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Population dynamics of chiku moth, *Nephopteryx eugraphella* (Ragonot) in relation to weather parameters

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Abstract
The present investigation was carried out to study population dynamics of *Nephopteryx eugraphella* (Ragonot) in relation to weather parameters at the Horticultural Farm, B. A. College of Agriculture, AAU, Anand during 2014-15. The results showed that the infestation of chiku moth was appeared more or less throughout the year. The population of chiku moth, per cent leaf and bud damage were found in the range of 0.00 to 8.90 larvae per twig, 7.85 to 44.01% and 0.00 to 7.98%, respectively. The incidence of *N. eugraphella* on sapota was found during 3rd week of November (46th SMW) to 1st week of May (18th SMW) and 3rd week of May (20th SMW) to 2nd week of November (45th SMW). The activity of this pest reached at peak during 1st week of August, 31th SMW (8.90 larvae per twig and 44.01 per cent leaf damage) to 3rd week of September (38th SMW). The higher incidence was noticed during 4th week of July (30th SMW) to 1st week of November (44th SMW) which reflected on leaf as well as bud damage. The wind speed had significantly positive correlation (r = 0.277*) with larval population. The morning relative humidity, evening relative humidity, morning vapour pressure, evening vapour pressure and minimum temperature had highly significant positive effect on the larval population of this pest. The bright sunshine hours and evening vapour pressure deficit had highly significantly negative correlation (r = -0.589** and r = -0.440**, respectively) with larval population of chiku moth.

Keywords: Population dynamics, *Nephopteryx eugraphella* Sapota, Kalipatti, Correlation

1. Introduction
The sapota, *Manilkara achras* (Mill.) Fosberg. (Synonym, *Achras zapota* Linn.) Belongs to family sapotaceae, is commonly known as chiku, ciku, dilly, nasberry, sapodilla, plum, chico [10]. It is native of Mexico and Central America and now widely cultivated throughout the tropics. It is largely grown for commercial purpose in Gujarat, Maharashtra, Karnataka, Tamil Nadu, Kerala, Uttar Pradesh, Haryana, Punjab and West Bengal [4, 13]. In India, sapota ranks fifth in both production and consumption. India is considered to be the largest producer of sapota in the world. It was cultivated in 1.77 lakh ha area with a total production of 17.44 lakh tonnes and productivity is 9.90 tonnes/ha [1]. In Gujarat, it was grown under 28,800 hectares area with a production of 2.97 lakh tonnes and productivity is 10.4 tonnes/ha [2].
More than 25 insect pests attacked to sapota tree [3]. Among the different insect pests attacking sapota, chiku moth, *N. eugraphella* is a major pest of sapota and active throughout the year on sapota tree in middle Gujarat. Day by day the cultivation of sapota is increasing in middle Gujarat and simultaneously the problem of *N. eugraphella* is also increased. The infestation owing to this pest was observed throughout the year and remained between 1.79 and 31.54 per cent. Maximum infestation of 31.54 per cent is found during 2nd fortnight of July. Overall, the activity of this pest was higher during monsoon period. *i.e.*, July to September [12]. It was first reported by [6]. The caterpillar feeds on leaves, often on buds and flowers; sometimes on tender fruits also. For developing any pest management programme, specific agro-ecosystem information on abundance and distribution of pest in relation to weather parameters is the basic requirement. Therefore, a study on seasonal abundance of chiku moth (*N. eugraphella*) on sapota was carried out under prevailing agro-climatic conditions of Middle Gujarat condition.

2. Materials and Methods
2.1 Seasonal incidence of chiku moth
To study the population dynamics of *N. eugraphella* on sapota, an experiment was conducted at the Horticultural Farm, B. A. College of Agriculture, AAU, Anand during 2014-15 with

Kalipatti variety. The experiment was laid out by selecting more or less equal age trees having similar size and canopy. The population dynamics was studied based on the per cent chiku moth infestation on leaves and buds as well as larval population per twig on sapota tree. For the purpose, five randomly selected trees from orchard were observed at weekly interval from 3rd week of November, 2014 to 2nd week of November, 2015 and kept free from insecticidal application. From each tree, ten twigs (20 cm length) were selected randomly for recording the observations on number of healthy and damaged leaves and buds as well as number of larvae.

2.2 Statistical analysis
The influence of weather parameters on *N. eugraphella* (larval population, leaf and bud damage) was analyzed by correlation analysis for a period of one year. The data was analyzed by using statistical software SPSS [9].

3. Result and Discussion
3.1 Seasonal incidence of chiku moth
3.1.1 Larval population
The activity of *N. eugraphella* (Table 1) was found during 3rd week of November [46th Standard Meteorological Week (SMW)] to 1st week of May (18th SMW) and 3rd week of May (20th SMW) to 2nd week of November (45th SMW). During these periods, the larval population was fluctuated between 0.30 and 3.00 as well as 1.00 and 8.90 per twig. The activity of *N. eugraphella* was found below one larva per twig during 2nd week of February (6th SMW), 4th week of February (8th SMW) to 1st week of March (9th SMW), 2nd week of March (10th SMW), 4th week of April (17th SMW) to 2nd week of May (19th SMW). The higher activity of this pest was noticed in 4th week of July (30th SMW) to 1st week of November (44th SMW) with peaks on 1st week of August (31th SMW) and 3rd week of September (38th SMW). The higher activity of pest was also reflected on leaf and bud damage of sapota. The activity of *N. eugraphella* was not found during 2nd week of May (19th SMW).

3.1.2 Leaf damage
Leaf damage due to *N. eugraphella* was observed throughout the year and it was found form 7.85 to 44.01 per cent (Table 1). However, it was below 10 per cent during 4th week of April (17th SMW) to 1st week of June (23th SMW), 10 to 20 per cent during 5th week of November (48th SMW) to 3rd week of April (16th SMW), 1st week of June (23th SMW), 2nd (24th SMW) and 3rd week of June (25th SMW), 20 to 30 per cent during 2nd week of September (37th SMW) to 4th week of November (48th SMW) and 3rd week of June (25th SMW) to 4th week of June (26th SMW), 30 to 40 per cent during 1st week of July (27th SMW) to 3rd week of July (29th SMW) and 2nd week of August (32th SMW) to 1st week of September (36th SMW) and 40 to 50 during 4th week of July (30th SMW) to 1st week of August (31th SMW). The highest infestation (44.01%) on leaves was found in 1st week of August (31th SMW), While lower infestation was found during 5th week of May (22th SMW). The infestation of the pest on leaves was higher (>30%) during monsoon, moderate (15 to 25%) during winter and lower (<15%) during summer.

3.1.3 Bud damage
The data on the per cent bud damage caused by *N. eugraphella* was presented in table 1. It was found that chiku moth damage on buds remained throughout the year. The damage varied from 0.00 (2ndweek of May) (19th SMW) to 7.98 per cent in 1st week of October (40th SMW) during present investigation. Moreover, damage on bud was found to be higher during the month of August to November with a peak (7.98%) in 1st week of October (40th SMW).

According to [5]. The damage caused by the *N. eugraphella* to the shoots was maximum (40 and 60%, respectively) in June and September – October. The infestation of this pest on leaves and buds was more or less throughout the year and remained higher during monsoon, moderate during winter and lower during summer [8].

The infestation of *N. eugraphella* on sapota in Anand throughout the year except during 16th to 20th standard weeks (2nd fortnight of April to 1st fortnight of May, the higher activity of *N. eugraphella* on sapota trees was found during last week of May to first week of October and November - December with a first peak in July and second in November, these higher activity and peak directly reflected on leaf damage too, the pest incidence was found to be zero or negligible during March to 3rd week of May, during the remaining period (2nd week of May to 4th week of February) pest activity and leaf damage was found moderate on sapota trees[12]. The extent of leaf area damage by *N. eugraphella* larvae varied from 11.55 to 16.15 per cent round the year, maximum leaf area damage was recorded in the month of July to September *i.e.*, 17.5 per cent, the damage to buds varied from 1.0 to 6.6 per cent during the study periods, the maximum bud damage was recorded in the month of May in 2008-09 with 4.25 per cent damage, whereas it was 6.6 per cent in the month of July 2009-10, under laboratory condition a single larva consumes on an average 13.60 chiku buds during its larval periods[11]. These reviews corroborate our findings.

3.2 Correlation with weather parameters
3.2.1 Larval population
The correlation analysis (Table-2) indicated that the larval population of *N. eugraphella* had significantly negative correlation with evaporation (r= -0.320*) and highly significant negative correlation with bright sunshine hour (r= -0.589**) and evening vapour pressure deficit (r= -0.440**), whereas non-significant negative correlation with maximum temperature (r= -0.044) and morning vapour pressure deficit (r= -0.198). The larval population was positively correlated with rainfall (r= 0.268), but it was non-significant. The wind speed (r= 0.277*) had significantly positive correlation while morning relative humidity (r=0.382**), evening relative humidity (r= 0.626**), morning vapour pressure (r= 0.557**), evening vapour pressure (r= 0.640**) and minimum temperature (r= 0.373**) had highly significant positive effect on the larval population of this pest.

3.2.2 Leaf damage
The leaf damage was highly significant negative association with evaporation (r= -0.400**), bright sunshine hour (r= -0.721**) and evening vapour pressure deficit (r= -0.523**) whereas significant negative relationship with minimum temperature (r= -0.303*). The leaf damage was negatively associated with maximum temperature (r= -0.156) and morning vapour pressure deficit (r= -0.251) but non-significant. Rainfall (r= 0.339*) and wind speed (r= 0.348*) had significant positive correlation while morning relative humidity (r= 0.410**), evening relative humidity (r= 0.633**), morning vapour pressure (r= 0.481**) and evening vapour pressure (r= 0.583**) had highly positive significant

correlation with leaf damage (Table - 2).

3.2.3 Bud damage

The bud damage had significant negative correlation with bright sunshine hours (r= -0.336*), morning vapour pressure deficit (r= -0.302*) and evening vapour pressure deficit (r= -0.301*), whereas highly significant negative correlation with evaporation (r= -0.401**). The bud damage was negatively associated with wind speed (r= -0.060) and maximum temperature (r= -0.033) but non-significant. The bud damage was positively correlated with minimum temperature (r= 0.164), but non-significant. Evening relative humidity (r= 0.346*), morning vapour pressure (r= 0334*) and evening vapour pressure (r= 0343*) had significant positive correlation, while morning relative humidity (r= 0.403**) had highly positive significant correlation with bud damage in sapota (Table - 2).

Infestation of *N. eugraphella* on bud in middle Gujarat had significant positive correlation with rainfall, minimum temperature, morning and afternoon relative humidity as well as morning and mean vapour pressure deficit. Similarly, its infestation on leaves also had significant positive correlation with bright sunshine, maximum temperature, mean relative humidity, morning afternoon vapour pressure and afternoon vapour pressure deficit [7, 8]. Bright sunshine had highly significant and negative correlation with the population of *N. eugraphella* and leaf damage, maximum temperature was negatively correlated with the pest incidence but it was non-significant with larval population and significant with leaf damage, minimum temperature, morning relative humidity, morning vapour pressure, rainy day, wind speed and rainfall had highly significant positive association with larval population and leaf damage, morning vapour pressure and evening vapour pressure had significantly positive correlation with larval population, the RH_1 was positively correlated with larval population and leaf damage but it was non-significant [12]. These findings are in close conformity with the present results.

Table 1: Population fluctuation of *N. eugraphella* and its damage on sapota during 2014-15

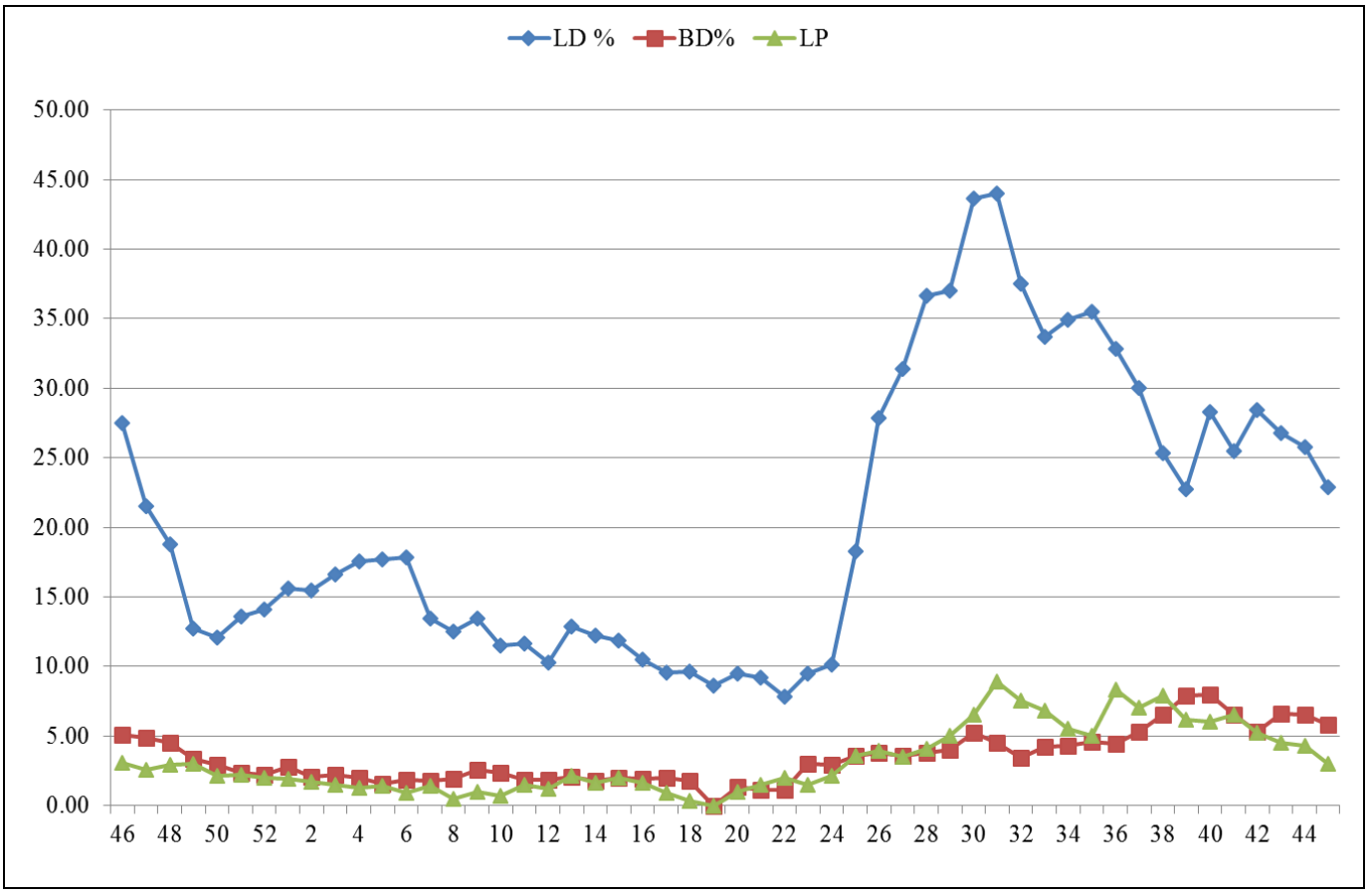
Sr. No.	Month and Year	Week	SMW	No. of larvae/twig	Damage (%)	
					Leaf	Bud
1	November 2014	III	46	3.10	27.50	05.10
2		IV	47	2.60	21.50	04.89
3		V	48	2.90	18.79	04.49
4	December 2014	I	49	3.00	12.72	03.36
5		II	50	2.10	12.09	02.89
6		III	51	2.20	13.58	02.37
7		IV	52	2.00	14.09	02.18
8	January 2015	I	1	1.90	15.64	02.78
9		II	2	1.70	15.46	02.09
10		III	3	1.50	16.63	02.19
11		IV	4	1.30	17.56	01.96
12	February 2015	I	5	1.40	17.71	01.54
13		II	6	0.90	17.87	01.87
14		III	7	1.40	13.44	01.75
15		IV	8	0.50	12.50	01.89
16	March 2015	I	9	0.95	13.45	02.59
17		II	10	0.70	11.49	02.32
18		III	11	1.50	11.65	01.85
19		IV	12	1.20	10.29	01.87
20		V	13	2.10	12.88	02.05
21	April 2015	I	14	1.60	12.25	01.80
22		II	15	2.00	11.88	02.00
23		III	16	1.60	10.50	01.88
24		IV	17	0.90	09.56	01.96
25	May 2015	I	18	0.30	09.65	01.77
26		II	19	0.00	08.59	00.00
27		III	20	1.00	09.50	01.32
28		IV	21	1.50	09.16	01.10
29		V	22	2.00	07.85	01.14
30	June 2015	I	23	1.50	09.50	02.98
31		II	24	2.10	10.15	02.91
32		III	25	3.60	18.30	03.58
33		IV	26	3.90	27.85	03.78
34	July 2015	I	27	3.50	31.38	03.55
35		II	28	4.10	36.63	03.79
36		III	29	5.00	36.97	04.01
37		IV	30	6.50	43.65	05.22
38	August 2015	I	31	8.90	44.01	04.54
39		II	32	7.50	37.50	03.45
40		III	33	6.80	33.70	04.25
41		IV	34	5.50	34.90	04.31
42		V	35	5.00	35.50	04.56
43	September 2015	I	36	8.30	32.83	04.44
44		II	37	7.00	30.00	05.32
45		III	38	7.90	25.30	06.50
46		IV	39	6.20	22.75	07.89

47	October 2015	I	40	6.00	28.30	07.98
48		II	41	6.50	25.50	06.56
49		III	42	5.20	28.45	05.31
50		IV	43	4.50	26.79	06.58
51	November 2015	I	44	4.30	25.75	06.50
52		II	45	3.00	22.90	05.80

Table 2: Correlation co-efficient between weather parameters and *N. eugraphella* incidence on sapota

Weather parameters	Correlation coefficient (r)		
	Larva Population	Damage (%)	
		Leaf	Bud
1	2	3	4
Evaporation	-0.320*	-0.400**	-0.401**
Bright sunshine hours, hr day^{-1} (BSS)	-0.589**	-0.721**	-0.336*
Rainfall, mm (RF)	0.268	0.339*	0.187
Wind Speed, kmhr^{-1}	0.277*	0.348*	-0.060
Maximum Temperature, ^{0}C (MaxT)	-0.044	-0.156	-0.033
Minimum Temperature, ^{0}C (MinT)	0.373**	0.303*	0.164
Morning Relative Humidity, % (RH_1)	0.382**	0.410**	0.403**
Evening Relative Humidity, % (RH_2)	0.626**	0.633**	0.346*
Morning Vapour pressure mm of HG (VP_1)	0.557**	0.481**	0.334*
Evening Vapour pressure mm of HG (VP_2)	0.640**	0.583**	0.343*
Morning Vapour pressure deficit (VPD_1)	-0.198	-0.251	-0.302*
Evening Vapour pressure deficit (VPD_2)	-0.440**	-0.523**	-0.301*

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



Graph 1: Activity of *N. eugraphella* and its damage in sapota during 2014-15

4. Conclusion

The results showed that the infestation of chiku moth was appeared more or less throughout the year. The peak activity of this pest reported during 1st week of August, 31th SMW (8.90 larvae per twig and 44.01 per cent leaf damage) to 3rd week of September (38th SMW). The higher incidence was noticed during 4th week of July (30th SMW) to 1st week of November (44th SMW) which reflected on leaf as well as bud damage. The seasonal incidence of *N. eugraphella* delineated the pest population build up and correlation with weather parameters which can be utilized for decision making and to predict the incidence of the pest.

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