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Population Dynamics of Citrus Leaf Miner (*Phyllocnistis citrella* Stainton) in Relation to Abiotic Factors

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Abstract: *In Jharnapani, Dimapur Nagaland the activity of Phyllocnistis citrella Stainton (Lepidoptera: Phyllocnistidae) on khasi mandarin (Citrus reticulata Blanco) was found throughout the year for two consecutive years except during cold winter months. In the first year the population and leaf infestation was highest in the 2nd week of June but later on it was reduced and reached its lowest in the 4th week of November. In the second year the maximum and minimum larval population and leaf infestation was observed in the 4th week of June and 4th week of February respectively. The activity of P.citrella was recorded nil from 49th standard week till 14th standard week in the first year and from 51st standard week till 8th standard week in the second year due to non availability of new tender flushes. Maximum temperature, maximum relative humidity, maximum vapour pressure and rainfall were found as most influencing factors and showed positive effect on the activity of P. citrella and leaf infestation whereas, minimum relative humidity, minimum vapour and evaporation had a direct negative effect.*

INTRODUCTION

Citrus is one of predominant fruit in India and ranks third in terms of area, production and productivity next to mango and banana (Singh, 2005). However citrus is the host to a large number of pests worldwide and amongst them citrus leaf miner (*Phyllocnistis citrella* Stainton Lepidoptera: Phyllocnistidae) is one of the most important pest in India. It is a regular occurrence in nurseries, young plantation and on new flushes. Eggs of CLM are laid singly on the underside of the leaves, upon hatching the pale yellow larvae immediately enter into the tender succulent leaves and begin feeding and form zigzag silvery white galleries which results in leaf curling. A real concern is that the CLM creates openings that permit citrus canker bacteria and aggravates development of saprophytic fungi which hinders photosynthetic activity leading to affect their vitality and low yield (Sandhu and Batra, 1978). Weather factors play an important role in population build up of *P.citrell*a and appear to have a close relationship between abiotic factors and the pest. However, no systematic research has been conducted so far in this area in Nagaland state and information available on this aspect is meager. So, considering the importance of its problem and to get a comprehensive idea, a detailed study was carried out to investigate the role of abiotic factors on the population build up of *P. citrella*.

MATERIALS AND METHODS

The experiment was carried out in a three years old khasi mandarin orchard at experimental farm, ICAR research complex for NEH Region, Nagaland centre, Jharnapani, during 2008-2009 and 2009-2010. In order to observe the larval population of CLM, total number of larvae of *P.citrella* was recorded from 10 twigs per plant from 15 randomly selected plants at weekly intervals and mean was worked out. Likewise, the leaf damage caused by *P.citrella* was recorded by observing total and infested leaves from 10 numbers of twigs per plant from each randomly selected 15 plants. The meteorological data were recorded daily from AMFU (Agro Meteorology Field Unit), ICAR Jharnapani, Nagaland centre during the study period. Statistical analysis of the data on

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Table 1
Population dynamics of Citrus leaf miner (*Phyllocnistis citrella*) in relation with abiotic factors (2008-2009)

Standard week	*Met. Month/ week*		*Average No. of Larvae/10 twig**		*Leaf Infestation (%)**	
			2008-09	*2009-10*	*2008-09*	*2009-10*
15	April	I	1.27	0.00	18.64	0.00
16		II	2.00	1.27	20.75	10.25
17		III	2.50	1.71	37.50	17.05
18		IV	4.09	4.50	47.18	47.10
19	May	I	4.00	5.32	57.47	55.55
20		II	5.10	7.30	61.11	66.32
21		III	5.10	8.50	65.04	67.76
22		IV	6.79	8.00	70.61	70.39
23	June	I	8.97	7.91	72.38	71.65
24		II	11.65	7.00	83.51	71.90
25		III	10.00	7.00	80.00	72.56
26		IV	8.03	12.00	72.70	91.69
27	July	I	9.93	11.90	80.65	90.81
28		II	5.29	10.00	71.53	87.86
29		III	6.10	8.97	71.06	79.83
30		IV	3.89	9.20	61.14	79.32
31		V	3.47	9.50	53.85	80.33
32	August	I	6.29	9.00	70.39	78.26
33		II	5.11	7.60	64.73	72.80
34		III	5.32	7.03	70.94	71.02
35		IV	4.60	6.72	64.03	70.68
36	September	I	3.07	4.93	42.86	56.28
37		II	3.19	5.09	55.00	64.43
38		III	3.83	4.50	61.97	60.57
39		IV	3.56	3.50	50.92	58.46
40		V	3.97	3.56	67.29	52.39
41	October	I	5.26	5.06	72.30	62.01
42		II	4.38	4.72	73.76	54.16
43		III	4.00	4.50	79.82	53.23
44		IV	5.80	3.92	73.00	51.92
45	November	I	5.50	3.50	79.21	50.69
46		II	1.36	3.20	49.21	50.21
47		III	0.60	3.00	15.00	43.49
48		IV	0.20	2.00	9.52	35.33
49	December	I	0.00	1.76	0.00	29.00
50		II	0.00	1.23	0.00	18.20
51		III	0.00	0.00	0.00	0.00
52		IV	0.00	0.00	0.00	0.00
1		V	0.00	0.00	0.00	0.00
2	January	I	0.00	0.00	0.00	0.00
3		II	0.00	0.00	0.00	0.00
4		III	0.00	0.00	0.00	0.00
5		IV	0.00	0.00	0.00	0.00
6	February	I	0.00	0.00	0.00	0.00
7		II	0.00	0.00	0.00	0.00
8		III	0.00	0.00	0.00	0.00
9		IV	0.00	0.75	0.00	11.23
10	March	I	0.00	1.02	0.00	14.00
11		II	0.00	1.02	0.00	16.48
12		III	0.00	1.02	0.00	18.53
13		IV	0.00	2.00	0.00	19.99
14		V	0.00	3.20	0.00	23.52

* Mean of Observations from 15 plants

P.citrella population and weather factors was carried out by correlation and regression analysis.

RESULT AND DISCUSSION

From the average data on larval population and leaf infestation by *P.citrella* from 2008 to 2010, it has been observed that the pest remained active from April till November but reduced and reached zero during the cold winter months. Its population comprised of different developmental stages in any time of the year indicating the overlapping generation of *P.citrella*. During the course of research weather impact on the population of the pest was evident and the temperature, relative humidity, vapour pressure, rainfall and evaporation ranged from 6.50 to 35.30 °C, 15 to 94 %, 4.10 to 23.20 mm, 0.00 to 20.24 cm and 0.50 to 7.70 mm respectively and these factors affected the population of the pest. The period of occurrence of *P.citrella* population peaks varied during different standard weeks and years as described below.

April 2008 to March 2009

It has been depicted in (Table 1) that the maximum larval population (11.65 larvae per ten twigs) and the highest (83.51%) leaf infestation by *P.citrella* were recorded in the 2nd week of June and minimum larval population (0.20 larvae per ten twigs) and the lowest (9.52%) leaf infestation was recorded in the 4th week of November. Gangwar and Shukla(1987) from Barapani, Meghalaya had also similar observations for larval population and percent leaf infestation.. It was recorded that from 49th standard week till 14th standard week the larval population was recorded nil due to non-availability of flush. Yabas and Ulubilir (1995) have reported that the damage by *P.citrella* fell to zero in December due to zero population of leaf miner

The result of correlation analysis (Table 2) revealed positive significant correlation between larval population of *P.citrella* with maximum, minimum temperature; maximum, minimum relative humidity; maximum, minimum vapour pressure and rainfall, whereas morning and evening sunshine hours exhibited a negative non-significant. Patel *et al*., (1994) have found significant positive correlation with minimum temperature and vapour pressure whereas Patel and Patel (2001) from Gujarat have reported that rainfall, minimum temperature, relative humidity and vapour pressure had significant positive correlation. Bihari and Narayan (2009) have reported that the population of *P.citrella* was found affected by temperature which showed positive

Table 2
Correlation co-efficient (*r*) values of Citrus leaf miner (*Phyllocnistis citrella*) population with respect to abiotic factors.

Sl. No.	Parameters	Correlation Co-efficient(r)			
		Average No. of Larvae/10 twig		Leaf Infestation (%)	
		2008-09	2009-10	2008-09	2009-10
1.	Max. Temperature (°C)	0.659*	0.741*	0.686*	0.782*
2.	Min. Temperature (°C)	0.797*	0.834*	0.883*	0.893*
3.	Max. Relative Humidity (%)	0.579*	0.287*	0.679*	0.364*
4.	Min. Relative Humidity (%)	0.666*	0.542*	0.769*	0.643*
5.	Max. Vapour Pressure (mm)	0.776*	0.688*	0.893*	0.722*
6.	Min. Vapour Pressure (mm)	0.774*	0.756*	0.864*	0.816*
7.	Rainfall (cm)	0.633*	0.575*	0.640*	0.601*
8.	Evaporation (mm)	0.139 (NS)	0.401*	0.051 (NS)	0.404*
9.	Morning Sunshine (Hours)	–0.326* (NS)	0.176 (NS)	–0.250 (NS)	0.192 (NS)
10.	Evening Sunshine (Hours)	-0.348*	0.294*	-0.297*	0.221 (NS)

* Significant at 5%
NS Non-Significant

correlation and the maximum temperature had a considerable role in the population of the pest.

The stepwise regression showed that among the various abiotic factors, maximum temperature, maximum relative humidity, minimum vapour pressure and rainfall were found to be most influencing factors, contributing a 75.90% variation in larval population of *P.citrella*.

The regression equation generated from the data taking *P.citrella* larval population (Y_1) as a dependent variable and abiotic factors having significant correlation co-efficient values as independent variable was,

$$Y_1 = 11.777 + 0.356X_1 + 0.0061X_2 + 0.151X_3 - 0.049X_4 - 0.054X_5 + 0.341X_6 + 0.079X_7$$

Where, Y_1 = Larval Population
X_1 = Maximum Temperature
X_2 = Minimum Temperature
X_3 = Maximum Relative Humidity
X_4 = Minimum Relative Humidity
X_5 = Maximum Vapour pressure
X_6 = Minimum Vapour pressure
X_7 = Rainfall

The coefficient of determination (R^2) was 0.759 showing thereby that as much as 75.90% variation by the effect of abiotic factors viz., maximum, minimum temperature; maximum, minimum relative humidity, maximum, minimum vapour pressure and rainfall on larval population.

The correlation on percent leaf infestation by *P.citrella* with abiotic factors revealed that maximum, minimum temperature; maximum, minimum relative humidity; maximum, minimum vapour pressure, rainfall, evaporation and evening sunshine hours had a positive significant correlation whereas morning sunshine hours showed a positive non-significant influence on the percent leaf infestation by *P.citrella.*

The stepwise regression revealed that among the various abiotic factors, maximum temperature, maximum relative humidity, rainfall, minimum vapour pressure and evening sunshine hours were most influencing factors and contributed a 80.20% variation on percent leaf infestation by *P.citrella*. The prediction equation obtained was,

$$Y_2 = 33.842 + 3.899X_1 + 0.191X_2 + 0.751X_3 - 0.0227X_4 + 0.051X_5 + 0.771X_6 + 0.213X_7 - 0.839X_8 + 0.327X_{10}$$

Where, Y_1 = Percent Leaf Infestation
X_8 = Evaporation
X_{10} = Evening Sunshine hours

The coefficient of determination (R^2) was 0.802 showing thereby that as much as 80.20% variation by the effect of abiotic factors *viz.*, maximum, minimum temperature ; maximum, minimum relative humidity, maximum, minimum vapour pressure, rainfall, evaporation and evening sunshine hours on the percent leaf infestation by *P.citrella.*

April 2009 to March 2010

The maximum larval population (12.00 larvae per ten twigs) and the highest (91.69%) leaf infestation were recorded in the 4th week of June and minimum population (0.75 larvae per ten twigs) and lowest leaf infestation (11.23%) was recorded in the 4th week of February. It was found that the larval population and leaf infestation was recorded nil from 51st standard week till 8th standard week (Table 1).

P.citrella larval population (Y_1) had a significant positive correlation with maximum, minimum temperature; maximum, minimum relative humidity; maximum, minimum vapour pressure and rainfall whereas, evaporation and morning and evening sunshine hours showed non-significant effect (Table 2).

The stepwise regression revealed that among the various abiotic factors, maximum temperature,

Table 3
Multiple linear regression with co-efficient of determination (R^2) between Citrus leaf miner (*Phyllocnistis citrella*) population with respect to abiotic factors.

Sl. No.	Variables (X)	Average No. of Larvae/10 twig		Leaf Infestation (%)	
		2008-09 (Y_1)	2009-10 (Y_1)	2008-09 (Y_2)	2009-10 (Y_2)
1.	Max. Temperature (ºC) X_1	0.356	0.383	3.899	3.539
2	Min. Temperature (ºC) X_2	0.061	0.047	0.191	0.295
3	Max. Relative Humidity (%) X_3	0.151	0.132	0.751	0.758
4	Min. Relative Humidity (%) X_4	-0.049	-0.009	-0.227	-0.294
5	Max. Vapour Pressure (mm) X_5	-0.054	0.021	0.051	0.030
6	Min. Vapour Pressure (mm) X_6	0.341	0.183	0.771	0.742
7	Rainfall (cm) X_7	0.079	0.031	0.213	0.112
8	Evaporation (mm) X_8	-0.439	0.030	-0.839	-0.137
9	Morning Sunshine (Hours) X_9	-0.508	-0.120	-0.547	-2.525
10	Evening Sunshine (Hours) X_{10}	0.156	0.452	0.327	2.025
	A value	-11.777	6.503	33.842	17.062
	R^2 value	0.759	0.758	0.802	0.837

minimum vapour pressure, maximum relative humidity and rainfall were found to be most influencing factors, contributing a 75.80% variation in larval population of *P.citrella*.

The regression equation generated from the data taking *P.citrella* larval population (Y_1) as dependent variable and abiotic factors having significant correlation coefficient values as independent variable was:

$$Y_1 = 6.503 + 0.383X_1 + 0.047X_2 + 0.132X_3 - 0.009X_4 - 0.021X_5 + 0.183X_6 + 0.031X_7$$

The coefficient of determination (R^2) was 0.758 showing thereby that as much as 75.80% variation by the effect of abiotic factors *viz*., maximum, minimum temperature; maximum, minimum relative humidity, maximum, minimum vapour pressure and rainfall on larval population.

The study on effect of abiotic factors on percent leaf infestation by *P.citrella* showed that maximum, minimum temperature, maximum, minimum relative humidity, maximum, minimum vapour pressure, rainfall and evaporation had a significant positive correlation whereas morning and evening sunshine hours exhibited a negative non-significant influence with the percent leaf infestation by *P.citrella.*

The stepwise regression revealed that among the various abiotic factors, maximum temperature, maximum relative humidity, minimum vapour pressure and rainfall were most influencing factors and contributed a 83.70% variation on percent leaf infestation by *P.citrella.*

The regression equation generated from the data taking percent leaf infestation by *P.citrella* (Y_2) as dependent variable and abiotic factors as independent variable (X) having significant coefficient values is being presented as,

$$Y_2 = 17.062 + 3.539X_1 + 0.259X_2 + 0.758X_3 - 0.294X_4 + 0.030X_5 + 0.742X_6 + 0.112X_7 - 0.137X_8$$

The coefficient of determination (R^2) was 0.837 showing thereby that as much as 83.70% variation by the effect of abiotic factors *viz*., maximum, minimum temperature; maximum, minimum relative humidity, maximum, minimum vapour pressure, rainfall and evaporation on percent leaf infestation by *P.citrella.*

CONCLUSION

Among the various abiotic factors, maximum and minimum temperature, maximum and minimum relative humidity, maximum and minimum vapour pressure and rainfall and evaporation had influence on the larval population and percent leaf infestation by *P.citrella*. Regression equation showed that seasonal flush determined the larval population of *P.citrella* and percent leaf infestation by *P.citrella*. This shows that there is a close relationship between climate and the prevalence of the pests.

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