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Seasonal incidence of papaya mealybug, *Paracoccus marginatus* Williams and Granara de Willink and its natural enemies with weather parameters

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Abstract

Seasonal incidence of papaya mealybug, *Paracoccus marginatus* Williams and Granara de Willink was studied during 2013-2014 in relation to weather parameters. It was observed that the insect was prevalent throughout the year. The peak activity of papaya mealybug was observed from 13th to 18th meteorological week. The maximum population was recorded (105.8 mealybugs/5 cm²/leaf/plant) in the 18th meteorological week. The mealybug incidence was positively correlated with maximum temperature and sunshine hours. Whereas, it was negatively correlated with minimum temperature, rainfall and relative humidity. In case of natural enemies of papaya mealybug it was observed that the highest population of *Acerophagus papayae*, *Pseudleptomastix maxicana*, *Aprostocetus* nr. *purpureus* and coccinellids were recorded (12.2, 7.4, 6.2 and 6.4 adults/leaf/ plant) in the 18th, 15th, 9th and 11th meteorological week, respectively. Further it was also noticed that natural enemies population was density dependent and positively correlated with maximum temperature and sunshine hours. Whereas, it was negatively correlated with minimum temperature, rainfall, morning and afternoon relative humidity.

Keywords: Seasonal incidence, Papaya mealybug (*Paracoccus marginatus*), *Acerophagus papayae*, *Pseudleptomastix maxicana*, *Aprostocetus* nr. *purpureus* and coccinellids

Introduction

The papaya (*Carica papaya* L.) is originated from southern Mexico. India is the largest producer of papaya, contributing 43.7 per cent of total world production. In India around 1,26,000 ha of area is under cultivation with the 55,08,000 tonne fruit production (Anonymous, 2016). The fruit is known for its nutritional, digestive and medicinal properties. In addition, the immature papaya fruit contains a milky latex containing papain. It has several uses in the industry viz., food processing, tanning and textile.

The first infestation of papaya mealybug was detected on July 10, 2008 in the campus orchard of Tamil Nadu Agricultural University (TNAU) by Muniappan and his team, during IPM CRSP project network visit. This was the first report of the papaya mealybug in India and South Asia (Muniappan *et al.*, 2008) [12]. Soon after the introduction of papaya mealybug into Tamil Nadu, the incidence of papaya mealybug in Maharashtra was first reported from Pune district in June, 2010 (Nakat *et al.*, 2012) [10]. The infestation of mealybug appears as clusters of cotton like mass on the above ground portion of plants with long waxy filaments. Immature and adult stages of *P. marginatus* suck the sap of the plant and weaken it. The leaves become crinkled, yellowish and wither. The honeydew excreted by the bug and the associated black sooty mould formation impairs photosynthetic efficiency of the affected plant. In India, the insect assumed the status of major pest in 2009-10 when it caused severe damage to economically important crops.

All the living organisms are influenced by the environmental factors because they have direct impact on the biology. For effective pest management strategy, it is necessary to know the proper ecological requirement of a pest species. Weather factors like temperature, relative humidity and rainfall plays a vital role in multiplication and distribution of insect pests. Seasonal abundance of phytophagous pests is influenced by these factors. Rainfall, temperature and relative humidity directly and indirectly influence seasonal abundance of pest by exerting negative or positive impact on numbers and suitability of host plants. To develop any pest management programme for a specific agro-ecosystem complete knowledge on abundance and distribution of pest in relation to weather factors is a basic requirement.

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Materials and Methods

In order to study the seasonal incidence of papaya mealybug and their natural enemies on papaya, var. Taiwan-786 (Red Lady) seedlings were transplanted within bed on the well cultivated soil in August, 2013. The observations were recorded at weekly interval for the period of one year from September, 2013 to August, 2014. Observations on number of live mealy bugs per 5 cm² leaf area from each tagged leaf were taken. The average number of mealy bugs per 5 cm² leaf areas was worked out (Shylesha *et al.*, 2010) [10]. In case of natural enemies, complete leaf was considered for counting the adult stage of predator and parasitoid (Arve *et al.*, 2011) [4]. In case of seasonal incidence study, data related to the abiotic factors (meteorological parameters) *i.e.*, temperature (maximum and minimum), relative humidity (morning and evening), sunshine hours and rainfall was made available from Agrometeorology of All India Co-ordinated Research Project on Irrigation and Water Management, MPKV, Rahuri for statistical analysis. Average number of mealybug and its major natural enemies recorded at weekly interval were worked out and correlated with weather parameters.

Results and Discussion

Seasonal incidence of papaya mealybug

The seasonal incidence of papaya mealybug over a year indicated that the incidence of mealybug were recorded from 47th meteorological week (2.2 mealybugs/5 cm²/leaf/plant) and increased up to 9th standard meteorological week *i.e.* 97.4 mealybugs/5 cm²/leaf/plant thereafter it declined up to 12th standard meteorological week with a population of 20.4 mealybugs/ 5 cm²/leaf/plant, then increased population and recorded to the peak of 105.8 mealybugs/ 5 cm²/leaf/plant in the 18th meteorological week and then gradually declined upto 35th meteorological week *i.e.* 0.4 mealybugs/5 cm²/leaf/plant.

Seasonal incidence of natural enemies of papaya mealybug

The seasonal incidence of different natural enemies of papaya mealybug *i.e.* *A. papayae*, *P. maxicana*, *A. nr. purpureus* and coccinellids were started after the incidence of mealybug, from 51st, 6th, 50th and 6th meteorological week upto 23rd, 29th, 24th and 20th meteorological week, respectively. However, peak incidence of *A. papayae*, *P. maxicana*, *A. nr. purpureus* and coccinellids with 12.2, 7.4, 6.2 and 6.4 adults/leaf/plant population in the 18th, 15th, 9th and 11th meteorological week, respectively were recorded which was found to be density dependent. Thereafter, gradual decline in the population of natural enemies *i.e.* *A. papayae*, *P. maxicana*, *A. nr. purpureus* and coccinellids on 23rd, 29th, 24th and 20th meteorological week, respectively was noticed.

Correlation of mealybugs and its natural enemy's population with weather parameters

Weather parameters played a significant role in the development of mealybug population on papaya. The correlations were worked out between mealybug and natural enemy's population and weather parameters that existed during the weekly observations during the study and presented in Table 2.

Correlation of mealybug population with weather parameters

Mealybug incidence correlated significantly positive with maximum temperature ($r=0.538$) and sunshine hours ($r=0.532$). Whereas, it was correlated non-significantly negative with minimum temperature ($r=-0.017$) and rainfall

($r=-0.178$). They also correlated negatively and significantly with morning relative humidity ($r= -0.581$) was found with evening relative humidity ($r=-0.679$) during week of observation.

Correlation of natural enemies of population with weather parameters

The data on correlation of natural enemies population with weather parameter (Table 2) showed that occurrence of parasitoid, *A. papayae* correlated significantly positive with maximum temperature during the week of observation ($r=0.502$). Whereas, it showed non-significantly negative correlation with minimum temperature ($r=-0.015$). Morning and evening relative humidity showed significantly negative correlation during the week of observation with ($r=-0.561$) and ($r=-0.622$), respectively. The natural enemy *A. papayae* correlated significantly positive with bright sunshine hours ($r=0.444$). Its incidence was non-significantly negative correlated with the rainfall received during the week of observation with $r=-0.210$. The population of *A. papayae* was density dependent of the host insect *i.e.*, papaya mealybug. Correlation of population of natural enemy parasitoid *P. maxicana* to weather parameter showed the significantly positive correlated to maximum temperature during the week of observation ($r=0.434$). Whereas, non-significantly negative correlation were recorded with minimum temperature ($r=-0.028$) and rainfall ($r=-0.111$). In case of morning and evening relative humidity significantly negative correlation was noticed during the weekly observation ($r=-0.641$) and ($r=-0.522$). They also found highly significant correlation with bright sunshine hours ($r=0.326$) during the weekly observation.

Population of another natural enemy *i.e.* parasitoid *A. nr. purpureus* highly significant positive correlation with maximum temperature ($r=0.281$) during the week of observation. Whereas, it correlated highly significant negative with minimum temperature ($r=-0.327$) during the week of observation. The rainfall ($r=-0.251$) showed the negative correlation during week of observation. They also correlated significantly negative with morning and evening relative humidity during the week of observation with ($r=-0.671$) and ($r=-0.700$), respectively. *A. nr. purpureus* incidence correlated significantly positive with bright sunshine hours ($r=0.583$) during the week observation.

The predatory coccinellids incidence correlated highly significant positive with maximum temperature ($r=0.280$) and sunshine hours ($r=0.316$) during the week of observation. Whereas, it correlated non-significantly negative with minimum temperature and rainfall ($r=-0.128$) and ($r=-0.112$). They also correlated significantly negative with morning and evening relative humidity during the week of observation with $r=-0.595$ and $r=-0.453$, respectively.

Manjunath (1985) [11] found that mealybugs were present throughout the year with peak incidence during February-March and to a lesser extent during October-November. Similarly, Mani (1989) [9] also reported that, the population of the mealybug was found to be heavy from January to May and low from June to December in vineyards of South India and in general, the activity of the natural enemies coincided with that of the mealy bugs. In the grape vine gardens situated at Arvi Pimpalgaon of Pune district (Maharashtra), the mealybug population was maximum from middle of February to May and middle of September to middle of November (Anonymous, 1992) [1]. In pomegranate, a significant and positive correlation with maximum temperature, minimum

temperature and significant negative correlation with morning relative humidity was reported for mealybugs (Anonymous, 1995).

According to Koli (2003) [8] the egg sacs, nymphs and adults of mealybugs on grapes showed highly significant positive correlation with maximum and minimum temperature and highly significant negative correlation with morning and evening relative humidity and non-significant negative correlation with rainfall. The present findings were similar to Katke (2008) [7] who reported that grape mealybug was observed to be most active and numerous in numbers during January to March, 2005 and February to April, 2006 in Karnataka. In case of correlation, the significant positive correlation with the maximum temperature and sunshine while the negative correlation with the minimum temperature,

rainfall and relative humidity. Suresh *et al.*, (2010) reported that seasonal incidence of cotton mealybug, *Phenacoccus solenopsis* population was maximum (35 mealybugs/ 5cm) during June and decreased slowly during September and there was no incidence up to February. Similarly, Seni and Sahoo (2015) [15] found that in the May month peak incidence of papaya mealybug was observed and significant positive correlation was observed between papaya mealybug population and maximum temperature whereas, the maximum relative humidity and rainfall had negative correlation with papaya mealybug population. Multiple correlation studies with weather parameters and natural enemy activities indicated that there was a positive correlation with maximum temperature and negative correlation with minimum temperature, rainfall and relative humidity.

Table 1: Seasonal incidence of papaya mealy bugs and its natural enemies (September, 2013 to August, 2014)

Met. Week	Number of mealybugs 5 cm ² / leaf/plant	Number of natural enemies/leaf/plant				Weather parameters					
		<i>A. papayae</i>	<i>P. maxicana</i>	<i>A. nr. purpureus</i>	Coccinellids	Temperature (°C)		R.H. (%)		Sunshine (hrs)	Rainfall (mm)
						Max.	Min.	Morn.	Eve.		
36	0.0	0.0	0.0	0.0	0.0	32.3	19.7	79.2	49.1	6.7	0.0
37	0.0	0.0	0.0	0.0	0.0	31.4	22.0	81.7	62.7	5.8	0.0
38	0.0	0.0	0.0	0.0	0.0	29.6	21.5	83.7	60.5	3.1	0.0
39	0.0	0.0	0.0	0.0	0.0	30.5	21.1	80.0	56.0	4.3	0.0
40	0.0	0.0	0.0	0.0	0.0	31.9	21.2	81.8	58.0	6.3	0.0
41	0.0	0.0	0.0	0.0	0.0	31.1	19.9	77.1	57.1	6.7	0.0
42	0.0	0.0	0.0	0.0	0.0	32.0	20.1	66.3	46.0	8.5	0.0
43	0.0	0.0	0.0	0.0	0.0	31.2	19.6	58.7	55.7	8.2	0.0
44	0.0	0.0	0.0	0.0	0.0	31.3	16.9	63.3	47.7	9.3	0.0
45	0.0	0.0	0.0	0.0	0.0	30.6	14.6	65.0	35.6	8.0	0.0
46	0.0	0.0	0.0	0.0	0.0	25.8	12.4	60.4	30.7	8.8	0.0
47	2.2	0.0	0.0	0.0	0.0	30.1	13.6	67.9	36.6	8.3	41.8
48	4.6	0.0	0.0	0.0	0.0	29.4	16.9	75.1	54.0	6.6	0.0
49	8.6	0.0	0.0	0.0	0.0	28.9	13.5	72.3	38.1	7.4	0.0
50	15.6	0.0	0.0	0.8	0.0	28.7	7.4	74.6	25.6	9.4	0.0
51	22.2	0.8	0.0	1.2	0.0	29.5	9.7	55.6	28.1	9.9	0.0
52	15.4	1.4	0.0	1.8	0.0	28.7	12.3	65.9	37.3	8.3	0.0
1	22.8	2.6	0.0	2.0	0.0	29.5	12.3	58.7	34	9.1	0.0
2	26.4	4.6	0.0	2.4	0.0	29.7	13.5	53.9	34.1	7.9	0.0
3	32.6	4.6	0.0	3.2	0.0	29.1	14.9	67.1	39.6	6.2	0.0
4	40.5	5.4	0.0	4.4	0.0	28.5	11.2	59.2	30.9	9.3	0.0
5	55.8	3.2	0.0	4.8	0.0	31.8	11.2	53.7	20.0	10.1	0.0
6	65.4	2.6	0.4	5.2	0.8	28.0	10.3	54.6	27.0	10.2	0.0
7	72.8	1.4	2.2	5.4	1.8	31.1	15.1	56.0	30.1	9.4	0.0
8	85.4	3.4	3.2	5.8	3.2	30.6	13.6	51.4	33.1	9.3	0.6
9	97.4	3.8	4.8	6.2	5.6	29.4	16.5	77.4	45.0	6.7	32.8
10	80.4	3.2	5.6	3.2	4.2	33.7	18.7	59.2	30.4	7.4	0.8
11	35.2	2.2	4.8	1.2	6.4	36.0	16.9	41.1	20.4	8.5	0.0
12	20.4	1.4	5.2	2.3	5.2	36.9	18.6	38.7	20.6	8.9	0.0
13	46.8	2.6	6.2	3.2	4.4	37.5	18.5	36.1	19.6	8.5	0.0
14	55.4	5.6	6.8	3.8	3.8	37.2	18.0	46.0	16.7	9.4	0.0
15	69.6	6.4	7.4	4.4	3.4	37.8	21.1	58.9	25.8	9.7	0.0
16	78.6	7.8	2.0	4.8	2.8	38.7	21.5	46.4	20.2	9.2	0.0
17	90.2	10.4	2.4	5.2	2.2	39.1	22.5	52.5	21.1	9.7	3.6
18	105.8	12.2	0.8	4.6	1.4	37.7	22.7	65.4	22.1	8.2	0.0
19	45.8	8.6	1.2	4.2	0.8	36.9	22.3	64.9	25.1	7.9	0.0
20	65.0	5.4	2.2	2.8	0.2	39.4	23.2	60.9	23.1	8.9	0.0
21	70.4	3.2	1.4	2.6	0.0	40.3	23.6	58.1	26.0	8.4	0.0
22	65.8	1.8	1.4	1.8	0.0	38.6	24.5	71.5	33.0	7.2	2.6
23	70.2	0.8	1.2	1.2	0.0	36.7	24.7	65.1	35.8	9.7	18.8
24	78.4	0.0	1.2	0.8	0.0	33.4	24.7	66.1	46.4	3.6	22.4
25	42.4	0.0	0.4	0.0	0.0	35.9	22.5	65.7	35.5	8.1	0.0
26	15.6	0.0	0.2	0.0	0.0	34.4	23.3	71.7	51.8	5.2	11.8
27	12.4	0.0	0.2	0.0	0.0	32.6	23.3	73.4	51.8	3.8	16.8
28	12.2	0.0	0.2	0.0	0.0	30.2	23.9	71.7	64.0	1.1	0.0
29	7.8	0.0	0.2	0.0	0.0	29.1	22.2	76.2	62.8	4.1	22.8
30	6.2	0.0	0.0	0.0	0.0	29.0	22.6	74.9	68.6	2.2	13.2
31	4.0	0.0	0.0	0.0	0.0	30.5	21.9	72.4	57.0	5.1	1.6
32	2.8	0.0	0.0	0.0	0.0	31.8	21.9	70.6	50.6	4.8	34.0
33	1.6	0.0	0.0	0.0	0.0	32.7	22.6	78.9	51.3	5.3	44.4
34	0.8	0.0	0.0	0.0	0.0	28.6	21.8	81.6	72.4	1.4	129.9
35	0.4	0.0	0.0	0.0	0.0	28.7	12.3	65.9	37.3	8.3	0.0

Table 2: Correlation coefficient (r) of papaya mealybug and its natural enemies with weather parameters (September, 2013 to August, 2014)

Variables	Meteorological parameters					
	Temperature (°C)		R.H. (%)		Sunshine (hrs)	Rainfall (mm)
	Max.	Min.	Morn.	Even.		
Papaya mealybug	0.538*	-0.017	-0.581*	-0.679*	0.532*	-0.178
<i>A. papayae</i>	0.502*	-0.015	-0.561*	-0.622*	0.444*	-0.210
<i>P. maxicana</i>	0.434*	-0.028	-0.641*	-0.522*	0.326**	-0.111
<i>A. nr. purpureus</i>	0.281**	-0.327**	-0.671*	-0.700*	0.583*	-0.251
Coccinellids	0.280**	-0.128	-0.595*	-0.453*	0.316**	-0.112

* Significant at 5% level (p = 0.05)

** Significant at 1% level (p = 0.01)

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