages per leaflet in different villages of East Godavari district were recorded as 6.26 spirals, 12.72 nymphs, 5.61 pupae and 6.57 adults per leaflet. Furthermore, 1.16 of mean *Encarsia guadeloupae* paralyzed pupae, 0.45 *E. guadeloupae* emergence holes, 0.17 A. astur and 0.08 *A. astur* eggs were also recorded in E. Godavari district. More number of RSW life stages were recorded in Dosakayala Palli village (11.25 spirals, 28.65 nymphs, 9.00 pupae and 7.74 adults) (Table 2). The predatory spiders (Table 2), coccinellids such as Coccinella septumpunctata and Chrysopid, *A. astur* were also documented in RSW infested coconut plantations.

The per cent palm infestation, RSW incidence and intensity (%) were recorded to be high in Podurupaka village which could be attributed to aqua culture based coconut ecosystem with more emphasis on aquaculture resulting in stressed palm conditions coupled with non- adoption of IPM for RSW. The dwarf Gauthami Ganga variety and Godavari Ganga hybrid are the major plantations observed in Nedunuru village of coconut which being highly attractive to RSW resulted in recording of high RSW incidence and intensity. The dwarf coconut palms are more prone to heavy RSW infestation compared to tall palms (Sundaraj and Selvaraj, 2017; Chandrika *et al.* 2017 and Fousiya *et al.* 2019). Selvaraj *et al.* (2016) observed that invasive RSW prefers to colonize on hybrid and dwarf varieties viz., Chowghat orange dwarf (COD), Malaysian orange dwarf (MOD) and Gauthami Ganga in Tamil Nadu.

In Kadiam and Kadiyapulanka, places with highest incidence and intensity were recorded. Kadiam nurseries are famous nursery hubs for planting material of mango, sapota, banana, guava, citrus, ornamental plants (hibiscus, gerbera, gladiolus, jatropha, heliconia and chrysanthemum) and avenue trees (Akasha malli, areca palm, butterfly tree, false rubber, karanj and *Lagerstroemia speciosa*) all of which were documented as alternate hosts to RSW

From the survey it was found that the studies on population dynamics were conducted in villages of East Godavari districts of Andhra Pradesh (A.P) along with documentation of potential natural enemies. In East Godavari district of AP, mean per cent palm infestation was recorded as 64.97 per cent. The mean incidence and intensity of RSW were recorded as 60.13 and 66.69 per cent. The mean population of RSW life stages per leaflet in different villages of East Godavari district were recorded as 6.26 spirals, 12.72 nymphs, 5.61 pupae and 6.57 adults per leaflet. Furthermore, 1.16 of mean *Encarsia guadeloupae* paralyzed pupae, 0.45 *E. guadeloupae* emergence holes, 0.17 *Apertochrysa astur* and 0.08 A. astur eggs were also recorded in East Godavari district. As a result of population dynamics studies, medium to high incidence of RSW was recorded in East Godavari districts of Andhra Pradesh.

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