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Research Paper

Forewarning models of tea mosquito bug {*Helopeltis antonii* (Signoret)} in cashew

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ABSTRACT

Field experiment was conducted to monitor tea mosquito bug damage with respect to weather variables for seven years from 2013 to 2020 at Cashew Research Station, Madakkathara. A seasonal pattern was observed in tea mosquito bug incidence, coinciding the crop phenophase, initiating from 24th October to 5th November, continuing till 18th to 30th March of the succeeding year. Peak damage and high seasonal indices were recorded during 16th to 28th December, 28th December to 10th January and 11th to 23rd January respectively in early, mid and late flowering types. Night temperature between 19.2 and 22.5^{0}C, morning relative humidity of 70-80 per cent, evening relative humidity between 40 and 60 per cent, a day length of 11.5 to11.7 hours, sunshine within 7 to 9 hours, and prevalence of low or no rainfall were the triggering factors for pest build up and infestation. The best fit regression with minimum temperature and morning relative humidity predicted the damage with 80-83 per cent accuracy. The models were validated with dataset for the year 2019-20 and RMSE, and other validation statistics revealed no significance difference between observed and predicted values of tea mosquito bug damage. Hence, the models could be utilized to disseminate the insect advisories to the farmers.

Keywords: Cashew, tea mosquito bug, weather, forewarning model, validation

Tea mosquito bug in cashew causes serious damage to tender flushes, inflorescences, and, green nuts. Each insect can damage 3-4 shoots or panicles leading to heavy yield loss. The buildup of this pest menace commences during October-November and reaches to its peak during December - February when trees are with flower and green nuts, survive in plantation till May and subsequently exists in negligible number during monsoon period (Sundararaju, 2005). However, the time of incidence varies depending upon the variety in response to the availability of succulent plant parts and so, the buildup naturally starts on *Anakkayam* -1 as flushing initiates very early in September being an early variety (Rao and Beevi, 2008). Lack of adequate monitoring mechanism is the main reason for failure of management strategy and hence, a strong surveillance and proper monitoring of the pest-situation has become imperative to rationalize management strategies. Moreover, the growth phase of cashew and the associated tea mosquito bug infestation are greatly influenced by weather variables. To deal with this, reliable forewarning systems are indispensable, and hence the study was initiated to understand the role of key weather variables on pest incidence and to develop and validate weather based prediction models.

MATERIALS AND METHODS

Three cashew varieties, *Anakkayam*-1, *Dhana* and *Madakkathara*-2 representing early, mid and late flowering types were monitored for seven years during 2013-2020 at Cashew Research Station, Madakkathara, Kerala Agricultural University to study the seasonal dynamics of tea mosquito bug, *Helopeltis antonii* (Signoret) with respect to fortnight. Four trees in each variety were monitored at fortnightly interval to record the extent of damage by scoring on 0-4 grid.

0: No lesions; 1: Up to 3 necrotic lesions/streaks; 2: 4-6 coalescing or non-coalescing lesions/streaks; 3 : Above 6 coalescing or non-coalescing lesions/streaks; 4 : Lesions/streaks confluent-complete drying of affected shoots/panicles

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All the shoots and panicles on 52 leader shoots of a cashew tree were scored and the mean score was worked out. The daily weather parameters during the period were collected from Department of Agricultural Meteorology, College of Agriculture, Vellanikkara, Thrissur.

The occurrence of tea mosquito bug was studied using fortnightly recorded mean damage score data. Seasonal indices were worked out assuming the multiplicative model, $U_t = T_t \times S_t \times C_t \times R_t$,

Where, U_t is the value of the time series at time t; T_t represents the trend value; S_t represents the seasonal index; C_t is the cyclical component; R_t the random fluctuation.

Seasonal indices were worked out using method of simple averages as there was no significant trend in the data. The damage score were arranged by years and computed the average of each season. The average for season was divided by overall average (average of averages) and multiplied by 100 to derive seasonal index for that season.

The regression models were developed based on step-wise multiple regressions to forecast the damage based on weather variables pertaining to the current fortnight. Statistically best model has been selected based on high R-squared statistics and low Variance Inflation Ratio (VIF) to avoid multi-co linearity problem and the predisposing weather factors for forewarning tea mosquito bug damage were worked out. All the statistical analysis was performed using SPSS version 17.0.

The testing and evaluation of the developed models were done using R^2, RMSE, and MBE values. Validation of the models were carried out using the data for the year 2019-20. Root mean square error (RMSE), and mean bias error (MBE) were used to carry out validation of observed and predicted values.

RESULTS AND DISCUSSION

Seasonality of occurrence

The incidence of tea mosquito bug follows a pattern of occurrence which repeats at regular intervals depending on the growth phase of cashew. The seasonal pattern of tea mosquito bug infestation was reported by several authors. The damage commenced with 24th October to 5th November and continued till 18th to 30th March. Peak damage coincided peak flowering stage and it was during 16th to 28th December, in early flowering type, lagged by a fortnight in mid flowering type, coinciding 28th December to 10th January and further by a fortnight in late flowering types and occurred during 11th to 23rd January. Two peaks of infestation were observed in mid and late flowering type, coinciding flushing and flowering phases respectively, with comparatively high damage in second peak. Rao and Beevi (2008) opined that late variety, Madakkathara-2 suffers maximum damage in flowering phase. However, according to them, early variety, Anakkayam-1 had maximum damage on flushes rather than on panicles. Dhana, always had less damage compared to early and late varieties. This clearly indicates the preference by tea mosquito bug towards inflorescences rather than flushes. Earlier report by Pillai *et al*. (1984) also indicated higher levels of damage on panicles than on shoots. The peak period of damage coincide December and January months and several authors reported severe damage during these periods (Rao *et al.,* 2002; Zote *et al*., 2017; Navik and Godase, 2017).

Damage per cent and seasonal index

High seasonal indices were observed in 3rd December to 23rd January (Table 1). During these periods, the sun rise is near to 6.45 am in Thrissur area and hence the presence of dews in lower atmosphere during the season is more. It is clear that during these periods of high infestation, the day length is below 12 hour and this condition favour sustained feeding by the insect. The maximum damage score was observed in day length around 11 hours and 35 minutes. Moreover, availability of inflorescences and green nuts in this period also favour the infestation.

Correlation studies

Correlation studies with mean weather variables of the current fortnight (Table 2) revealed the influence of agro-meteorological conditions on tea mosquito bug damage. Overall correlation analysis indicated significant negative correlation with minimum temperature, morning and evening relative humidity, rainfall and day length and positive correlation with average sunshine hours and wind speed. Morning relative humidity and average day length had the high significant negative correlation. Negative correlation with minimum temperature, relative humidity, and rainfall and positive correlation with sunshine was there in earlier reports (Rao *et al*., 2002; Pillai and Abraham, 1974; Rai, 1981). Significant negative correlation of tea mosquito bug damage with morning relative humidity was reported by Nirala *et al*. (2019). According to them, the pest population was high during flowering and nut set coinciding December-February months during which the maximum and minimum temperatures were relatively low. Even if the growth phase of cashew continues further, the negative effect due to increase in temperature could be the reason for decline in damage after February months. According to (Rao, 2002), minimum temperature between 13 and 18^{0}C favours tea mosquito bug incidence at Chinthamani, Karnataka.

Among the weather elements, significantly high positive correlation was obtained with wind velocity. The strong positive correlation with wind velocity can be attributed to the peculiar seasonal factor during November to February when *vruschikakattu,* the wind blowing during the local calendar *Vrischikam* though *Makaram*, blowing in Thrissur and Palakkad belt, characterized with heavy speed and having no moisture content as it passes through the Palakkad Gap of the Western Ghats and subsequently gains momentum.

Development and validation of prediction model

Step-wise multiple regressions was used to develop prediction model to forecast the damage based on weather variables and the best fit models have been selected.

The results of the best fit regression models (Table 3) revealed that tea mosquito bug damage was significantly affected either by minimum temperature and/or morning relative humidity of the current fortnight. The variables included in the models explained

Table 1: Per cent damage and seasonal index of tea mosquito bug damage in early, mid and late flowering types of cashew during different at Madakkathara.

Sr. No.	Periods	Anakkayam-1		Dhana		Madakkathara-2	
		Per cent damage	Seasonal index	Per cent damage	Seasonal index	Per cent damage	Seasonal index
1.	Oct. 11-23	0.28	13.26	0.10	15.08	0.25	17.43
2.	Oct.24 – Nov. 5	1.91	90.55	0.11	17.38	0.15	10.17
3.	Nov. 6- 19	1.35	64.19	0.24	37.74	0.42	28.73
4.	Nov. 20- Dec. 2	3.53	167.55	0.34	53.59	2.51	173.32
5.	Dec. 3 - 15	7.03	333.79	4.16	647.36	4.97	343.13
6.	Dec. 16 - 28	11.50	545.95	3.84	597.75	7.05	486.37
7.	Dec. 29 – Jan. 10	10.23	485.75	4.16	647.24	6.22	429.57
8.	Jan. 11-23	7.82	371.21	2.61	406.47	9.64	665.55
9.	Jan. 24 – Feb. 7	5.08	241.48	0.39	61.10	2.68	185.04
10.	Feb. 8-18	2.81	133.42	0.70	109.12	1.78	122.81
11.	Feb. 19- March 3	0.83	39.57	0.14	21.82	0.63	43.56
12.	March 4-17	0.55	26.22	0.10	15.57	0.45	30.91
13.	March 18-30	0.36	16.92	0.06	9.45	0.50	34.25
14.	March 31- April-13	0.44	20.78	0.00	0.00	0.11	7.76

Anakkayam-1- early flowering, Dhana –mid flowering, Madakkathara-2- late flowering

Table 2: Correlations of tea mosquito bug damage with average weather variables of a fortnight lag

Varieties	Anakkayam-1		Dhana		Madakkathara-2	
Weather variables	Current fortnight	One fortnight lag	Current fortnight	One fortnight lag	Current fortnight	One fortnight lag
Max temp. (Tmax)	0.182	0.217	0.134	0.202	0.191	0.142
Min. temp. (Tmin)	-0.534**	-0.336**	-0.471**	-0.510*	-0.471**	-0.709**
Morning relative humidity (RHI)	-0.822**	-0.577**	-0.711**	-0.464*	-0.807**	-0.283
Afternoon relative humidity (RHII)	-0.683**	-0.516**	-0.583**	-0.224	-0.663**	-0.077
Wind speed	0.933**	0.549**,	0.857**	0.713**	0.900**	0.562**
Sunshine hours	0.601**	0.330	0.505**	0.010	0.586**	0.184
Rainfall	-0.496**	-0.305	-0.430*	-0.197	-0.459*	-0.001
Rainy days	-0.487**	-0.485	-0.429**	-0.423	-0.462*	-0.462
Day length	-0.724**	-0.408*	-0.645**	- 0.501**	-0.665**	-0.392*

* Significant at 5 % level: ** Significant at 1% level

Table 3: Prediction models for tea mosquito bug damage for different flowering types of cashew

Varieties	(Model)	R^2 value	RMSE	MBE
Anakkayam-1	$TMB_w = 1.952-0.010*RHI_F-0.044*Tmin_F$	0.803	-0.053	-0.017
Dhana	$TMB_w = 0.980-0.005*RHI_F-0.022*Tmin_F$	0.809	0.027	0.000
Madakkathara-2	$TMB_w = 1.559-0.009*RHI_F-0.033*Tmin_F$	0.835	0.062	-0.049

80-83 per cent of the total variation in damage. Observed and predicted damage of tea mosquito bug in different flowering types of cashew is presented in the form of a scatter plot (Fig. 1) with RMSE and MBE values. Prediction models developed earlier (Rao *et al*., 2002) using multiple regression models with ten years data revealed the influence of temperature, relative humidity, rainfall and sunshine hours and could explain the damage with 54 per cent accountability.

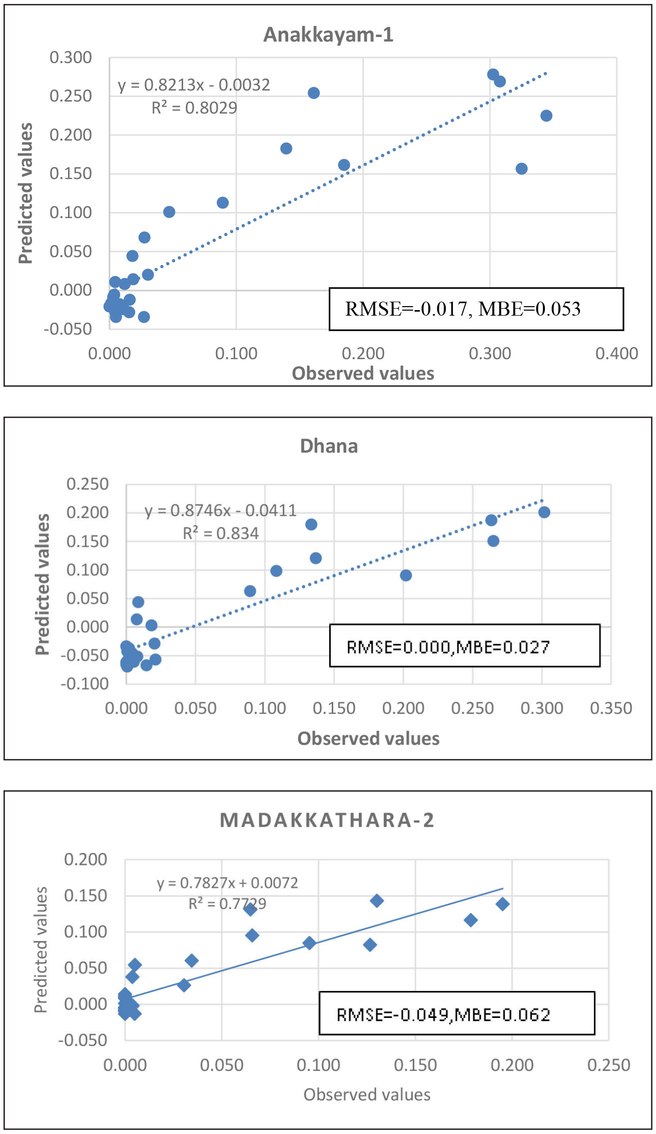

Fig. 1: Observed and predicted values for tea mosquito bug damage in different flowering types of cashew at Madakkathara.

Validation of models

The best fit models for each flowering types of cashew was validated by predicting the tea mosquito bug damage for the year 2019-20. The validation statistics are given in Table 5. The validation by RMSE and MBE showed no significant difference between observed and predicted values. Hence, the models were validated satisfactorily.

CONCLUSION

The study revealed that the weather variables have significant role in tea mosquito bug damage. The favorable weather conditions for tea mosquito bug incidence on cashew at Madakkathara were observed to be minimum temperature ranging from 19.2 to 22.5^{0}C, morning relative humidity falling within the range of 70-80 per cent, average evening relative humidity falling within the range of 40-60 per cent, average sunshine hours ranging between 7 to 9 hours, day length within the range of 11.5 to 11.7 hours, and prevalence of low or no rainfall. The model developed can be utilized to predict the infestation and forewarn the farmers and disseminate the advisory of tea mosquito bug incidence well in advance to take precautionary measure and protect the crop from insect damage by optimizing management practices.

Conflict of Interest Statement: The author (s) declares (s) that there is no conflict of interest.

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