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Population dynamics of rugose spiralling whitefly, *Aleurodicus rugioperculatus* (Martin) on coconut

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Abstract
An experiment entitled 'Population dynamics of rugose spiralling whitefly, *Aleurodicus rugioperculatus* (Martin) on coconut' were conducted on the coconut orchard at Nursery No. 4, Department of Horticulture, College of Horticulture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli during the period of one year starting from December 2018 to December 2019. The population of rugose spiralling whitefly (RSW) recorded throughout the year on coconut palm but the density of total population varied from 4.24 to 102.87 adults per frond per palm in different SMW. The observations on the pest population were started from 50th SMW (10th Dec. to 16th Dec.) which recorded 34.31 RSW per frond per palm which reached its peak *i.e.*, 102.87 RSW per frond per palm during 15th SMW (9th April. to 15th April) and remained more or less stable till 21st SMW (21st May to 27th May). Correlation of pest incidence and weather parameters revealed that the population of RSW had a positively highly significant correlation with maximum temperature, bright sunshine hours and evaporation and recorded as r = 0.574**, 0.473** and 0.708**, respectively. In the multiple regression study, R^2 value indicated that weather parameters contributed to 56.0 per cent of the total variation in the population of RSW on coconut.

Keywords: Population dynamics, RSW, coconut, weather parameters, correlation, regression

Introduction
Coconut (*Cocos nucifera* L.) is eulogized as the 'Kalpavriksha', the 'Tree of life', due to its multifarious utilization as food, fuel, medicine, timber, and other utility purposes of different parts from root to leaves, from tender nut water to outer husk, etc. offers scope for sustaining the livelihood of growers, farm communities and industries in major coconut growing countries of the world. India occupies the premier position in the world, overtaking Indonesia and the Philippines, the other two prominent coconut-growing countries (Raghavi *et al*., 2019) [9]. Coconut is one of the major plantation crops in India with a total cultivated area of 2082.11 thousand hectares with a production of 23904.10 million nuts. Maharashtra occupies the 7th place in area and the 9th in production with the annual production of 209.87 million nuts over a period of 33 years from 1986-87 to 2018-2019, the area under coconut has increase from 6900 ha to 43320 ha and production from 76.32 million nuts to 209.87 million nuts (Shinde *et al*., 2020) [12]. The total area under coconut in the Konkan region is about 25035 hectares with a production of 1597.73 lakh nuts (Anonymous, 2016). In August-September, 2016, one invasive rugose spiralling whitefly (RSW), *Aleurodicus rugioperculatus* Martin (Aleyrodidae: Hemiptera) found heavily infesting coconut palm (*Cocos nucifera* L.) for the first time from India (Sundararaj and Selvaraj, 2017) [13]. Severe damage was noticed in the coastal areas of Mangalore and Udupi and the infestation ranged from 20-35 percent in coconut (Selvaraj *et al*., 2017) [11]. Hence, the investigation was undertaken to study the population dynamics of RSW on coconut and their correlation and regression with weather parameters.

Material and Methods
The experiment was carried out on the coconut orchard at the Department of Horticulture, College of Horticulture, Dapoli. The coconut variety was Orange Dwarf and the age of orchard was 6 years. Four palms were selected and used to study the population dynamic. The care had been taken to keep the orchard away from any insecticidal application. The observation of RSW on coconut was recorded at weekly intervals for the period of one year starting from December 2018 to December 2019. Four palms were selected for taking observations. Four fronds in four directions were selected from each palm. Two leaflets from top, middle and bottom regions from each frond were tagged for taking observations and the number of only

adults were counted using magnifier (15x) at weekly interval. The data on weather parameters *viz*., maximum temperature, minimum temperature, relative humidity, wind speed, rainfall, rainy days, bright sunshine and evapo-transpiration were collected from the meteorological observatory of the College of Agriculture, Dapoli. The data on the adult population were averaged. The correlation and regression were worked out between weather parameters and adult population as per Panse and Sukhatme (1967) [8] by using WASP software.

Results and Discussion

The observations on the RSW population were recorded at the weekly interval and summarized data are presented in Table 1 and depicted in Fig. 1.

The data on the population of rugose spiralling whitefly revealed that the infestation of RSW was observed on coconut throughout the year with the density of total population varied from 4.24 to 102.87 adults per frond per palm in different SMW during the present study. The observations on the pest population were started from 50th SMW (10th Dec. to 16th Dec.) which recorded 34.31 RSW per frond per palm which reached its peak *i.e.*, 102.87 RSW per frond per palm during 15th SMW (9th April. to 15th April) and remained more or less stable till 21st SMW (21st May to 27th May). Then suddenly dropped up to 7.40 RSW per frond per palm in 35th SMW. Further declined suddenly and remained at a low level (less than 9 RSW per frond per palm) from 37th SMW to 43rd SMW. Again sudden rise in the population was noticed from 44th SMW (29th Oct. to 04th Nov.).

Investigation on population dynamics of RSW indicated that the population of RSW was relatively low *i.e.*, 4.24 RSW per frond per palm during 40th SMW approximately corresponding to the first week of September, 2019 and maximum *i.e.*, 102.87 RSW per frond per palm during 15th SMW approximately corresponding to the second week of April, 2019. The overall seasonal population fluctuation indicated that the population of RSW is high during *Summer*, low in the *Rainy* season and moderate during post *Rainy* season.

The results of present findings are discussed here with earlier research workers. Ranjith *et al.* (1996) [10] reported a drastic increase in spiralling whitefly population in *Summer* and a decrease after showers in Kerala. Muralikrishna (1999) [7] reported that the population of spiralling whitefly was higher (164.2 to 218.6 per leaf) from March to June and low (11.7 to 21.9 per leaf) from October to January. Morde (2014) [6] reported the incidence of spiralling whitefly throughout the year except for the 44th meteorological week on guava. He reported the peak period from first week of March to last week of May. Elango and Nelson (2020a) [3] reported that the infestation of RSW was low during the Rainy season, moderate during post rainy season and high in *Summer*.

Table 1: Population dynamics of rugose spiralling whitefly, *A. rugioperculatus* on coconut in relation to weather parameters

SMW	Period	Mean Population of RSW/ Frond/ Palm	Tmax (^{0}C)	Tmin (^{0}C)	RH-I (%)	RH-II (%)	Wind speed (Kmph)	Rain (mm)	Rainy days	BSS (hrs.)	Epan (mm)
50	10.12.18 to 16.12.18	34.31	31.4	13.2	84	63	1.8	0.0	0	6.7	3.8
51	17. 12.18 to 23.12.18	46.80	26.6	12.0	88	65	1.2	0.0	0	7.0	3.9
52	24.12.18 to 31.12.19	31.60	31.8	11.9	88	66	0.8	0.0	0	8.5	4.5
1	01.01.19 to 07.01.19	34.61	32.6	10.1	90	61	0.2	0.0	0	8.8	4.3
2	08.01.11 to 14.01.19	44.50	32.0	10.6	86	60	1.4	0.0	0	8.5	4.1
3	15.01.19 to 21.01.19	36.41	33.8	13.4	89	58	2.2	0.0	0	8.0	4.0
4	22.01.19 to 28.01.19	27.89	29.2	11.5	89	59	3.0	0.0	0	8.4	3.8
5	29.01.19 to 04.02.19	46.96	31.4	13.3	90	61	3.8	0.0	0	8.2	4.3
6	05.02.19 to 11.02.19	32.68	30.5	10.8	88	62	4.5	0.0	0	8.8	4.8
7	12.02.19 to 18.02.19	23.00	32.1	12.8	88	62	3.8	0.0	0	9.1	5.4
8	19.02.19 to 25.02.19	28.24	32.6	14.9	89	60	3.8	0.0	0	8.5	5.9
9	26.02.19 to 04.03.19	26.80	31.2	12.7	90	65	4.6	0.0	0	8.8	6.1
10	05.03.19 to 11.03.19	18.49	31.0	14.0	90	64	4.7	0.0	0	7.0	5.8
11	12.03.19 to 18.03.19	35.80	32.4	14.5	85	56	4.8	0.0	0	7.6	5.7
12	19.03.19 to 25.03.19	45.55	33.0	14.6	89	52	4.4	0.0	0	7.6	6.4
13	26.03.19 to 01.04.19	76.81	34.6	20.5	88	64	4.7	0.0	0	7.3	6.3
14	02.04.19 to 08.04.19	89.90	33.2	20.1	89	53	5.0	0.0	0	7.2	6.6
15	09.04.19to 15.04.19	102.87	33.7	21.7	90	52	5.7	0.0	0	7.2	6.9
16	16.04.19 to 22. 04.19	69.53	33.6	19.6	90	56	5.7	0.0	0	8.4	6.8
17	23.04.19 to 29.04.19	76.81	34.9	23.4	85	65	6.0	0.0	0	7.9	6.4
18	30.04.19 to 06.05.19	78.80	33.0	21.1	85	60	5.2	0.0	0	8.0	6.7
19	07.05.19 to 13.05.19	100.20	33.5	22.5	82	60	6.2	0.0	0	8.8	6.7
20	14.05.19 to 20.05.19	92.00	33.7	21.1	81	55	6.9	0.0	0	9.3	6.8
21	21.05.19 to 27.05.19	56.65	33.9	23.7	83	56	6.5	0.0	0	9.0	6.9
22	28.05.19 to 03.06.19	20.41	34.0	23.9	81	57	6.2	0.0	0	8.6	7.2
23	04.06.19 to 10.06.19	10.10	34.5	25.9	86	61	6.4	10.0	1	6.7	6.8
24	11.06.19 to 17.06.19	16.96	32.6	25.1	91	81	11.1	110.4	5	6.4	4.0
25	18.06.19 to 24.06.19	22.66	31.1	24.2	94	84	4.7	162.3	5	5.1	3.3
26	25.06.19 to 01.07.19	19.18	28.7	24.2	95	91	6.2	455.2	6	1.9	1.8
27	02.07.19 to 08.07.19	8.79	29.1	24.2	95	89	9.3	294.2	7	1.5	2.5
28	09.07.19 to 15.07.19	14.88	29.1	23.9	98	92	9.6	399.4	7	2.9	1.1
29	16.07.19 to 22.07.19	13.53	29.6	24.1	94	86	2.7	118.2	6	5.2	4.4
30	23.07.19 to 29.07.19	12.54	27.6	23.6	98	96	4.5	759.6	7	1.3	2.5
31	30.07.19 to 05.08.19	8.13	26.9	23.5	98	96	10.7	719.2	7	0.1	3.3
32	06.08.19 to 12.08.19	13.41	27.2	24.6	96	93	9.4	353.8	7	0.1	2.8
33	13.08.19 to 19.08.19	12.39	29.1	24.3	95	86	1.8	112.6	7	3.5	3.4

34	20.08.19 to 26.08.19	11.19	29.1	20.9	95	83	2.6	103.6	6	7.2	3.3
35	27.08.19 to 02.09.19	7.40	28.4	23.7	97	87	3.3	318.4	6	4.3	3.2
36	03.09.19 to 09.09.19	11.41	26.5	23.1	99	96	5.8	771.6	7	0.0	2.0
37	10.09.19 to 16.09.19	8.69	28.3	23.8	97	90	3.4	167.2	7	2.8	3.1
38	17.09.19 to 23.09.19	7.54	29.1	24.1	95	86	2.9	53.4	6	4.5	2.9
39	24.09.19 to 30.09.19	4.40	29.7	23.4	93	85	2.1	55.0	3	5.4	3.8
40	01.10.19 to 07.10.19	4.24	30.7	22.7	92	75	1.6	0.2	0	8.9	4.0
41	08.10.19 to 14.10.19	6.04	31.7	19.8	94	71	1.3	29.8	2	7.6	3.7
42	15.10.19 to 21.10.19	4.65	31.7	23.0	89	73	0.5	63.4	3	4.7	2.9
43	22.10.19 - 28.10.19	5.68	28.8	21.9	94	79	1.9	61.2	5	2.6	2.1
44	29.10.19 to 04.11.19	16.49	31.9	22.0	90	67	2.3	2.6	1	8.3	3.8
45	05.11.19 to 11.11.19	18.66	31.0	21.5	94	71	2.5	9.6	1	8.4	3.6
46	12.11.19 to 18.11.19	20.25	33.3	20.6	89	55	2.3	0.0	0	7.8	3.3
47	19.11.19 - 25.11.19	27.79	33.0	19.1	93	55	2.1	0.0	0	7.2	3.5
48	26.11.19 to 02.12.19	16.49	33.3	18.9	90.9	51.4	2.2	0.0	0	7.6	3.8
49	03.12.19 to 09.12.19	18.66	31.4	20.1	91	57	2.7	0.0	0	6.1	3.2

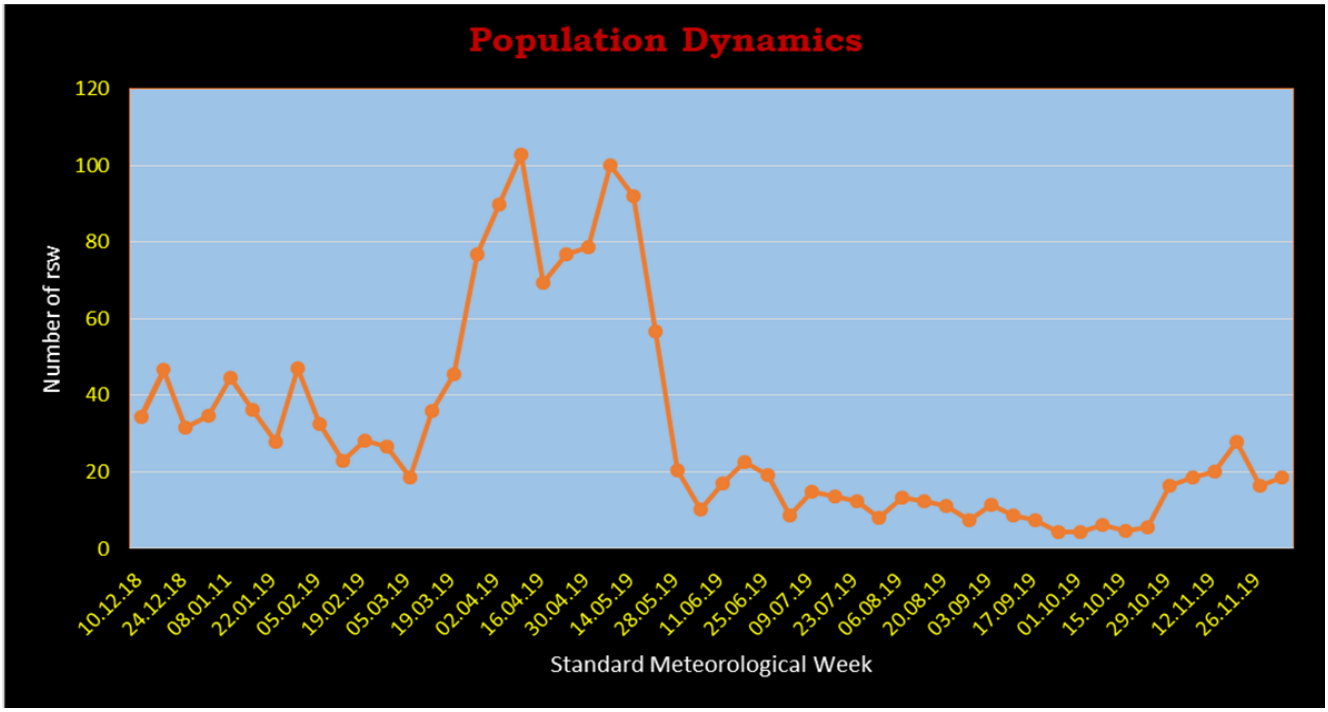

Fig 1: Population dynamics of rugose spiralling whitefly, *Aleurodicus rugioperculatus* (Martin) on coconut in relation to weather parameters

Correlation between weather parameters and RSW on coconut

The data on the correlation between weather parameters and RSW population from December 2018 to December 2019 are presented in Table 2.

Table 2: Correlation between weather parameters and adult population of rugose spiralling whitefly on coconut

Weather parameters		Correlation coefficients (r)
Temperature	Maximum Temp. (°C)	0.574**
	Minimum Temp. (°C)	-0.182
Relative Humidity	RH morning (%)	-0.611**
	RH afternoon (%)	-0.595**
Wind speed (km/hours)		-0.164
Rainfall (mm)		-0.362**
Rainy days		-0.548**
Bright sunshine		0.473**
Epan (mm)		0.708**

N=52

** Correlation is significant at the 0.01 level 'r' value = 0.354

* Correlation is significant at the 0.05 level 'r' value = 0.273

The correlation study indicated that the population of RSW had a positively highly significant correlation with maximum temperature, bright sunshine hours and evaporation and recorded as r = 0.574**, 0.473** and 0.708**, respectively. The negatively highly non-significant correlation was recorded between RSW and morning relative humidity, afternoon relative humidity, rainfall and rainy days and recorded as r = -0.611**, -0.595**, -0.362** and -0.548**, respectively. While, the minimum temperature and wind speed had a negatively non-significant correlation with the RSW population and recorded as r = -0.182 and -0.164, respectively.

Multiple linear regression between weather parameters and RSW on coconut

The multiple regression was worked out between weather parameters and RSW population and regression coefficient (b) and intercept (a) are presented in Table 3.

The regression equation worked out is as follows.

Y = 137.875 - 0.039 (X1) + 0.053 (X2) - 0.995 (X3) - 0.858 (X4) + 0.943 (X5) + 0.025(X6) + 0.662 (X7) – 0.847 (X8) + 7.890 (X9)

The coefficient of determination (R^2) represents the proportion of common variation in the two variables. The investigation revealed that the weather parameters contributed to 56.0 per cent of the total variation in the population of RSW on coconut.

Table 3: Multiple linear regression between weather parameters and adult population of RSW on coconut

Sr. No	Parameters	Regression Coefficient (b)	S.E. (b)	't' Value
(X_1)	Temp. Max	- 0.039	2.787	- 0.014
(X_2)	Temp. Min.	0.053	0.946	0.056
(X_3)	RH-I	-0.925	1.170	-0.791
(X_4)	RH-II	-0.858	0.701	-1.224
(X_5)	WS	0.943	1.532	0.615
(X_6)	Rain	0.025	0.030	0.841
(X_7)	RD	0.662	3.646	0.182
(X_8)	BSS	-0.847	2.931	-0.289
(X_9)	EVP	7.890	3.218	2.452
Intercept (a) = 137.875, N=52, F value= 6.02, R^2 = 0.56				

The present findings are in close agreement with the earlier research work of Mani (2010) [5] recorded that the density of the whitefly was positively correlated with maximum temperature and negatively correlated with relative humidity. Chandrika Mohan *et al.* (2017) [2] reported that a shift in weather pattern reflected as deficit monsoon as one of the primary reasons for immediate upsurge of RSW. Mane (2019) [4] reported that the RSW showed positive correlation with maximum temperature, bright sunshine hours and evaporation. Elango and Nelson (2020a) [3] reported that RSW showed a significant positive correlation with maximum temperature.

Conclusion

The overall results of the present study revealed that, the weather parameters play an important role in the incidence of RSW on coconut. The population of RSW present throughout the year on the coconut palm and start increasing as the temperature start increasing and again the population start decreasing during rainy season in Konkan region. The population of RSW had a positively highly significant correlation with maximum temperature, bright sunshine hours and evaporation. As population of RSW reaches its peak during warmer and humid climatic condition the appropriate control measures should be undertaken during this period *i.e.* during summer season.

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