

Seasonal Incidence and Alternate hosts of Papaya Mealybug, *Paracoccus marginatus* Williams and Granara de Willink, (Pseudococcidae: Hemiptera) in Chittoor and Kadapa districts of Andhra Pradesh in India

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ABSTRACT

Study on survey for the seasonal incidence of papaya mealybug (PMB), *Paracoccus marginatus* in both Chittoor and Kadapa districts of Andhra Pradesh in India revealed that in Chittoor district the per cent infested fruits were decreased gradually from June, 2013 to January, 2014 due to decrease in maximum and minimum temperatures, increase in rainfall. *Acerophagus papayae*, a predominant parasitoid activity was also observed during this period. The PMB infested fruits increased gradually from February to April, 2014 due to increase in temperature and prolonged dry spell. Whereas in Kadapa district the per cent PMB infested fruits decreased continuously from June, 2013 to December, 2013 due to decrease in maximum and minimum temperatures, high rainfall and also increase in natural enemy activity observed during this period. Then the PMB infested fruits increased gradually up to April, 2014 due to the fact that prolonged dry weather lead to increase in temperature which encouraged heavy population build-up and further spread of papaya mealybug. In Chittoor and Kadapa districts the correlation of per cent papaya mealybug infested fruits with abiotic factors revealed that, both maximum temperature had a significant positive association with infestation of PMB on fruits. *Parthenium hysterophorus* is the major alternate host of papaya mealybug in and around the papaya fields in Chittoor and Kadapa districts.

Key words: Papaya mealybug, Seasonal incidence, *Parthenium hysterophorus*

INTRODUCTION

India is the largest producer of papaya (*Carica papaya* L.) contributing 25 per cent of total world production. In India around 132.18 thousand ha of area, 5381.73 thousand MT of production and 38.6 MT/ha productivity, while in Andhra Pradesh 20.65 thousand ha of area,

1651.95 thousand MT of production and 80 MT/ha productivity was recorded in 2012-13¹⁵. The leading papaya producing states in India are Andhra Pradesh (30.7%), Gujarat (22.1%) and Karnataka (8.5%) during 2012-13.

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Papaya mealybug (PMB), *Paracoccus marginatus* Williams and Granara de Willink (Hemiptera: Pseudococcidae), native to Mexico and Central America⁷ was introduced into the Caribbean islands and had become a pest in early 1990's; In India, the pest was first reported from Coimbatore during 2008 infesting papaya and there after the list of agricultural and horticultural crops infested by this invasive pest is expanding².

PMB is a polyphagous pest which cause damage to a large number of economically important field crops, tropical and sub tropical fruits and the ornamental plants⁶ (Miller and Miller, 2002). It was recorded from 133 host plants⁸ and the major host plants of *P. marginatus* are papaya, tapioca, cotton, *Plumeria alba*, jatropha, mulberry, almost all vegetables, some flower

crops, weeds, forest trees like teak and *Prosopis*².

MATERIALS AND METHODS

Survey was conducted in Chittoor and Kadapa districts of Andhra Pradesh to document the seasonal incidence of papaya mealybug at monthly intervals in relation to weather parameters starting from June, 2013 to April, 2014. From each district three villages were selected for the survey.

Recording of Data

During survey at monthly intervals, in each village one papaya orchard was selected in that five randomly selected plants were observed. On each plant total number of fruits and number of fruits infested with mealybug was recorded. Per cent infested fruits were calculated as given below.

$$\text{Per cent infested fruits} = \frac{\text{No. of infested fruits}}{\text{Total No. of fruits}} \times 100$$

The data on weather parameters viz., maximum temperature, minimum temperature, morning and evening relative humidity, rainfall and sunshine hours during the period of study were collected with the support of meteorological observatory at RARS, Tirupati and ARS, Kadapa. Simple correlation between per cent infested fruits and weather parameters were statistically analysed.

In and around the survey field, the incidence of PMB on the alternate host plants was also recorded.

RESULTS AND DISCUSSION

The results of the survey conducted for the seasonal incidence and alternate hosts of papaya mealybug in major papaya growing areas of Chittoor and Kadapa districts of Andhra Pradesh are presented hereunder.

Survey for the

Seasonal Incidence of Papaya Mealybug, *P. marginatus* in Chittoor District

The data regarding the per cent infested fruits by PMB and weather parameters during the period of study were presented in the Table.1. The data

revealed that in all the selected villages of the Chittoor district, mealybug infestation on fruits was first observed in the month of June, 2013 and continued till April, 2014. The incidence was ranged from 10 to 90.34 per cent. Infestation of mealybugs was decreased from October, 2013 to January, 2014 during the period of survey and then again gradually increased from February to April, 2014. In Tekalakona village the per cent infested fruits were high (90.43%) in the month of April, 2014 and low (10%) in the month of November, 2013. In Itlamvaripalli village the per cent PMB infested fruits were high (86.45%) in the month of April, 2014 and low (24.43%) in the month of January, 2014. In Thummachenupalli village the per cent infested fruits were high (81.66%) in the month of April, 2014 and low (18.34%) in the month of January, 2014. The survey in Chittoor district revealed that, the per cent infested fruits was very high (90.34%) in April, 2014 and low (10%) in November, 2013. The survey results of present investigation are in agreement with the

findings of Sarma⁹ who reported that the infestation of *P. marginatus* started increasing with the onset of dry spell, more particularly the papaya plants were attacked by mealybug during March–April. Goolsby *et al*³, reported that the peak incidence of *Maconellicoccus hirsutus* (Green) in the vineyard occurred during summer months and below detectable

levels during winter months. On contrary, Thangamalar *et al*¹⁴, reported that the PMB population was on the rise during June to September 2009 with peak incidence of the pest during second fortnight of July 2009 on mulberry crop, this might be due to variations in the agro-climatic conditions.

Table 1: Per cent infestation of papaya mealybug, *Paracoccus marginatus* on fruits and weather parameters from June 2013 to April 2014 in Chittoor district

Month	Per cent infested fruits*			Weather parameters					
	Tekalakona	Itlamvaripalli	Thummachenupalli	Max. Temp (°C)	Min. Temp (°C)	Morning RH (%)	Evening RH (%)	RF (mm)	SSH (h/day)
30 th Jun	83.23	82.45	77.32	37.3	27.0	70.5	36.3	0.8	5.9
31 th Jul	81.46	81.77	72.15	34.2	25.6	75.1	46.8	2.1	1.7
31 th Aug	75.11	75.42	65.37	34.2	24.9	80.9	47.6	3.5	5.4
30 th Sep	57.14	73.00	52.44	33.4	24.2	88.9	53.9	10.0	4.5
31 th Oct	15.66	61.89	38.33	32.7	23.9	88.9	55.4	6.3	4.6
30 th Nov	10.00	52.67	32.00	30.3	20.8	90.6	59.9	2.5	5.2
31 th Dec	14.00	30.00	18.34	29.9	17.9	90.8	48.3	0.0	5.5
31 th Jan	12.67	24.43	28.23	30.1	17.4	19.7	44.9	0.0	6.5
28 th Feb	43.00	53.00	57.00	32.4	18.1	82.1	39.2	0.0	7.6
31 th Mar	73.56	66.64	70.14	35.6	20.1	82.4	35.2	0.0	7.9
30 th Apr	90.34	86.45	81.66	41.2	23.9	58.7	24.9	0.0	7.5

*Mean number of five plants

The correlation of per cent PMB infested fruits with abiotic factors *viz.*, maximum temperature, minimum temperature, morning relative humidity, evening relative humidity, rainfall and sunshine hours of the corresponding period showed that, both maximum, minimum temperature, sunshine hours had a positive association with infestation of PMB on fruits while morning, evening relative humidity and rainfall showed negative influence. Among which, maximum and minimum temperature had a significant positive influence on per cent infested fruits in all the three villages selected for survey in Chittoor district i.e. Tekalakona ($r = +0.857$, $r =$

$+0.659$), Itlamvaripalli ($r = +0.817$, $r = +0.877$) and Thummachenupalli ($r = +0.885$, $r = +0.652$). Whereas evening relative humidity showed significant negative influence on per cent infested fruits from Tekalakona ($r = -0.658$) and Thummachenupalli ($r = -0.674$) villages, but it was not significant in Itlamvaripalli village. Similarly morning relative humidity had negative influence but non-significant in all the three villages. The association between rainfall and infestation of PMB on fruits was negative but the influence was not significant in all the three villages of Chittoor district (Table.2)

Table 2: Correlation of papaya mealybug, *Paracoccus marginatus* infestation on fruits with weather parameters from June 2013 to April 2014 in Chittoor district

Particulars	Correlation coefficient values for Infestation of <i>P. Marginatus</i> At		
	Tekalakona	Itlamvaripalli	Thummachenupalli
Maximum temperature	0.857**	0.817**	0.885**
Minimum temperature	0.659*	0.877**	0.652*
Morning relative humidity (mor RH)	-0.005	0.261	-0.014
Evening relative humidity (eve RH)	-0.658*	-0.346	-0.674*
Rainfall (RF)	-0.074	0.262	-0.100
Sun shine hours (SSH)	0.023	-0.198	0.096

*Significant at 5% ** Significant at 1%

The association between per cent infested fruits of PMB in Tekalakona and weather parameters could be explained by multiple linear regression model ($Y=174.088 -2.414 \text{ max temp} +5.171 \text{ min temp} +0.268 \text{ mor RH} -3.575 \text{ Eve RH} +1.775 \text{ RF} -3.677 \text{ SSH}$) to a tune of 86.3 ($R^2= 0.863$) per cent. In case of Itlamvaripalli full model multiple linear

regression fitted was, $Y= -125.389 +3.925 \text{ max temp} +2.224 \text{ min temp} +0.199 \text{ mor RH} -0.039 \text{ Eve RH} +0.367 \text{ RF} -1.419 \text{ SSH}$ ($R^2 = 0.939$) and in case of Thummachenupalli multiple linear regression model fitted was, $Y= 39.516 +0.077 \text{ max temp} +3.396 \text{ min temp} +0.139 \text{ mor RH} -1.600 \text{ eve RH} +0.359 \text{ RF} -0.562 \text{ SSH}$ ($R^2 = 0.853$), (Table.3).

Table 3: Regression models developed for occurrence of papaya mealybug infestation on fruits from June 2013 to April 2014 in Chittoor district

Villages	Model	Regression equation	R ² value
Tekalakona	Full model	$Y=174.088-2.414 \text{ max temp}+5.171 \text{ min temp} +0.268 \text{ mor RH} -3.575 \text{ eve RH} +1.775 \text{ RF} -3.677 \text{ SSH}$	0.863
Itlamvaripalli	Full model	$Y=-125.389+3.925 \text{ max temp}+2.224 \text{ min temp} +0.199 \text{ mor RH}-0.039 \text{ eve RH}+0.367 \text{ RF}-1.419 \text{ SSH}$	0.939
Thummachenupalli	Full model	$Y=39.516+0.077 \text{ max temp} +3.396 \text{ min temp} +0.139 \text{ mor RH}-1.600 \text{ eve RH}+0.359 \text{ RF} -0.562 \text{ SSH}$	0.853

The results of present investigations are in conformity with the findings of Suresh *et al*¹³, who reported that the incidence of *P. marginatus* on *Plumeria alba* was positively correlated with maximum temperature and positively correlated with minimum temperature on *Carica papaya*, *Jatropha curcas* and *Psidium guajava*. Similarly, Sridharan *et al*¹², reported that the population of mealybug *Planococcus citri* (Risso) in mandarin orange was positively correlated

with the temperature and negatively with relative humidity.

Survey for the

Seasonal Incidence of Papaya Mealybug, *P. marginatus* in Kadapa District

The data pertaining to the per cent infested fruits of PMB and weather parameters during the period of study were presented in the Table.4. The data revealed that in all the three selected villages of the Kadapa district, mealybug infestation on fruits was first observed in the month of June 2013 afterwards the per cent infested fruits

were decreased gradually up to December, 2013 and then again increased up to April, 2014. In Settigunta village the per cent infested fruits were high (79.17%) in the month of April, 2014 and low (12.46%) in the month of December, 2013. In Anantharajupeta village the per cent infested fruits were high (72.17%) in the month of April, 2014 and low (17.76%) in the month of December, 2013. In Narayanarajupodu village the per cent PMB infested fruits were high (69.19%) in the month of April, 2014 and low (16%) in the month of October, 2013. In Kadapa district,

the per cent infested fruits was very high (79.17%) in April, 2014 and low (12.46%) in December, 2013. The present results are in agreement with the findings of Mani *et al*⁵., who reported that the incidence of *P. marginatus* was noticed throughout the year, but active in warm dry weather. Similarly, Suresh *et al*¹³., studied the seasonal incidence of *Phenacoccus solenopsis* on cotton and reported that the incidence was high during June and decreased slowly from September and negligible by the end of February.

Table 4: Per cent infestation of papaya mealybug, *Paracoccus marginatus* on fruits and weather parameters from June 2013 to April 2014 in Kadapa district

Month	Per cent infested fruits*			Weather parameters					
	Settig- unta	Ananthar- ajupeta	Narayanaraj- upodu	Max.Temp (°C)	Min.Temp (°C)	Morning RH (%)	Evening RH (%)	RF (mm)	SSH (h/day)
16 th Jun	55.24	62.38	66.24	36.0	14.0	84.0	80.0	59.7	1.8
16 th Jul	32.16	48.84	43.42	33.7	25.7	82.0	49.4	113.2	1.8
16 th Aug	31.67	39.21	26.15	33.3	25.1	85.4	51.2	130.7	1.4
16 th Sep	22.00	32.56	22.63	35.1	23.2	89.6	52.1	201.5	1.2
16 th Oct	18.00	21.22	16.00	33.5	23.5	95.2	61.4	382.0	1.0
16 th Nov	17.33	20.00	19.19	30.1	20.2	89.6	54.0	43.7	2.2
16 th Dec	12.46	17.76	18.22	30.1	18.1	88.8	44.8	2.1	4.6
16 th Jan	28.55	23.14	26.28	30.7	18.0	87.6	44.7	0.0	6.8
16 th Feb	59.18	40.11	39.25	32.9	20.4	85.1	35.8	0.0	8.2
16 th Mar	70.11	54.28	53.76	36.5	22.9	53.6	23.5	0.0	8.6
16 th Apr	79.17	72.17	69.19	41.3	26.4	59.9	17.2	4.2	8.4

*Mean number of five plants

The association between PMB and abiotic factors *viz.*, maximum temperature, minimum temperature, morning relative humidity, evening relative humidity, rainfall and sunshine hours of the three villages in Kadapa district was studied. Correlation studies on different abiotic factors with per cent infested fruits revealed that, both maximum, minimum temperature, sunshine hours had a positive association with per cent

infested fruits and morning, evening relative humidity and rainfall showed negative influence. In case of maximum temperature, the influence was highly significant on per cent infested fruits due to PMB in Settigunta ($r=+0.788$), Anantharajupeta ($r=+0.880$) and Narayanarajupodu ($r=+0.799$) villages. While morning relative humidity showed significant negative association with PMB infestation in

Settigunta (r= -0.834), Anantharajupeta (r=-0.742) and Narayanarajupodu(r=-0.742). Whereas minimum temperature, evening relative humidity, rainfall did not show any significant influence on per cent infested fruits due to PMB in all the three villages of Kadapa district. However, sunshine hours showed a significant positive influence on PMB in Settigunta village (Table.5). The results of present study are in conformity with the findings of Ayyasamy and Regupathy¹ who reported the incidence of *P.marginatus* throughout the year

but active in warm dry weather. They also reported that, prolonged drought with scanty rainfall and less rainy days favour the faster multiplication of *P.marginatus*. Similarly, Koli⁴ reported that, maximum and minimum temperature showed highly significant positive correlation with *M. hirsutus* on grapevine in Rahuri, whereas, morning, evening relative humidity showed highly significant negative correlation and non significant negative correlation with rainfall.

Table 5: Correlation of papaya mealybug, *Paracoccus marginatus* infestation on fruits with weather parameters from June 2013 to April 2014 in Kadapa district

Particulars	Correlation coefficient values for Infestation of <i>P. marginatus</i> At		
	Settigunta	Anantharajupeta	Narayanarajupodu
Maximum temperature	0.788**	0.880**	0.799**
Minimum temperature	0.140	0.210	0.005
Morning relative humidity (mor RH)	-0.834**	-0.742**	-0.742**
Evening relative humidity (eve RH)	-0.530	-0.280	-0.260
Rainfall (RF)	-0.460	-0.290	-0.430
Sun shine hours (SSH)	0.680*	0.320	0.430

*Significant at 5%, ** Significant at 1%

The association between per cent PMB infested fruits in Settigunta and weather parameters could be explained by multiple linear regression model (Y=-263.883 +3.168 max temp +4.713 min temp -0.462 mor RH +2.046 eve RH -0.068 RF + 9.875 SSH) to the extent of 97 per cent (R²= 0.97). In case of PMB infestation at Anantharajupeta multiple linear regression model fitted was, Y= -

239.056 +4.005 max temp +3.989 min temp +-0.327 mor RH +1.586 eve RH -0.100 RF +4.123 SSH (R² =0.981) and for Narayanarajupodu village the regression model developed was, Y= -214.304 +3.760 max temp +3.140 min temp- 0.454 mor RH + 1.693 eve RH -0.097 RF+5.147 SSH (R² = 0.969), (Table.6).

Table 6: Regression models developed for occurrence of papaya mealybug infestation on fruits from June 2013 to April 2014 in Kadapa district

Villages	Model	Regression equation	R ² value
Settigunta	Full model	Y=-263.883+3.168 max temp+4.713 min temp - 0.462 mor RH +2.046 eve RH -0.068 RF +9.875 SSH	0.970
Anantharajupeta	Full model	Y=-239.056+4.005 max temp+3.989 min temp - 0.327 mor RH+1.586 eve RH-0.100 RF+4.123 SSH	0.981
Narayanarajupodu	Full model	Y=-214.304+3.760 max temp +3.140min temp - 0.454 mor RH+1.693 eve RH-0.097 RF -+5.147 SSH	0.969

The present study on survey for the incidence of papaya mealybug, *P. marginatus* in both Chittoor and Kadapa districts revealed that in Chittoor district the per cent infested fruits were decreased gradually from June, 2013 to January, 2014 due to decrease in maximum and minimum temperatures, increase in rainfall. Natural enemies like *Acerophagus papayae* activity was observed during this period which is a predominant parasitoid on papaya mealybug. The PMB infested fruits increased gradually from February to April, 2014 due to increase in temperature and prolonged dry spell.

In Kadapa district also, the per cent PMB infested fruits decreased continuously from June, 2013 to December, 2013 due to decrease in maximum and minimum temperatures, heavy rainfall and also natural enemies activity observed during this period.

Then the PMB infested fruits increased gradually upto April, 2014 due to the fact that prolonged dry weather lead to increase in temperature which encouraged heavy population build-up and further spread of papaya mealybug.

The maximum temperature, minimum temperature, and rainfall prevailed during the peak period of incidence of papaya mealybug, *Paracoccus marginatus* were 41.2⁰C, 23.9⁰C, and 0 mm in Chittoor district and in Kadapa district 41.3⁰C, 26.47⁰C, and 4.25 mm, respectively.

During the period of survey, various plants have been observed for alternate hosts of *P. marginatus* which included field crops, fruit crops, trees and weeds (Table.7). These were major reservoirs for mealybug colonies throughout the year.

Table 7: Alternate hosts of papaya mealybug recorded during survey

S.No.	Common name	Scientific name	Family
1	Congress weed	<i>Parthenium hysterophorus</i> L.	Asteraceae
2	Indian Mallow	<i>Abutilon indicum</i> L.	Malvaceae
3	Bill goat weed	<i>Ageratum conyzoides</i>	Asteraceae
4	Day flower	<i>Commelina benghalensis</i>	Commelinaceae
5	Sida	<i>Sida acuta</i>	Malvaceae
6	Teak	<i>Tectona grandis</i> L.	Verbenaceae
7	Brinjal	<i>Solanum melongena</i> L.	Solanaceae
8	Bhendi	<i>Abelmoschus esculentus</i> L.	Malvaceae
9	Guava	<i>Psidium guajava</i> L.	Myrtaceae
10	Mango	<i>Mangifera indica</i> L.	Anacardiaceae
11	Custard apple	<i>Annona squamosa</i> L.	Annonaceae
12	Tomato	<i>Lycopersicon esculentum</i>	Solanaceae
13	Swallow wort	<i>Calotropis gigantea</i>	Asclepiadaceae
14	Coat buttons	<i>Tridax procumbens</i> L.	Asteraceae
15	Jatropha	<i>Jatropha curcus</i> L.	Euphorbiaceae
16	Kuppinta (Telugu)	<i>Acalypha indica</i>	Euphorbiaceae
17	Pulikampa (Telugu)	<i>Lantana camara</i>	Verbenaceae

P. marginatus is a highly polyphagous insect pest that can damage large number of tropical and subtropical fruits, vegetables and ornamental plants⁶. According to Muniyappan

et al., papaya mealybug was known to infest plants belonging to 22 families from Asia. Shylesha *et al*¹¹, reported that *P.marginatus* attacks over 60 species of plants including

field crops, fruit trees, ornamentals, weed and scrub vegetation in India.

Selvaraju and Sakhthivel¹⁰ reported that high host preference of mealybug on the plants belonging to the family Euphorbiaceae, Fabaceae, Malvaceae, Solanaceae, Apocynaceae, and Amaranthaceae.

CONCLUSION

Study on survey for the incidence of papaya mealybug, *P. marginatus* in both Chittoor and Kadapa districts revealed that in Chittoor district the per cent infested fruits were decreased gradually from June, 2013 to January, 2014 due to decrease in maximum and minimum temperatures, increase in rainfall. *Acerophagus papayae*, a predominant parasitoid activity was also observed during this period. The PMB infested fruits increased gradually from February to April, 2014 due to increase in temperature and prolonged dry spell.

In Chittoor district the correlation of per cent papaya mealybug infested fruits with abiotic factors revealed that, both maximum, minimum temperature and evening relative humidity had a significant positive association with infestation of PMB on fruits.

In Kadapa district the per cent PMB infested fruits decreased continuously from June, 2013 to December, 2013 due to decrease in maximum and minimum temperatures, heavy rainfall and also natural enemies' activity observed during this period. Then the PMB infested fruits increased gradually up to April, 2014 due to the fact that prolonged dry weather lead to increase in temperature which encouraged heavy population build-up and further spread of papaya mealybug.

In Kadapa district, the correlation studies on different abiotic factors with per cent infested fruits revealed that, maximum temperature, morning relative humidity and sunshine hours had a significant positive association with infestation of PMB on fruits.

Parthenium hysterophorus is the major alternate host of papaya mealybug in and around the papaya fields in Chittoor and Kadapa districts.

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