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Seasonal incidence and weather based forecasting model for mango leaf webber *Orthaga eudrusalis* walker (Lepidoptera: Pyralidae) under subtropical conditions

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ABSTRACT

A field experiment was conducted for two consecutive seasons (2013 and 2014) in Lucknow, Uttar Pradesh to study seasonal incidence and develop weather based forecasting model for mango leaf webber. A wide variation was observed in the leaf webber incidence across fixed plot orchards, standard meteorological weeks (SMW) and between two seasons. The peak incidence of leaf webber was found during the 37th SMW during the year 2013 with 9.7 webs per tree, whereas, in the consecutive season its peak incidence was observed during 38th SMW with 3.5 webs per tree. Mango leaf webber incidence was found to be significant negative correlation with minimum temperature (r = - 0.39), wind speed (r = - 0.48**) and positively correlated with the minimum relative humidity (r = 0.37**). Compare to linear models, polynomial models had explained highest amount of variation. Minimum temperature, minimum relative humidity along with wind speed had explained 36 per cent of variation in the leaf webber incidence. Hence, the weather based forecasting model for the leaf webber (Y) for Lucknow region is Y = 31.90 - 1.35 × minimum temperature - 0.72 × wind speed + 0.08 × minimum relative humidity (R^2 = 0.36; F = 4.20 p< 0.01). This prediction model after validation can be utilized in the agro advisories for predicting the incidence and timely management of leaf webber.**

Key words: Leaf webber, Mango, Regression model, Seasonal incidence

Mango (*Mangifera indica* L.) is considered as a major fruit crop, popularly known as king of fruits. This crop suffers regularly a huge loss due to ravages of insect pests. Mango leaf webber, *Orthaga euadrusalis* recently has become major limiting factor in mango production regions of Uttar Pradesh, Bihar and other parts in north India (Rajkumar *et al*., 2013). Leaf webber is a lepidopteran pest, the adult moth do not directly cause any economic damage to the host plant. The larvae of the Pyralid moth are voracious leaf eaters that web together the cluster of leaves in to a colony. A heavily infested tree shows many clusters of webbed and dried leaves, presenting it a conspicuous burnt up appearance (Rafeeq and Ranjini, 2011). The extent of damage caused by this pest under favourable conditions was estimated as 35 per cent (Srivastava and Tandon, 1982). Verghese (1998) reported that severe infestation of mango leaf webber results in complete failure of flowering.

Many workers has studied the different aspects of mango leaf webber time to time, that includes biology and incidence of the pest (Hasseb *et al*., 2000; Singh, 2002; Beria *et al*., 2008; Reddy, 2013), screening of the germplasm to identify the resistance source (Reddy *et al*., 2001), exploration of entomopathogenic fungi (Asari *et al*., 1977), efficacy of neem formulation and insecticides (Singh, 1999; Bhatia and Gupta, 2002). However, management of mango leaf webber is difficult due to the large size of mango tree, micro-ecosystem of the mango orchard in which the pest breeds in active period and remained in the same orchard during off-season (Shukla *et al*., 2001). Hence, timely management is the very crucial step to be followed for the effective control of this pest. Studies on population dynamics leaf webber and effect of abiotic factors are very few (Lakshmi *et al*., 2011; Singh and Verma, 2013). Keeping in this view, the present study was conducted with the objective of quantifying seasonal incidence of leaf webber and develop weather based forecasting model for leaf webber for major mango growing area of Uttar Pradesh.

MATERIALS AND METHODS

A field experiment was conducted for two consecutive seasons (2013 and 2014) in Lucknow, Uttar Pradesh, India at 22 locations. The climate of the experimental site is semi-arid subtropical with hot dry summers and cold winters. Orchards of Mango cv. *Dashehari* of 20-35 years age were selected with planting 10 m × 10 m. Data on leaf webber incidence was recorded on weekly basis from 5 randomly selected trees in four direction of the tree. Leaf webber incidence was taken by visual counting of number of webs formed by the pest. For analysis, mean number of webs per tree was taken. Concurrently, daily weather data of temperature (maximum and minimum), relative humidity (maximum and minimum), rainfall, wind speed were recorded in the agromet observatory located within the experimental site. Mean weekly data of weather paramneters were taken for the analysis.

The mean weekly data on incidence of leaf webber and was subjected for the correlation and regression analyses with leaf webber incidence as a dependent factor. Significant correlation coefficient (r) values are the criteria to select suitable factor (s) to develop linear models with leaf webber incidence on the Y-ordinate. The extent of variability in the leaf webber incidence due the factor was determined based on the R-value (R^2) or coefficient of determination. All the required statistical analyses were carried out by using Microsoft excel.

RESULTS AND DISCUSSION

Weather conditions during the study period

The agro climatic analyses during the current study period (2013-2014) indicated that the maximum temperature varied between 21.44 to 40°C in first season (2013) as compare to 16.43 to 43.44°C in the second season (2014). However during the period of peak occurrence of leaf webber (31st to 41st SMW), 29.07 to 34.43°C and 30.93 to 36.57°C was recorded in two seasons, respectively. During this period minimum temperature was higher during 2013 season as compare to 2014. Declining trend of minimum temperature was observed after 38th SMW. Wide variation in wind speed was found, higher wind speed was recorded in 2014 as compared to 2013. Maximum and minimum relative humidity was in the range of 77.0 to 90.57 per cent and 48.29 to 77.43 per cent across these seasons during the peak period of the pest. The total amount of week's average rainfall was 130 mm in 2013 as compared to 93 mm 2014. The highest amount of 21.74 mm followed by 13.71 mm rainfall was recorded in period of peak occurrence in 2013, while only 13.23 followed by 12.86 mm was received in 2014. Higher pan evaporation was observed in 2014 i.e. 6.39 to 10.09 mm per day while in 2013, only 3.70 to 6.59 mm per day was noted (Table 1).

Table 1. Weather parameters during the study period

SMW	Temp. max (°C)		RH max (%)		RH min (%)		Rainfall (mm)		Evaporation (mm day^{-1})	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
20	39.29	38.59	69.57	51.71	43.57	24.14	0.00	0.00	9.31	11.03
21	40.00	40.57	77.43	46.57	44.71	22.86	0.00	0.00	8.67	12.09
22	37.36	38.04	76.14	68.57	47.43	37.71	0.00	0.00	8.66	11.26
23	35.64	43.44	81.71	59.00	56.29	28.71	0.00	0.00	5.51	11.83
24	34.91	40.57	76.57	72.86	56.71	38.43	1.29	0.43	4.90	12.64
25	32.36	36.50	85.86	85.71	62.57	57.00	15.47	3.00	5.99	9.30
26	30.14	39.40	87.00	76.00	79.86	45.29	23.34	0.00	5.17	11.91
27	31.79	34.64	87.14	82.71	73.00	58.29	6.51	1.57	4.19	11.79
28	32.29	34.36	84.14	88.29	67.86	65.14	11.14	8.36	4.13	8.86
29	33.14	31.36	86.43	88.29	70.86	77.43	7.00	12.60	5.19	6.34
30	33.19	32.07	86.71	88.29	66.86	71.29	13.29	1.97	5.23	6.09
31	34.26	33.86	77.57	86.00	60.00	66.14	0.00	3.49	6.59	6.86
32	31.47	32.00	90.57	89.29	77.43	70.86	13.71	11.63	4.09	6.39
33	33.00	33.64	90.29	86.86	73.00	64.14	21.74	0.40	5.10	7.80
34	34.03	36.57	88.86	83.29	60.29	53.43	1.00	1.26	4.54	9.10
35	32.03	35.79	87.00	77.00	70.43	54.43	7.43	0.00	4.44	10.09
36	34.33	32.71	82.14	88.43	57.14	64.71	0.17	13.23	5.41	7.24
37	34.10	30.93	84.14	89.29	61.43	72.71	0.63	12.86	5.40	7.61
38	34.43	33.14	83.71	86.57	54.00	64.14	0.00	6.97	4.70	7.49
39	34.14	34.43	85.71	77.14	65.14	59.00	2.97	0.00	3.86	8.21
40	29.07	34.36	86.57	81.43	72.00	57.57	3.69	1.60	3.70	8.23
41	31.03	34.43	86.71	83.29	62.71	48.29	0.66	0.00	3.73	7.93
42	30.69	27.57	63.43	88.29	85.57	63.29	0.00	10.91	3.13	5.69
43	31.81	30.71	76.43	84.86	47.57	47.14	0.00	0.00	3.49	6.57
44	30.93	29.89	82.43	87.57	40.29	50.86	0.00	0.00	3.07	6.56
45	28.14	30.21	82.00	81.86	41.86	43.00	0.00	0.00	2.49	5.71
46	27.07	28.14	78.57	79.86	33.43	32.14	0.00	0.00	2.47	5.90
47	26.44	27.20	86.29	81.29	34.43	32.43	0.00	0.00	2.57	4.24
48	26.83	27.00	82.14	86.14	39.29	33.57	0.00	0.00	2.84	3.83
49	25.43	24.43	82.86	83.00	35.71	44.14	0.00	0.00	2.39	3.61
50	24.00	21.07	84.57	87.43	39.14	53.71	0.00	2.77	2.53	3.14
51	22.37	17.61	90.29	90.00	56.14	62.71	0.00	0.00	2.59	2.90
52	21.44	16.43	86.47	86.00	46.88	59.57	0.00	0.00	2.34	2.37

SMW – Standard meteorological week; Temp. max- Maximum temperature; RH max- Maximum relative humidity; RH min – Minimum Relative humidity

Dynamics of leaf webber incidence

A wide variation was observed in the leaf webber incidence across the 22 fixed plot orchards and between two consecutive seasons (Fig. 1). During the year 2013 the highest leaf webber incidence was observed at Navipana (Fixed I) and Hafizkhera (Fixed I) with 5.9 webs per tree, whereas, during the year 2014 the highest incidence was observed at CISH III Block with 11 webs per tree. The variation in the incidence of leaf webber is attributed to the microclimatic conditions existing within the orchard. The leaf webber incidence also varied across the standard meteorological weeks (SMW). The peak incidence of leaf webber was recorded during the 37th SMW during the year 2013 with 9.7 webs per tree, whereas, in the consecutive season its peak incidence was observed during 38th SMW with 3.5 webs per tree. In general the leaf webber incidence was found to be higher during the year 2013

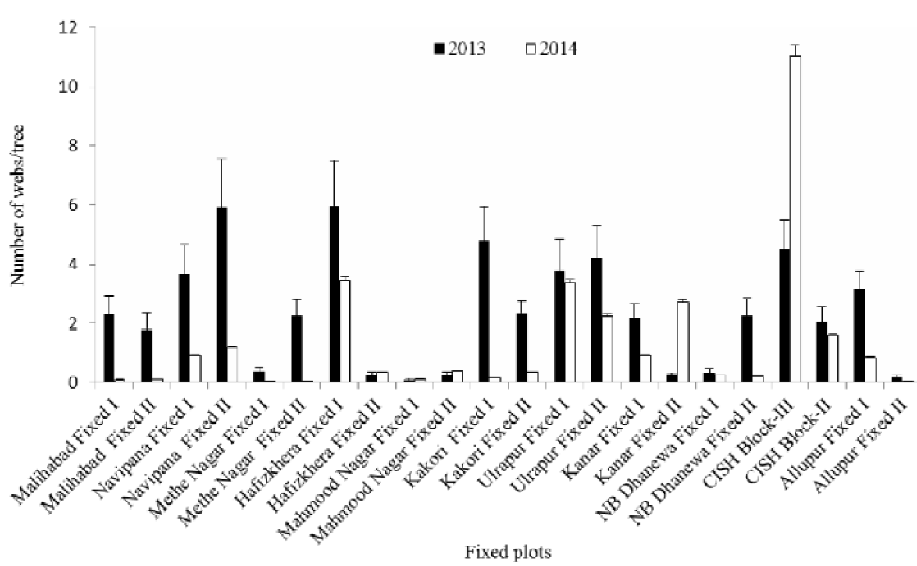

Fig. 1. Mango leaf webber incidence in different fixed plots

as compare to 2014 (Fig. 2). The variation in the incidence attributed to higher amount of rainfall received during peak occurrence of leaf webber during 2013 as compared to 2014 season. This indicated humid/wet conditions were favourable for leaf webber incidence. Higher pan evaporation during 2014 coupled with high wind speed, low rainfall and higher maximum temperature resulted in dry condition could be responsible factors for the low incidence of leaf webber during the year 2014 as compare to 2013 season (Table 1; Fig. 3 and Fig. 4). Observations with respect to the spatio-temporal variation in the leaf webber incidence are corroborated with the findings of Reddy *et al.* (2001). Lakshmi *et al.* (2011) reported that the peak incidence of leaf webber was observed during 44th SMW at Hyderabad, Andhra Pradesh. Verma and Singh (2010) observed the three distinct peaks of leaf webber incidence during first fortnight of August, September and October at Bhopal, Madhya Pradesh. The distinct different peaks of pest was attributed to it's overlapping generations from June to December. In the present study, however two distinct peaks were observed during 33rd and 37th SMW that coincides with first fortnight of August and September.

Leaf webber incidence was subjected for the correlation analyses where leaf webber incidence was taken as dependent factor and weather parameters were taken as independent factor. The results indicated that mango leaf webber incidence had significant negative correlation with minimum temperature (r = - 0.39**), wind speed (r = - 0.48**) and positively correlation with the minimum relative humidity (r = 0.37**) (Table 2). Our findings are in line with findings of Lakshmi *et al.* (2011), where in leaf webber incidence was negatively correlated with all the weather parameters except sunshine hours. However in our study positive correlation was observed with the minimum relative humidity. A step-wise regression analysis was carried out by considering significant weather factors

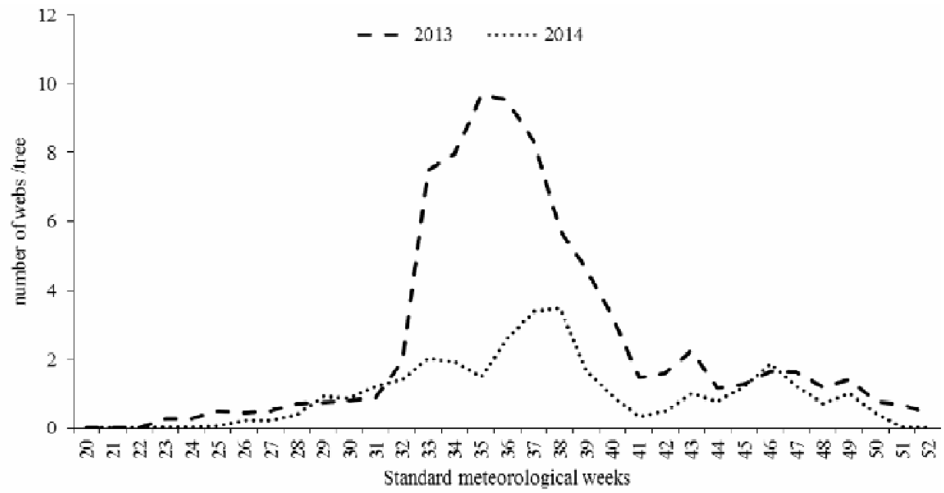

Fig. 2. Leaf webber incidence in different fixed plots across standard meteorological weeks

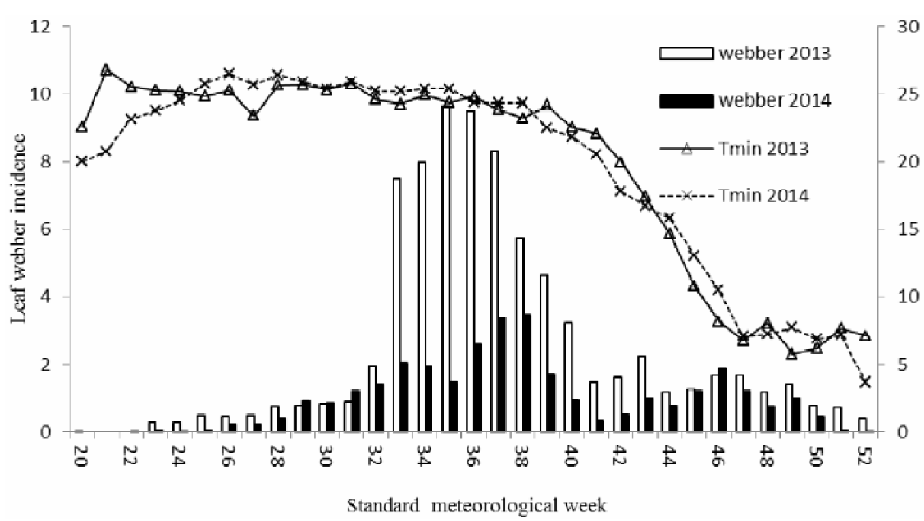

Fig. 3. Dynamics of leaf webber incidence in relation to minimum temperature

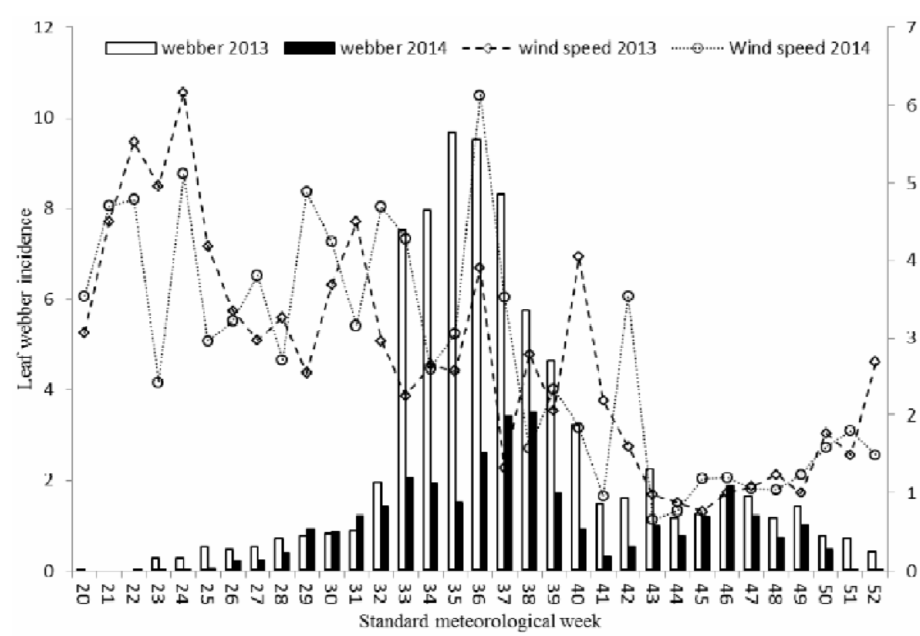

Fig. 4. Dynamics of leaf webber incidence in relation to wind speed

Table 2. Correlation between weather parameters and leaf webber incidence

Weather parameters (Units)	Correlation co-efficient (r)
Maximum Temperature (°C)	-0.16
Minimum Temperature (°C)	-0.48**
Relative humidity minimum (%)	0.37**
Relative humidity maximum (%)	0.15
Wind speed (km/hr)	-0.39**
Rainfall (mm)	0.14

** Significant at P=0.01

as an independent variable and leaf webber incidence as dependent variable. The results revealed that linear models for the leaf webber had explained 14 to 23 per cent of variation. Among the significant weather factors influencing the leaf webber incidence minimum temperature alone had explained 23 per cent of variation. Second order polynomial models had explained 24 to 34 per cent variation. Minimum temperature along with wind speed had explained 34 per cent of variation in the leaf webber incidence (Table 3). This clearly indicates that these two factors play a crucial role in the population buildup and survival of the leaf webber successfully. However, minimum relative humidity positively correlated with leaf webber incidence its contribution for the variation is only 2 per cent. Adding minimum relative humidity to the third order polynomial model could explain up to 36 per cent variation in the leaf webber incidence. Kavitha *et al.* (2005) developed regression model for mango leaf webber in relation to weather parameters and predicted the incidence to an extent of 76 per cent with minimum temperature and forenoon relative humidity. Lakshmi *et al.* (2011) also opined that compare to linear models non-liner models could explain the maximum variation in the leaf webber incidence. This prediction models after validation can be used in the agro advisories for predicting the incidence and timely management of leaf webber.

Table 3. Weather based regression models for mango leaf webber

Models	Equation	R^2	Adj. R^2	F	P <
Linear	Y = 44.76-1.69 × Minimum temperature	0.23	0.19	7.18	0.01
	Y= 5.23-0.88× Wind speed	0.15	0.12	4.49	0.04
	Y= -16.99+0.22× Maximum relative humidity	0.14	0.10	4.04	0.05
Polynomial	Y= 44.07-1.55 × Minimum temperature -0.77× Wind speed	0.34	0.29	6.18	0.00
	Y= -10.55-0.73× Wind speed+0.17 × Maximum relative humidity	0.24	0.17	3.73	0.03
	Y= 26.07-1.37× Minimum temperature +0.12× Maximum relative humidity	0.26	0.20	4.17	0.02
	Y= 31.90-1.35× Minimum temperature -0.72× wind speed+0.08× Maximum relative humidity	0.36	0.27	4.20	0.01

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