Journal of Agrometeorology 14 (2) : 170-172 (December 2012)

Sucking pest population dynamics of cotton crop in relation to agrometeorological parameters and spectral indices

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ABSTRACT

Present study was designed to reveal the impact of different meteorological factors on sucking pest population dynamics and to work out multiple regression equations using different weather parameters and spectral indices. Leafhopper population was positively correlated with T_{max} (Maximum temperature), T_{min} (Minimum temperature), RH_M (Morning RH) and RH_E (Evening RH) and negatively associated with VPD (Vapour pressure deficit). However, whitefly population was negatively correlated with T_{max}, T_{min} and VPD and positively related with RH_M and RH_E. In case of leafhopper, regression equation consisting all the weather variables were more suitable to predict their population (R^2 = 0.79). But for whitefly population, equation with only temperature variables explained more variability (R^2 = 0.89). Multiple regression analysis with spectral indices showed variable performance for these pests.

Key words: Cotton, leafhopper, whitefly, correlation, weather, multiple regressions

Cotton (*Gossypium Spp.*) being the king of natural fiber is grown in 111 countries all over the world. In India it is cultivated in 8.97 million ha with a production of 21.3million bales of seed cotton (Anon., 2005). The average productivity of cotton in India is 463 kg per ha (Anon., 2006) as compared to world average of 621 kg per ha. India occupies 26 per cent of global cotton area contributing 18.3 per cent of world production (Anon., 2007). Thus India ranks first in area and fourth in production on global basis. Despite the large area, the productivity in India is very low. In Karnataka, cotton is being grown in an area of 5.50 lakh ha with a productivity of 248 kg per ha (Anon., 2005). Cotton fiber is an important raw material to the textile industries and plays a key role in national economy in terms of employment generation and foreign exchange.

Among the insect pests, a complex of sucking pests viz., leafhopper, *Amrasca biguttula biguttula* (Ishida), whitefly, *Bemisia tabaci* (Gennadius) occupy major pest status and cause considerable damage in cotton. Information on seasonal activity of sucking pests on cotton helps to take up effective management strategies. Keeping this in view present study was undertaken to develop regression models for sucking pests based on weather and spectral indices.

MATERIALS AND METHODS

Present study was carried out during *Kharif* 2007 and 2008 at the Research Farm of the Department of Entomology, CCS Haryana Agricultural University, Hisar under irrigated condition. Two cotton cultivars HS-6 and H-1226 having different growth habit were sown with row to row spacing of 60 cm. Thinning was done one month after sowing maintaining plant to plant spacing of 30 cm. The experiment was laid out in a split plot design with three replications. Three different dates of sowing viz. 15 April, 1 May and 15 May were kept as main plot treatments and varieties as subplot treatments. Fertilization and irrigation were applied as per the recommended package of practices released by CCSHAU, Hisar.

Pest population assessment: Top three leaves of a branch were selected for population study of sucking pests because of their tender and succulent nature. Randomly three branches were selected from each cotton plant to count leafhopper nymphs and whitefly adults. Likewise, ten plants were observed randomly from each plot. Observations were recorded on population build up of sucking pests at 15 days interval starting from vegetative phase to 50% boll formation for each date of sowing. Therefore, mean population of the sucking pests were calculated as:

$$\textit{Mean leafhopper population per leaf} = \frac{\textit{Total nymphs on 10 plants at each level of canopy}}{30}$$

$$\textit{Mean whitefly population per leaf} = \frac{\textit{Total adults on 10 plants at each level of canopy}}{30}$$

Table 1 : Correlation analysis among leafhopper, whitefly population and different microclimatic parameters and spectral indices

Parameters	Leafhopper	Whitefly
T_{max}	0.85*	-0.81
T_{min}	0.51	-0.87*
RH_M	-0.60	0.80
RH_E	-0.27	0.42
VPD	-0.53	-0.45
SR	082*	0.79*
NDVI	0.93*	0.88*
TVI	0.89*	0.84*

* Significant at $P \leq 0.05$

Table 2: Multiple regression equations for the population dynamics of leafhopper and whitefly with different microclimatic parameters.

Pest	Regression Equation	R^2
Leafhopper (Y)		
	$Y = -18.03 + 0.54T_{max} + 0.2T_{min}$	0.74
	$Y = -22.20 + 0.61T_{max} - 0.02T_{min} + 0.04RH_M - 0.02RH_E + 0.1VPD$	0.79
Whitefly (Y)		
	$Y = 75.56 - 1.92\ T_{max} - 0.16\ T_{min}$	0.89
	$Y = 77.52 - 1.82\ T_{max} - 0.19\ T_{min} + 0.06\ RH_M$	0.80

Weather observation: Dry and wet bulb temperatures were measured at bottom, middle and top of the canopy from 0800hrs to 1600 hrs at two hours interval with the help of Assmann Psychrometer at different phenophases of cotton. These values were used to find out relative humidity and vapour pressure in the crop with the help of psychrometric tables. The mean of diurnal microclimatic parameters i.e maximum temperature, minimum temperature, morning relative humidity, evening relative humidity of three levels was computed. Vapour pressure deficit (VPD) was calculated as difference between saturated vapour pressure and actual vapour pressure.

Spectral indices: The following spectral indices were calculated using the per cent spectral reflectance values observed in 4 IRS bands with spectroradiometer i.e. Ground truth radiometer at different phenophases from 10.00 AM to 12.00 noon over cotton crop in all the treatment combinations. The spectral reflectance was also measured over Ba_2SO_4 plate and used as standard reflectance value. The per cent spectral reflectance was calculated by taking the ratio of spectral reflectance measured over the crop to the standard reflectance measured over Ba_2SO_4 plate.

(i) Simple ratio: Simple ratio (SR) is the ratio of percent reflectance in infrared to percent reflectance in red band.

$$SR = IR / R$$

Where,

IR= Per cent reflectance in Infrared band

R= Per cent reflectance in red band

(ii) Normalized difference vegetation index: Normalized difference vegetation index (NDVI) is the ratio of difference of infrared and red to the sum of the infrared and red per cent reflectance.

$$NDVI = (IR - R) / (IR + R)$$

(iii) Transformed vegetation index: Transformed vegetation index (TVI) was calculated using the formula:

$$TVI = \sqrt{(NDVI + 0.5)}$$

Correlation coefficients were computed between the leafhopper and whitefly population and agromet-spectral parameters. Regression analysis was carried out to develop the relationship of the population of leafhopper and whitefly with significant microclimatic parametrs and spectral indices.

RESULTS AND DISCUSSION

The leafhopper and whitefly population were correlated and best fit models were developed using stepwise regression techniques. The relationship of population of sucking pests (leafhopper and whitefly) with weather parameters: maximum temperature (T_{max}), minimum temperature (T_{min}), morning relative humidity (RH_M), evening relative humidity (RH_E) and vapour

Table 3: Multiple regression equations of leafhopper and whitefly population with spectral indices at different phenophases

Phenophase	Regression Equation	R^2
Leafhopper population (Y)		
Vegetative	Y = 7.71-0.29SR+0.03 NDVI-4.31TVI	0.89
50% Flowering	Y=24.33-0.83SR+6.07 NDVI-22.11TVI	0.91
50% Boll Formation	Y=4.75+0.9SR+0.91 NDVI-5.42TVI	0.69
Whitefly population (Y)		
Vegetative	Y = 5.15-0.5SR+0.02 NDVI-2.65TVI	0.74
50% Flowering	Y=10.91+0.46SR-56.40 NDVI36.19TVI	0.87
50% Boll Formation	Y=116.04+3.4SR+4.01 NDVI-125.5TVI	0.85
50% Boll Opening	Y=89.41-33.28SR+199.9 NDVI-85.6TVI	0.78

pressure deficit (VPD)was quantified using the pooled data of both the years.

Weather based models:

Correlation analysis of leafhopper with different weather parameters is given in Table 1. Leafhopper population was positively correlated with T_{max}, T_{min}, RH_M and RH_E and negatively associated with VPD however, it was significant with T_{max} only while the correlation of white fly was significantly negatively correlated with T_{min} only. Stepwise multiple regression equations for the population dynamics of leafhopper and whitefly were developed. The model based on maximum and minimum temperature were found the best. These two weather parameters could explain the populations of leafhopper and whitefly by 74 and 89 percent respectively, which were statistically significant (Table 2). Shivanna *et al.* (2011) reported that simple correlation analysis showed significant positive effect with maximum temperature on all the sucking pests.

Spectral Models:

Multiple linear regression equations using leafhopper and whitefly population as dependent variable and three spectral indices (SR, NDVI and TVI) as independent variables were worked out for different phenophases individually. Leafhopper population fluctuation was significantly explained by spectral indices at different phenophases (Table 3). Linear relationship developed for 50% flowering stage has highest R^2 value (0.91) followed by vegetative phase (0.89) and 50% boll formation (0.69). Multiple regression lines computed for whitefly population also showed higher coefficient of determination for each phenophases (Table 3). Toulios *et al.* (1996) used similar technique to assess early wheat biomass based on spectral and meteorological parameters. So, above equations can be used for estimating sucking pest population at a particular growth stage and subsequently insecticides can be applied in a sustainable manner to minimize input losses.

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Received :November 2011 ; Accepted : September 2012

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