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Influence of weather parameters on the population dynamics of mango hopper

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ABSTRACT

Field experiments were conducted during 1998-99 to 2000-2001 to study the mango hopper population dynamics in relation to weather parameters. Results revealed that although mango hopper's initiation and buildup were closely associated with the reproductive stages of mango, the weather parameters were found to expediting the population growth and/or inhibited their further growth. Low mean temperatures (Tmean <22 °C) were found to be unfavourable. Maximum population was associated with higher mean temperature (>28 °C). Fortnightly rainfalls of more than 100 mm were found to have washing out effect although the temperatures were optimum. Correlations worked out on seasonal basis were higher than that obtained on annual basis. Wind speed, minimum temperature and vapour pressure had maximum association with hopper population (r = 0.76 to 0.78**). Linear models could explain only 36 to 61% variation in mango hopper population but the nonlinear model such as power or exponential explained up to 78% of the variation in population.

Key words : Mango hopper, Weather, Correlation, Non -linear models

Mango (*Mangifera indica L.*) is one of the most important fruit crop of the tropics and sub tropics. In India it is cultivated in 12.8 lakh hectares with annual production of 97.81 lakh metric tonne. In Gujarat it is cultivated in 57.5 thousand hectares with the production of 3.69 lakh tonne fruit. The popular varieties grown in Gujarat are *kesar, langdo* and *alphanso*. The export trend of mango is increasing day by day and India ranks third for the export of mango. The export is largely dependent upon the quality of fruit, which is affected by biotic and abiotic factors. Mango hoppers are the most serious pests causing damage almost every year throughout the country. A countless number of nymphs and adults suck the cell sap from the inflorescences and flower buds during flowering season. The infested flowers shrivel turn brown and ultimately fall off. They destroy entire crop in cases of severe attack, but usually the losses may range from 25 to 60 per cent (Wadhi and Batra, 1964). In spite of various improved technologies adopted by the farmers for cultivation of mango fruit crop, the pest problem still continues to be the major limiting factor, resulting in heavy loss in the yield and its quality. Patel *et al* (1994) have reported that the mango hopper population had close association with weather parameters particularly vapour pressure. The status of the pest changes rapidly because of their dynamic nature and is affected in general by the abiotic factors.

In order to understand the complex relationships between weather parameter on the population build up of mango hopper, this study was under taken.

MATERIALS AND METHODS

Field experiments were conducted during 1998-99 to 2000-01 at Horticultural farm of B.A. College of Agriculture, GAU, Anand, to study the population dynamics of mango hopper in relation to weather parameters. Five random trees were selected from mango orchard (cv. *Langado*). The mango hopper population was recorded at 15 days interval starting from May 1998. The samples of mango hopper were collected per sweep by shaking small branches with the upper edge of sampling sweep stick. The numbers were counted and were averaged over five trees. The corresponding weather parameters were collected from the agro-meteorological observatory situated near the orchard within the campus. The daily weather data were averaged over 15 days preceding the dates of observation of mango hopper population. Correlation analysis was carried out to find out the degree of association between the populations of mango hopper and preceding weather parameters. Multiple regression equations were developed using those weather parameters which had consistent and significant correlation.

RESULTS AND DISCUSSION

Mango hopper population dynamics

The three-year fortnightly mean weather parameters along with the hopper population are presented in Table 1. The hopper population was found to vary from 1 to 361 hoppers during the year. The lowest population (1 to 5 hoppers) was observed during winter season (December to first fortnight of February). Population gradually increased from 16 to 91 hoppers during second fortnight of February to first fortnight of April months. These periods coincides with the floral bud initiation of mango. The hoppers become active and start laying eggs on the inflorescence. During subsequent periods, with the availability of adequate food for hoppers, their reproduction capacity increased. This caused maximum population buildup (265 to 361 hoppers) of hoppers during second fortnight of April to first fortnight of June. Thereafter its population decreased continuously due to unfavouable weather conditions particularly rainfall.

The seasonal variation of mango hopper population in all the three years (1998-99; 1999-2000 and 2000-2001) is presented in Figs. 1 (a-c). During 1998-99, very low population (<35 hoppers) was observed during June to first fortnight of February (Fig.1a). The maximum population of 660 was observed during second fortnight of April, which was the highest among all the years. During 1999-2000, the population decreased gradually from 180 to 70 hoppers during June to September months and as usual the peak populations (205-565 hoppers) were observed during April and May (Fig 1b). However, the year 2000-01 tells slightly different story (Fig.1c). The populations during June to August periods were higher (100-415 hoppers) than that usually observed during April and May (60-125 hoppers).

Table 1 : Fortnightly average weather parameters and mango hopper population.

Period	EP (mm day^{-1})	BSS (h day^{-1})	Rain fall (mm)	WS (km h^{-1})	Tmax (°C)	Tmin (°C)	Tmean (°C)	RH mean (%)	VP mean (mm of Hg)	Mean Hoppers population
Jan-I	2.6	6.3	1.4	2.0	28.1	11.9	20.0	65.8	10.4	1
Jan-II	3.5	9.4	0.0	2.1	27.7	10.6	19.1	57.5	10.6	4
Feb-I	4.0	9.7	0.0	2.9	28.5	10.9	19.7	57.0	10.2	4
Feb-II	4.0	9.5	0.0	3.2	28.9	11.6	20.3	55.6	10.3	16
Mar-I	5.0	9.5	0.0	3.1	32.7	14.3	23.5	50.6	9.4	51
Mar-II	6.5	9.9	0.0	3.0	35.6	15.7	25.6	44.0	8.4	45
Apr-I	6.7	10.2	0.0	2.7	37.0	17.1	27.0	49.6	11.6	91
Apr-II	7.8	10.2	0.0	4.2	37.0	19.6	28.3	51.7	14.1	290
May-I	7.7	9.7	0.0	4.9	37.1	23.1	30.1	57.7	17.7	361
May-II	7.9	9.5	28.1	5.9	36.7	23.6	30.1	56.2	17.8	309
Jun-I	8.4	9.1	44.5	7.4	37.2	26.8	32.0	63.8	21.9	265
Jun-II	7.1	7.2	69.6	7.7	35.9	27.2	31.5	68.6	22.9	188
July-I	4.5	3.6	134.5	6.3	32.4	26.0	29.2	82.0	24.3	203
July-II	3.9	4.1	80.4	5.7	31.7	25.9	28.8	78.7	23.2	98
Aug-I	3.8	3.2	114.1	5.1	31.6	25.5	28.5	81.8	23.4	90
Aug-II	4.6	5.1	32.1	4.3	32.9	25.4	29.2	77.3	22.9	145
Sept-I	4.8	6.1	77.1	5.2	32.6	24.8	28.7	75.8	21.8	99
Sept-II	4.9	7.3	35.8	3.7	34.2	24.8	29.5	74.2	22.3	47
Oct-I	4.9	7.8	21.1	3.0	35.3	24.5	29.9	70.9	21.5	53
Oct-II	4.8	9.2	13.6	2.3	35.0	19.2	27.1	61.2	15.2	48
Nov-I	4.6	9.4	3.7	2.2	34.4	17.4	25.9	56.3	13.1	22
Nov-II	3.7	9.2	0.0	2.1	32.1	14.4	23.3	55.7	10.8	16
Dec-I	3.6	9.5	0.0	2.4	30.6	11.4	21.0	54.4	9.1	5
Dec-II	3.0	9.2	0.0	2.0	29.8	11.4	20.6	58.3	9.5	5

Where, E.P. is pan evaporation, BSS is bright sunshine hours, WS is wind speed, Tmax is minimum temperature, Tmean is mean temperature, RH is relative humidity and VPmean is mean vapour pressure.

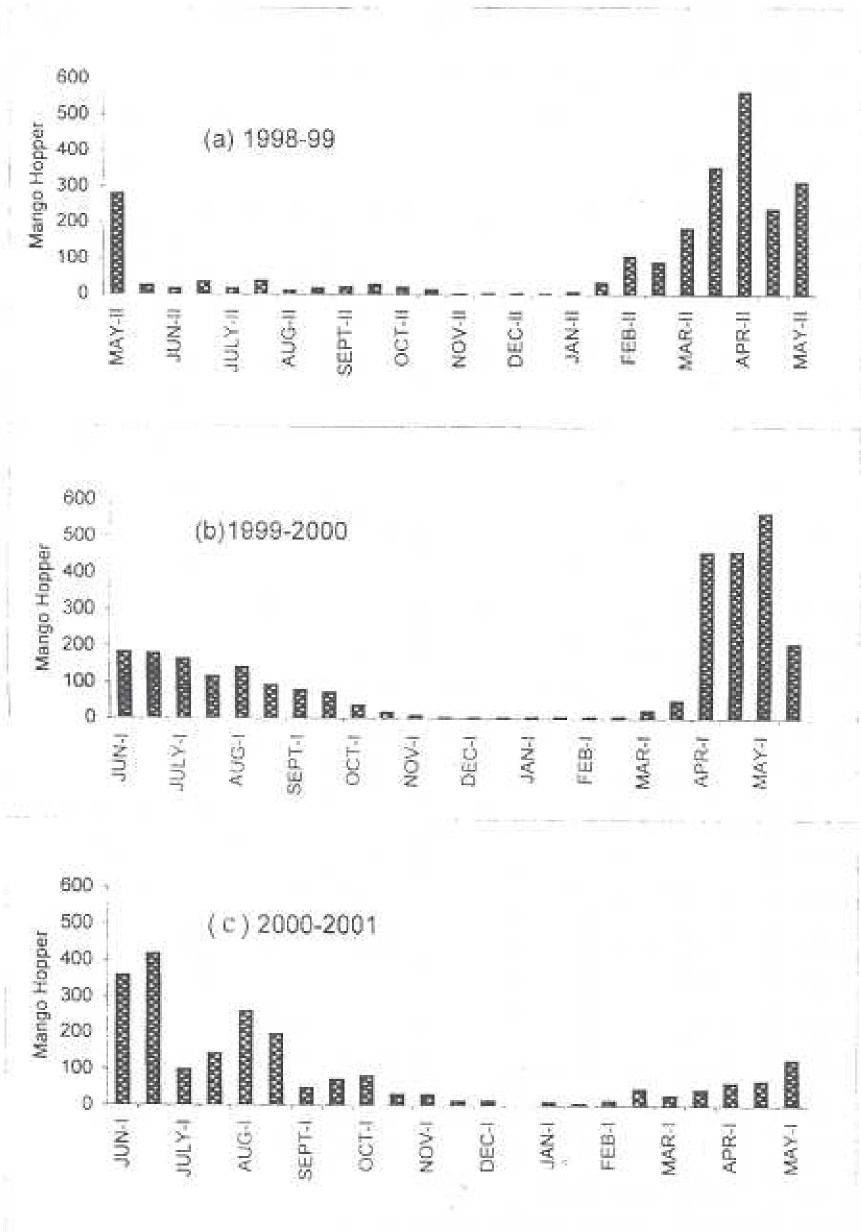

Fig. 1 : Fortnightly variation in the population build up of mango hopper during (a) 1998-99 (b) 1999-2000 and (c) 2000-2001

Table 2 : Fort-nightly rainfall distribution (June to September) during three years.

Month	Fort-night	1998 Rainfall (mm)	1998 Rainy days	1999 Rainfall (mm)	1999 Rainy days	2000 Rainfall (mm)	2000 Rainy days
June	I	95.4	3	0.0	--	38.0	2
	II	32.7	1	164.7	6	11.5	1
July	I	177.9	9	38.4	4	187.7	7
	II	73.8	4	141.5	4	34.5	3
August	I	274.2	10	29.8	3	29.7	4
	II	56.6	5	0.0	--	51.2	6
September	I	203.4	7	7.4	1	13.3	1
	II	104.2	5	2.8	1	--	--
Total		1018.2	44	384.6	19	365.9	24
No. of fortnights with rainfall >100 mm		4		2		1	
Hooper populations during June to September		Range: 10-37		71-182		47-417	
		Mean : 22		127		198	

Table 3. Correlation coefficients between weather parameters and mango hopper population

Weather parameters	1998-99	1999-2000	2000-2001	Pooled Annual	Pooled Seasonal
Rainfall-	0.23	0.31	0.75 **	0.11	-0.40 *
Evaporation (EP)	0.82 **	0.65 **	0.41 *	0.66 **	0.68 **
BSS	0.43 *	0.02 -	0.47 *	0.03	0.41 *
Wind Speed (WS)	0.56 **	0.69 **	0.79 **	0.64 **	0.77 **
Max. Temperature	0.72 **	0.57 **	0.16	0.52 **	0.60 **
Min. Temperature	0.36	0.64 **	0.69 **	0.54 **	0.76 **
Mean Temperature	0.54 **	0.68 **	0.58 **	0.56 **	0.72 **
Mean Relative Humidity	-0.36	0.26	0.58 **	0.12	0.19
Mean Vapour Pressure	0.15	0.59 **	0.72 **	0.45 **	0.78 **
No. of observations (N)	24	24	24	72	48 (24 for rainfall)

Weather parameters and population buildup

Although the populations buildup of mango hopper are largely dependent on the food availability on the host trees, forgoing observations revealed the large variation in hopper population within years and seasons. These can be explained in terms of variation in weather parameters. The lowest population observed during winter season (December - February) in all the years (Table 1) was due to low maximum temperatures (Tmax < 31 °C); minimum temperatures (Tmin <12 °C) and mean temperatures (Tmean < 21 °C). Thus the low temperatures inhibited the growth and development of mango hoppers. During the year 1999-2000 (Fig.1b), the population was less up to first fortnight of March which was largely due to low temperature (Tmean <22 °C) prevailed during the periods.

As the temperatures started increasing during March, the population buildups were also found to increase. Maximum temperatures between 31 and 37 °C; minimum temperatures between 12 and 18 °C and mean temperatures between 23 and 28 °C were found conducive for hopper breeding and thereby helpful in increasing their population buildup during subsequent months (Table 1). The higher temperatures (Tmax. > 35 °C; Tmin >23 °C and Tmean >30 °C) in conjunction with higher relative humidity (50 to 80 %) and vapour pressure (between 20 - 24 mm of Hg) were most suitable for mango hoppers for maintaining their populations. In year 2000-01 (Fig.1c) the population could not increase mainly due to low vapour pressure (<15 mm of Hg) prevailed up to April, which inhibited their further breeding (Fig. 3). The maximum populations were found to be associated with maximum temperature of 35-40 °C, minimum temperatures of 23 to 28 °C, mean temperature of 27 to 32 °C and evaporation of 7-9 mm day^{-1}.

During rainy season (June to September), rainfall played major role in controlling the populations, although the temperatures were optimum. During 1998 the rainfall was maximum (1018.2 mm) among all the years (Table 2) while the population was minimum (10-37 hoppers) in this season. During years 1999 and 2000, the rainfalls were more or less same (384.6 mm and 365.9 mm respectively) but the populations varied greatly (71-182 hoppers in year 1999 and 47 - 417 hoppers in year 2000 (Fig. 2)). This large variation was mainly due variation in rainfall amounts and intensity. Although the total number of rainy days in year 2000 was more than that in 1999, the population buildup was higher. Moreover, the numbers of fortnights receiving 100 mm or more rainfall were 4, 2 and 1 in years 1998, 1999 and 2000 respectively (Table 2) while the populations were 22, 127 and 198 in the respective years. This revealed that the heavy showers of more than 100 mm in a fortnightly rainfall had washing out effect on hopper population whereas the light showers did not have adverse effect on the population. In year 1998, the effect was maximum with 4 fortnights of heavy showers, which did not allow hoppers to reestablish their population, while in year 2000, effect was minimum as there was only one fortnight receiving such rainfall which could slightly reduce their population (First fortnight of July) but could not prevent its further growth (Fig.1c).

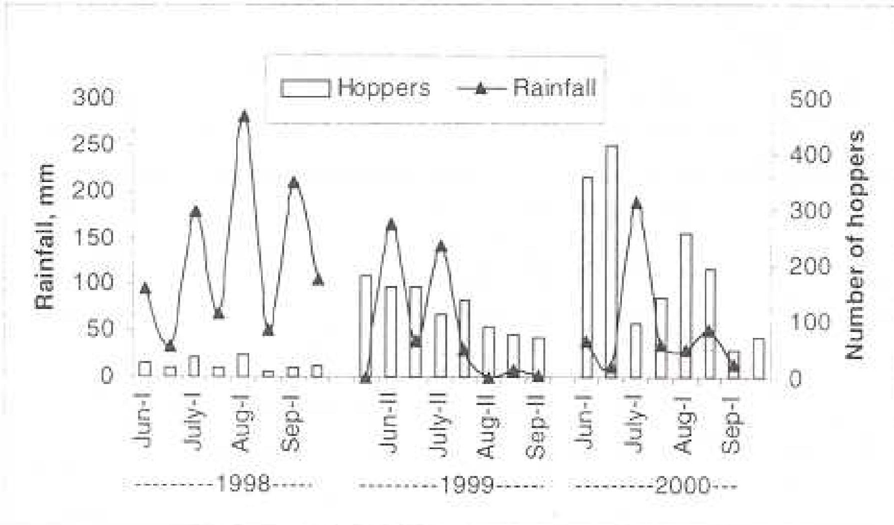

Fig. 2 : Rainfall during June to September and hopper population

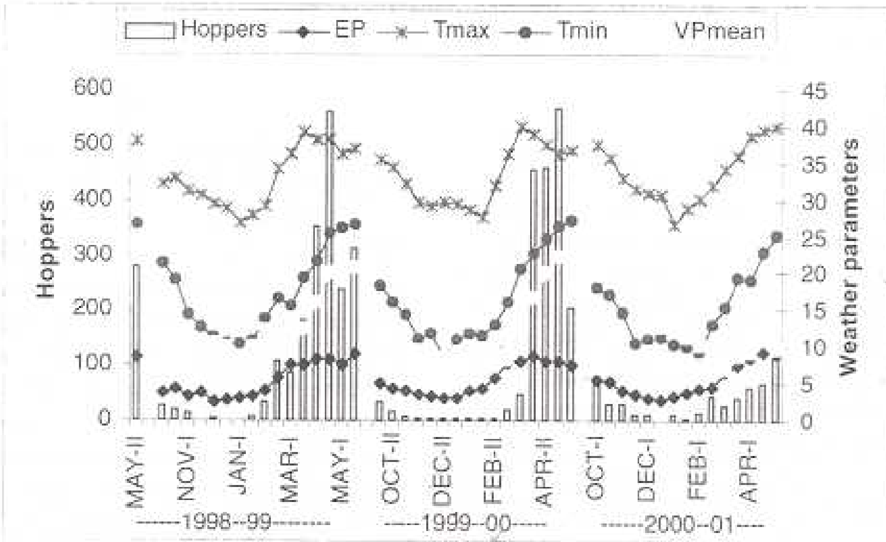

Fig. 3 : Maximum (Tmax) and minimum temperatures (Tmin), vapour pressure (VPmean) and evaporation (EP) during October to May along with Hopper population.

Table 4 : Linear and non linear models with weather parameters for predicting mango hopper population

Sr. No.	Models	R^2
Linear Models		
1	$Y = 20.48*X1 - 243.4$	0.58**
2	$Y = 23.03*X2 - 673.9$	0.36**
3	$Y = 23.77*X3 - 498.2$	0.52**
4	$Y = 46.23*X4 - 157.6$	0.48**
5	$Y = 66.99*X5 - 131.0$	0.59**
6	$Y = 27.13*X6 - 243.7$	0.61**
Non-Linear Models		
1	$Y = 3E\text{-}05*X1^{4.966}$	0.75**
2	$Y = 3E\text{-}05*e^{(0.4048*X2)}$	0.69**
3	$Y = 0.0021*e^{(0.3705*X3)}$	0.78**
4	$Y = 0.0359*X_4^{3.984}$	0.73**
5	$Y = 1.5809*e^{(0.758*X5)}$	0.50**
6	$Y = 0.513*e^{(0.3025*X6)}$	0.47**

Where X_1, X_2, X_3, X_4, X_5 and X_6 stand for Tmin, Tmax, Tmean, EP, WS and Vpmean respectively

Correlation studies

Correlation coefficients were worked out between population build up of mango hopper and mean weather parameters during preceding fortnight for individual year and pooled data basis (Table 3). The mango hopper population build up had significant positive correlation with the rate of evaporation, wind speed and mean temperature consistent in all the three years while on pooled basis it had significant correlations also with maximum and minimum temperatures, and mean vapour pressure. Higher rainfall had adverse effect (-ve correlation in year 1998) due to high intensity of rainfall and lower rainfall had favourable effect ($r = 0.75^{**}$) because of even distribution and low intensity of rainfall with hopper population in year 2000-01 (Table 3). Similarly the relative humidity, which was higher in year 1998-99, had negative correlation while it had significant positive correlation in year 2000-2001. On annual pooled basis rainfall, bright sunshine hours and relative humidity had non-significant correlations with hopper population. However when the correlation were worked out separately for rainy and non rainy seasons, the magnitude of correlations increased with all the weather parameters, and the correlations with rainfall and sunshine hours were found to be significant (Table 3).

Development of regression models

Table 4 shows linear and non-linear regressions equations developed with weather parameters. Among the linear models, vapour pressure explained the maximum (R^2 = 0.61**) variation in mango hopper population followed by wind speed (R^2 = 0.59**) and minimum temperature (R^2 = 0.58**). Since the biological development are non-linear function of weather, an attempt here was made to fit the non-linear functions such as power and exponential. It may be seen (Table 4) that the coefficient of determination (R^2) increased considerably with non-linear models (R^2 = 69-78%) with maximum, minimum and mean temperatures and evaporation rates. However, non-linear models with wind speed and vapour pressure could not explain better that linear models. Using these equations, it would be possible to forecast pest out break and accordingly pest management practices could be under taken to keep its population under check.

REFERENCES

Patel, J. R., Shekh, A. M. and Ratanpara, H. C. 1994. Seasonal incidence and effect of minimum temperature and vapour pressure on the population of mango hopper *(Amritodus atkinsoni Leth)* in middle Gujarat. *Guj. Agril. Univ. Res. J.* 20 (1) : 5-8.

Wadhi, S. R. and Batra, H. N. 1964. Pest of tropical and sub-tropical trees. *Entomology in India*: 227-267. Entomological Society of India Publication, New Delhi.