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Research Article

Variability of Thermal Indices and Peak Mango Hoppers Incidence under Subtropical Conditions

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ABSTRACT

A 3-year study with 20-35 years old mango orchards of *cv. Dashehari* was conducted to study the mango hoppers and their thermal requirement association. Hopper populations significantly varied across seasons within a year. Lower populations (0.69-1.15 hoppers sweep^{-1}) were recorded during 2011-12 as compared to higher populations of 1.32-4.03 hoppers sweep^{-1} during 2013-14. The highest population was observed during 10-22 standard meteorological week in each season coinciding with reproductive phase of mango. Thermal indices *viz*., growing degree days, heliothermal units and photothermal units were applied to estimate the peak hopper population in Lucknow region. A total of 1000°Cd GDD, 9265.2 HTU and 15169.5 PTU were required to reach the peak hopper incidence with significant linear relationships. These regression equations were explained up to 80-90% variations in mango hopper populations. The association between mongo hoppers and thermal indices could be used for prediction of peak incidence in Lucknow region for taking up timely management practices.

Key words: Mango hopper, Thermal indices, Correlation, Regression model

Introduction

Mango (*Mangifera indica* L.) is an important commercial fruit crop in India and it covers nearly 2.51 M ha area and produce 18.43 Mt fruits with a productivity of 7.3 Mt ha^{1} (NHB, 2014). In India, Uttar Pradesh contributes major share in production (23.3 %) and majority of livelihood of famers in Malihabad region of Uttar Pradesh is dependent on mango cultivation. However, productivity is very low due to effects of several biotic and abiotic factors (Adak *et al*., 2012). Among biotic factors, insect pests affects considerably to the mango crop by feeding on all parts of the plant. Among the pests, mango hoppers are causing about 60 per cent of yield loss (Kumar *et al*., 1985).

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The thermal index plays a pivotal role in assessing and predicting pest weather interactions, biophysical variables in different crops (Srivastava *et al*., 2011; Narjary *et al*., 2013; Adak *et al*., 2013; Suresh *et al*., 2013; Selvaraj *et al*., 2014). Thermal indices may also be used in predicting the occurrence and infestation of pest (Srivastava and Prajapati, 2012). The aim of this study was to develop thermal indices based regression models for prediction of hoppers in mango orchard under Lucknow conditions.

Materials and Methods

Data on the hoppers occurrence on mango leaves panicle^{-1} trunk^{-1} were recorded on weekly basis from five randomly selected trees by net sweeping method and expressed as number of hoppers sweep^{-1} and collected from mango orchards of CISH, Rehmankhera farm Lucknow,

Uttar Pradesh for three consecutive seasons (2011-12, 2012-13 and 2013-14). Mango orchards with *cv. Dashehari* trees of 20-35 years old planted with spacing of 10 m × 10 m. Mean population of hopper per standard meteorological week (SMW) was taken into consideration for further analysis. Daily data of temperature (maximum and minimum), relative humidity (morning and evening), rainfall, wind speed, bright sunshine hours and evaporation rates were recorded from the Agromet Observatory located within the experimental site. Thermal indices were computed by following Adak *et al*. (2013), on daily basis taking 1st September as base for each year since mango is harvested during June and July in Northern India and post harvest vegetative phase started. The incidence of the pest was also plotted against these indices and cumulated up to peak/maximum hopper incidence for generating regression based prediction models. Statistical analysis viz., computation of Pearson's correlation coefficients and regression equations was carried out using MS Excel and SPSS packages (Ver 12.0).

Results and Discussion

Weather and mango hoppers

The peak mango hopper population was observed during reproductive phase and again in off-season phase. Mean weekly maximum temperature during reproductive phase of mango crop was varied from 16.2 to 49.5°C at 10-22nd SMW while during off-season (34-49 SMW) it was ranged as 17.1-34.5°C. A range of 9.3-26.8°C and 5.6-25.3°C minimum temperatures were recorded during two peaks of hoppers population, respectively. Wide variations were recorded in maximum and minimum relative humidity (RH) during the hoppers incidence with minimum of 14% and maximum 93%. The sunshine hours recorded during the reproductive phase of mango crop was 2.1-10.8 h whereas during off-season, it was 2.2-8.8 h. Temporal variations in rainfall were found during three seasons of study. During the first phase of peak hoper population, only a scanty amount of rainfall (6.0 mm) was received in 2011-12 while in next two seasons, no rainfall

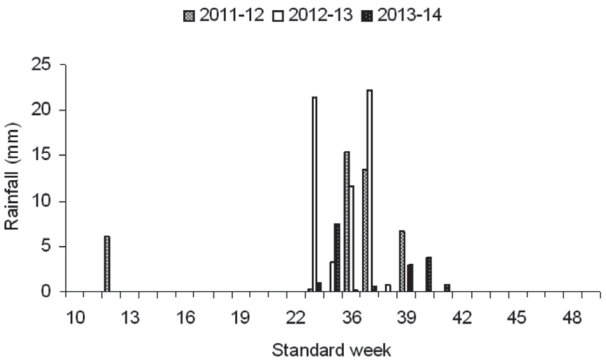

Fig. 1. Rainfall distribution during peak incidence of mango hoppers in CISH, Rehmankhera farm, Lucknow during 2011-14

was recorded. However, rainfall in the next peak *i.e.*, off-season, a total of 35.7, 59.3 and 16.6 mm was received (Fig 1; Table 1).

Thermal variability and mango hoppers

Mango hoppers population significantly varied among different SMWs within a given year. Moreover, the hopper population varied across the seasons (Fig. 2). The highest population of hopper was observed during 10-22 SMW in each season during vegetative as well as reproductive phase. Lower populations (0.69 to 1.15 hoppers sweep^{-1}) were recorded during 2011-12 as compared to other seasons, and population was maximum (1.32 to 4.03 hoppers sweep^{-1}) in 2013-14. Comparatively higher population (1.8, 2.42 and 2.83 hoppers sweep^{-1}) was recorded during 34-49 SMW at 2011-12, 2012-13 and 2013-14 respectively, with considerable variations across seasons. Hoppers hide on trunk during off-season. Shulka *et al*. (2013) observed that the peak mango hopper takes place in 2-3rd week of April, when average minimum and maximum temperatures ranged between 22.1-32.4°C and RH between 28.3-66.5%.

The peak occurrence of the hoppers population was between 2nd weeks of March to last week of May. However, two distinct peaks were observed between reproductive stage (inflorescence emergence, flowering, fruit set and fruit development) and an initiation to next season vegetative growth. This observation is supported by the findings of Patel *et al*., (1990), who

Table 1. Meteorological parameters during peak hopper population at CISH, Rehmankhera, Lucknow

SMW	Temperature (^{0}C)						Relative Humidity (%)						Sunshine hours (h)		
	Max.			Min.			Max.			Min.					
	2011-12	2012-13	2013-14	2011-12	2012-13	2013-14	2011-12	2012-13	2013-14	2011-12	2012-13	2013-14	2011-12	2012-13	2013-14
10	33.6	29.4	31.1	9.3	10.7	13	47	84	80.7	22	45	35.6	6.9	9.4	8.2
11	32.7	30.6	32.5	9.4	13.2	14.6	49	86	71.1	30	47	29.3	7.8	8.6	8.4
12	37.4	31.4	31.9	11.8	14.6	14.1	45	83	73	26	46	31.7	7.5	9.2	8.3
13	40.4	32.9	16.2	13	17	2.6	54	86	88.8	22	48	58	6.6	8.7	2.1
14	36.9	36.9	34.9	17.2	17.2	14.2	56	56	58.7	29	29	21.3	8	8	10
15	40.6	40.6	38.2	17.5	17.5	17.2	54	54	59	29	29	22.7	6.9	6.9	8.8
16	43	43	37	18	18	17.8	46	46	63.7	23	23	33.1	7.5	7.5	7.4
17	44	44	36.9	19	19	19.3	46	46	71.9	21	21	33.4	8.1	8.1	10
18	43.2	43.2	40.3	17	17	20.2	56	56	69.4	22	22	31	7.2	7.2	10.8
19	38.1	38.1	40.3	21.5	21.5	22.5	69	69	81.3	30	30	50.1	6.5	6.5	9.4
20	39	39	39.3	20.8	20.8	22.6	62	62	69.6	23	23	43.6	7.6	7.6	10.4
21	48.5	48.5	40	23.4	23.4	26.8	51	51	77.4	14	14	44.7	9	9	9.3
22	49.5	49.5	37.4	25.1	25.1	25.6	56	56	76.1	19	19	47.4	8.4	8.4	8.7
34	32.7	30.2	34	25.3	24.9	24.9	83	93	88.9	57	80	60.3	4.5	2.2	6.9
35	33.2	33.2	32	22.3	25.2	24.4	91	92	87	79	81	70.4	10.4	3.4	2.7
36	32.7	32.2	34.3	24.9	24.6	24.8	87	90	82.1	69	79	57.1	5.1	3.9	7.5
37	32	31.8	34.1	24.9	24.8	23.9	90	91	84.1	67	80	61.4	5.1	3.1	6.9
38	33.5	30.2	34.4	24.3	25.3	23.3	88	94	83.7	59	81	54	7.4	4	8.6
39	33.9	33.4	34.1	22.7	18.8	24.2	85	81	85.7	50	52	65.1	5.1	8.3	5.6
40	32.5	38.8	29.1	21.2	20.1	22.5	84	78	86.6	49	46	72	6.7	8.9	3.7
41	29.6	34.3	31	19.9	18.2	22.1	79	86	86.7	34	50	62.7	8.1	9.1	6.8
42	29.8	33.6	30.7	15.5	17.4	20	89	81	63.4	40	48	85.6	6.5	8.8	5
43	28.9	34.5	31.8	14.6	13.3	17.4	87	80	76.4	43	39	47.6	8.8	7.6	8.1
44	23.1	29.8	30.9	11.9	11.5	14.7	90	84	82.4	45	42	40.3	8.2	7.9	6
45	26.1	32.9	28.1	12.3	12.8	10.8	89	87	82	45	40	41.9	7.1	3.8	6.3
46	24.9	28.5	27.1	12.1	13.2	8.2	93	85	78.6	52	41	33.4	5.1	4.2	7.2
47	20.8	31.2	26.4	12.1	7.4	6.7	88	83	86.3	43	37	34.4	5.1	7.2	6.5
48	17.1	29.4	26.8	8.6	6.9	8.1	91	89	82.1	53	34	39.3	3.9	7.8	6.2
49	23.3	29.6	25.4	10.3	5.6	5.8	93	70	82.9	60	29	35.7	5.9	7.7	7.3

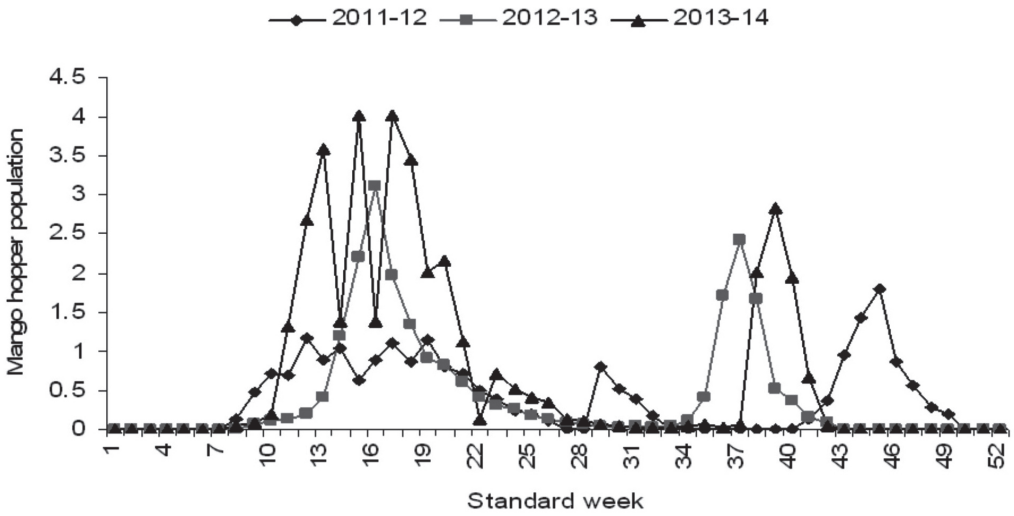

Fig. 2. Population dynamics of mango hoppers in CISH, Rehmankhera farm, Lucknow during 2011-14

reported that hopper population started increasing with beginning of flowering in January to June, and adult's population built up from March onwards with a gradual fall from July onwards.

Correlation between hopper population and weather parameters

The hopper population was positively correlated with maximum temperature and sunshine hours and was negatively correlated with minimum and maximum RH across years (Table 2). Zagade and Chaudhari (2010) observed similar correlation pattern between hopper population and meteorological parameters under high rainfall zone of Konkan region of Maharashtra. It was revealed that hopper population was inversely related to relative humidity and minimum temperature. Similar findings were reported by Patel *et al*. (1994) and Pandey *et al.* (2003).

Table 2. Pearson's Correlation matrix between weather parameters with mango hopper population

Weather parameters	2011-12	2012-13	2013-14
T_{max}	0.291*	0.422**	0.388**
T_{min}	NS	0.327*	NS
RH_{max}	-0.331*	-0.410**	-0.494**
RH_{min}	-0.426**	NS	-0.342*
Sunshine hours	0.416**	NS	0.378**

*Significant at 0.05 and **Significant at 0.01 level (2-tailed).

T_{max} and T_{min} = minimum and maximum temperature,

RH_{max} and RH_{min} = minimum and maximum relative humidity

NS= Non significant

Variability in thermal indices and hopper population

Hopper populations increased gradually, attained peak levels and thereafter decreased down to a certain level, following sigmoid trend during some parts of seasonal incidence. The GDD accumulation in mango crop varied from 100 to 3000°Cd in three seasons. The HTU and PTU varied as 116.6-9265.2 and 743.5-15169.5, respectively in 2011-14 seasons (Fig 3). Whenever the zero sunshine hours were recorded, wide variations in HTU were recorded. The progressive changes in peak hopper incidence and population thus stands at 1000°Cd GDD, 9265.2 HTU and 15169.5 PTU (Fig. 4). A regression equation between peak hopper populations and thermal indices, were worked out after pooling the three years data and is presented below:

(a) Hopper population = 0.004 × GDD – 1.31 +0.299(S.E) (n = 54, R^2 = 0.80**) …(1)

(b) Hopper population = 0.0005 × HTU – 0.83 +0.342(S.E) (n = 44, R^2 = 0.89**) …(2)

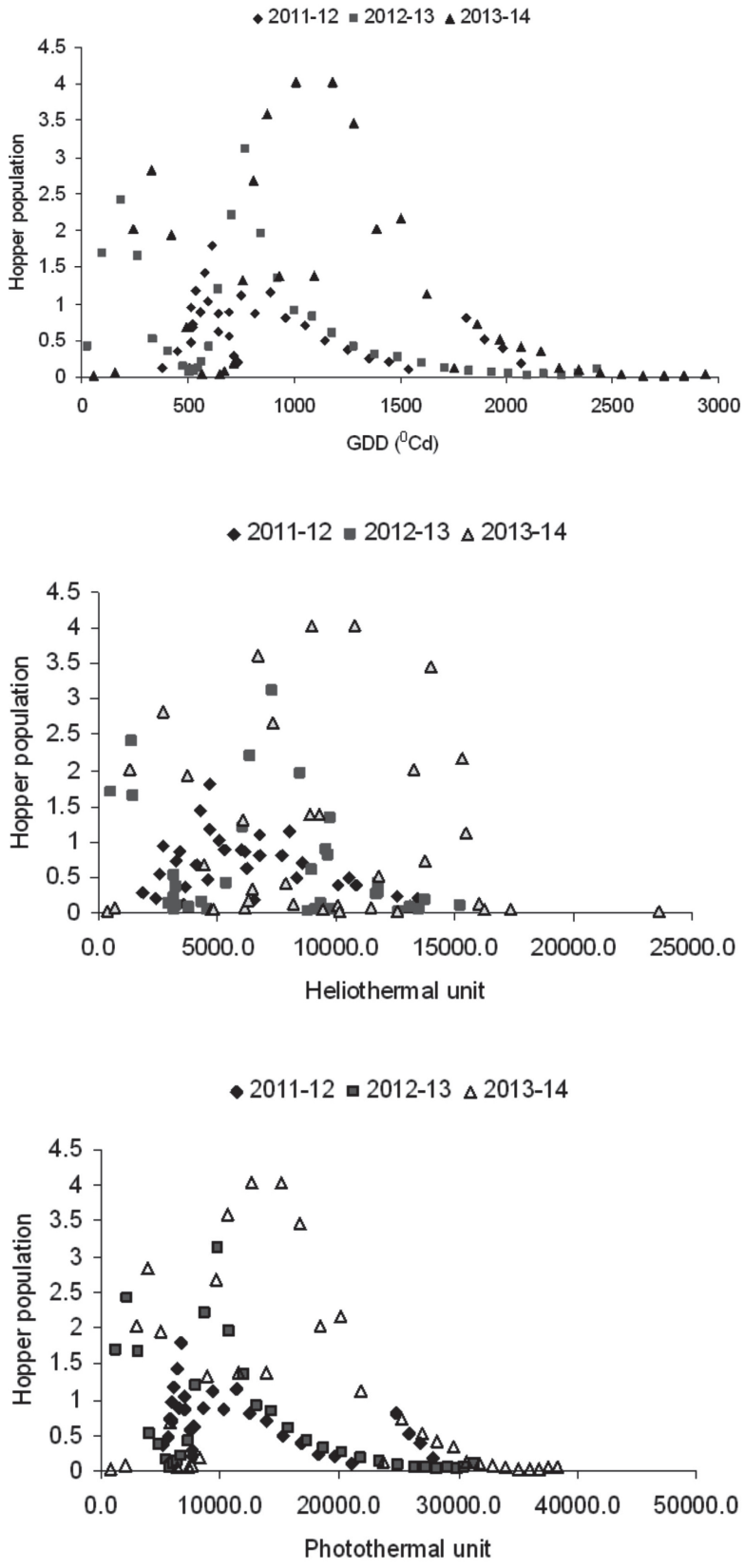

Fig. 3. Distribution of hopper population across different thermal indices during 2011-14

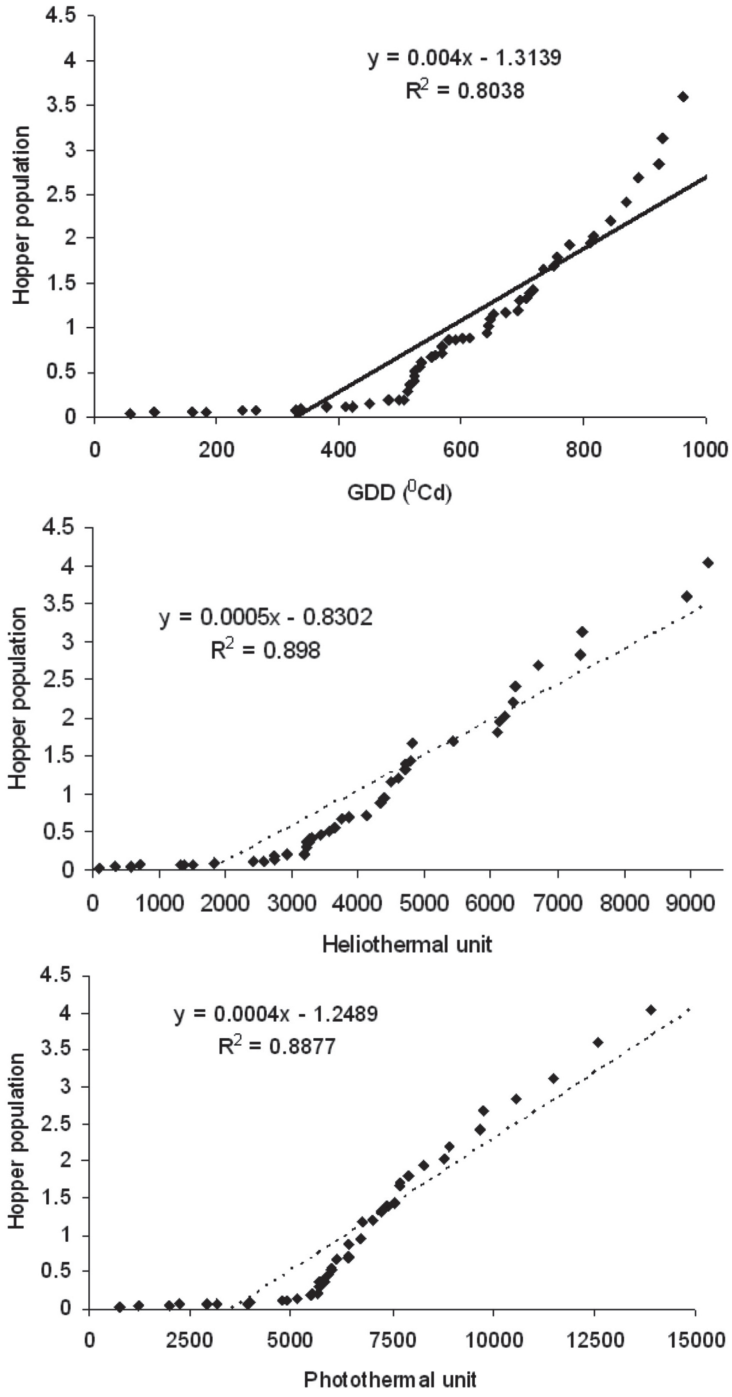

Fig. 4. Prediction models for mango hoppers using different thermal indices

(c) Hopper population = 0.0004 × PTU – 1.25 +0.317(S.E) (n = 45, R^2 = 0.89**) …(3)

The thermal indices during the reproductive stages, particularly during flowering and fruit set, varied across the seasons and thus influenced the populations. These equations are able to explain more than 80 per cent variations in peak mango hopper populations. Zagade and Chaudhari (2010) have reported through multiple regression analysis that the variation in weather accounted for 79% variation in mango hopper population under Konkan region of Maharashtra.

Conclusions

The highest population of hopper was observed during 10-22 SMW in each season coinciding with reproductive phase of mango. The peak hopper incidence requires a total of 1000°Cd GDD, 9265.2 HTU and 15169.5 PTU were required. Linear relationship was obtained between peak hopper populations and thermal indices. Regression equations could explain 80-90% variations in hopper populations. Hence, the association between hoppers and thermal indices could be used for prediction of peak incidence in Lucknow region. Thus, this study will be useful in assessing the pest-weather dynamics of region and forecast mango hopper occurrence for timely management.

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