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Progression of Cotton Leaf Curl Disease and its Vector Whitefly under Weather Influences

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A B S T R A C T

Cotton leaf curl disease (CLCuD) is a potential threat, responsible for low yield in cotton, exclusively transmitted by whitefly (*Bemisia tabaci*). The investigation was carried out at Cotton Research Station, Sirsa to evaluate progression of CLCuD and whitefly (*Bemisia tabaci*) in relation to weather parameters. Two Bt-cotton hybrids and two non Bt varieties were sown at three different dates of sowing. Per cent CLCuD incidence increases continuously from appearance to picking. Early sowing found to be more appropriate to minimize CLCuD infestation having less per cent disease incidence and whitefly population as compared to late sown crop. Bt-cotton hybrids are susceptible to CLCuD having higher per cent CLCuD incidence as compare to non-Bt varieties. Correlation analysis reveals that per cent CLCuD incidence and whitefly population shows a significant negative correlation with temperature maximum and minimum while positively correlated with relative humidity morning and evening. Sunshine hours are significant positively correlated with both per cent CLCuD incidence and whitefly population. Whitefly population decreases with increased rainfall and negatively correlated with rainfall. Maximum variability (54.4%) in per cent CLCuD incidence appears due to temperature minimum.

Introduction

Cotton occupies the most prominent position in the agricultural scenario of the country, as well as Haryana owing to its importance as a cash crop. Among the diseases, Cotton leaf curl disease (CLCuD) is the most important, causing enormous loss to the crop (Brown and Nelson, 1984; Briddon and Markham, 2000). Cotton leaf curl virus belongs to genus Begomovirus and is transmitted by its exclusive vector whitefly (*Bemisia tabaci* gem) in circulative and persistent manner (Sharma and Rishi, 2003).

Epidemiology is the study of the variable incidence of diseases in populations (Hirst, 1991). The important populations are those of the host and the pathogen. Diseases are however not independent entities but the result of a complex interaction among host plants, pathogens and the environment. This

is embodied in the basic concept of the disease triangle. As the same way of ecology, epidemiology includes the biotic environment (alternate sources of infection, vectors, and even the activity of man such as in pathogen dissemination) and the abiotic environment (climate, soil nutrition, etc) (Zadoks and Schein, 1979; Dickinson and Lucas, 1982). Temporal and spatial variance of meteorological conditions can affect soil conditions, water availability, agricultural yields and susceptibility to pest and pathogen infestations. Virus ecology is more complicated than a simple disease triangle. This is because the incidence and spread of a single virus disease may be dependent on several vectors which have complicated ecologies themselves (Bos, 1986). Whitefly (*Bamasia tabaci*) transmitted cotton leaf curl virus disease was the major problem in cotton cultivation (Sharma *et al.,* 2006). However, weather has a very crucial role in CLCuD spread and development and also affects its vector whitefly's ecology.

Materials and Methods

The experimental material encompassed four cotton cultivars viz. two Bt cotton hybrids (SP 7007 and Jai Bt) and two non Bt varieties (H 1098 i and H 1300). The experiment was sown on three different dates of sowing i.e. 29th April, 2014, 14th May, 2014 and 27th May, 2014 at CCS HAU Cotton Research Station, Sirsa. Each sowing was done in a split plot design with four cultivars and replicated thrice. All conventional agronomical practices were followed to grow good crop.

Observations recorded

Disease incidence and white fly population were recorded at the end of every standard meteorological week. Disease incidence was calculated by using the formula given below:

$$\text{Disease incidence} = \frac{\text{Number of infected plants}}{\text{Total number of plants}} \times 100$$

Whitefly population per three leaves was counted directly on the leaves in the morning when they were less active.

Data analysis

Computer programme SPSS was used for all the statistical analysis of the research field data.

Results and Discussion

Climate change is altering temperature and relative humidity resulting in the shift of some insect/pest from small population to large population thus effecting crops yield (Hussain *et al.,* 2015). Our research findings reveals that in all the cultivars CLCuD incidence continuously increased with increased population of whitefly except 30th, 36th and 37th standard meteorological week (SMW), where CLCuD incidence remained constant while whitefly population decreased in all dates of sowing. Jai Bt showed maximum increment in CLCuD incidence with increasing whitefly population. There was a significant difference between various dates of sowing and also founded that late sown crop was a higher whitefly population with severe CLCuD incidence (Fig. 1 to Fig. 4). Progress of disease was maximum during the month of August as compared to July and September (Mahmood *et al.,* 2014). A highly significant positive correlation was found between CLCuD incidence and whitefly population in all the three dates of sowing and their mean values. It indicates that whitefly population increases, disease incidence also increases simultaneously (Table 1). Similarly, Monga *et al.,* (2011) reported that population was less in beginning and increased at the end of the crop season and there was positive

correlation between whitefly population and disease incidence. Earliness allows development of crop during period of favorable moisture and timely picking prevent the crop from unfavorable weather (Rauf *et al.,* 2005). A strong positive correlation was found between whitefly population and disease incidence (Sharma *et al.,* 2006). Correlation analysis was carried out to find out the role of weather parameters in progression of whitefly population leading to CLCuD development. It was found that per cent CLCuD incidence and whitefly population shows a significant negative correlation with temperature maximum and minimum while positively correlated with relative humidity morning and evening.

Fig.1 Relative progression of CLCuD intensity with whitefly population in cotton cultivars for 29th April, 2014 sown crop
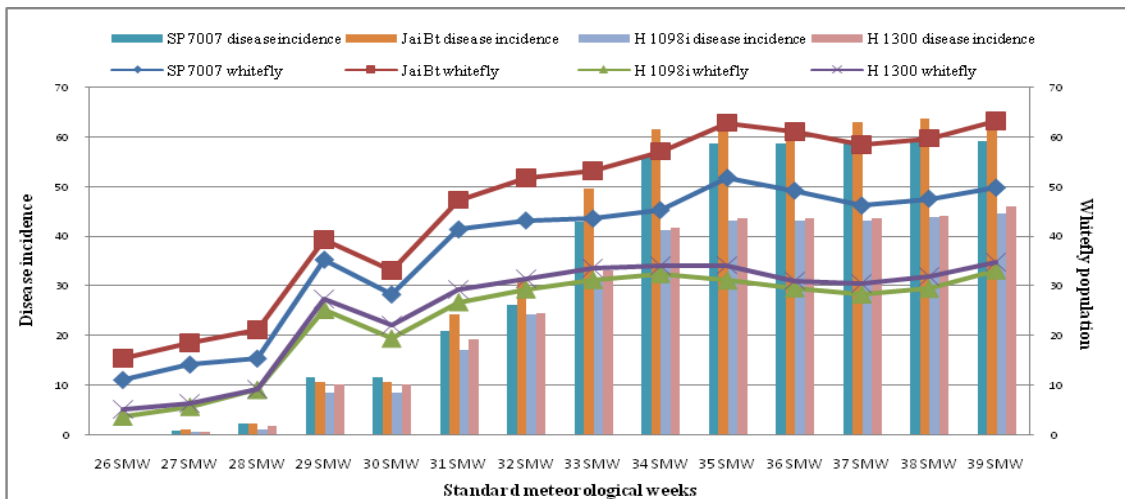

Fig. 2 Relative progression of CLCuD incidence with whitefly population in cotton cultivars for 14th May, 2014 sown crop
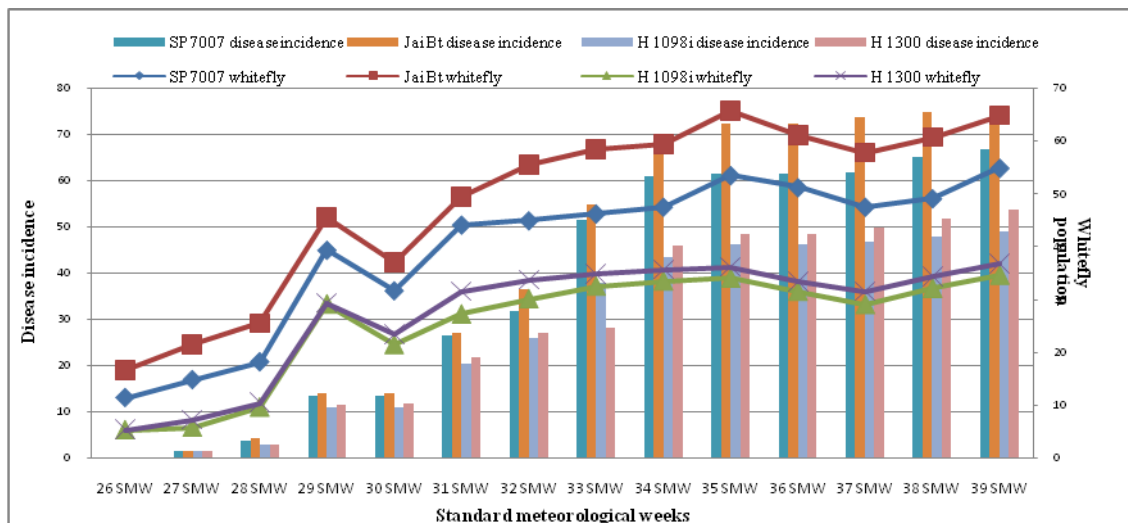
Fig. 3 Relative progression of CLCuD incidence with whitefly population
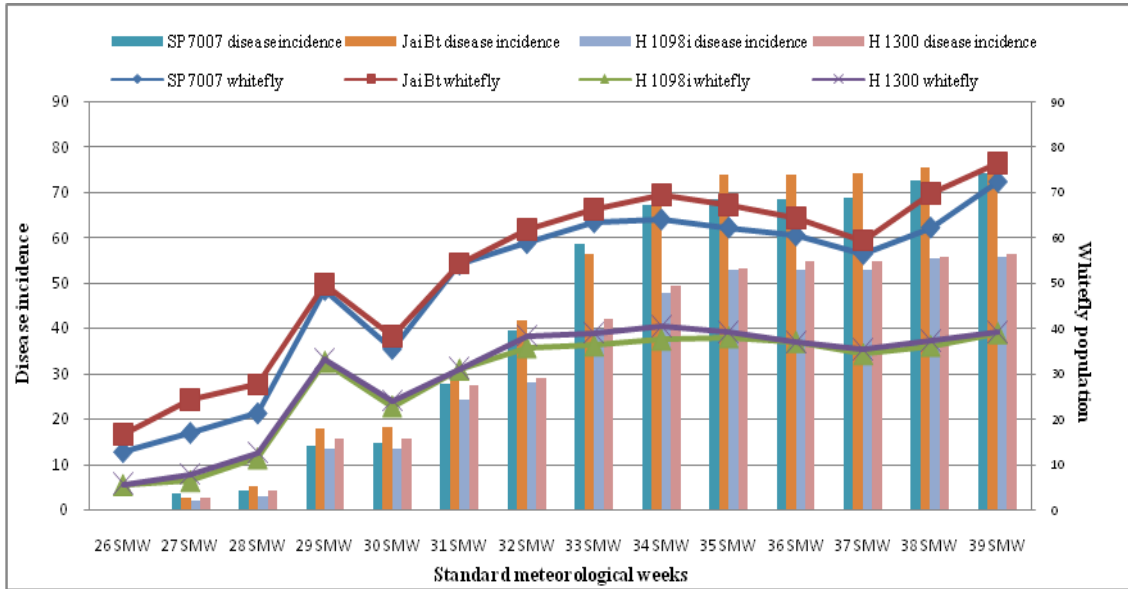In cotton cultivars for 29th May, 2014 sown crop

Fig. 4 Relative progression mean CLCuD incidence with mean whitefly population
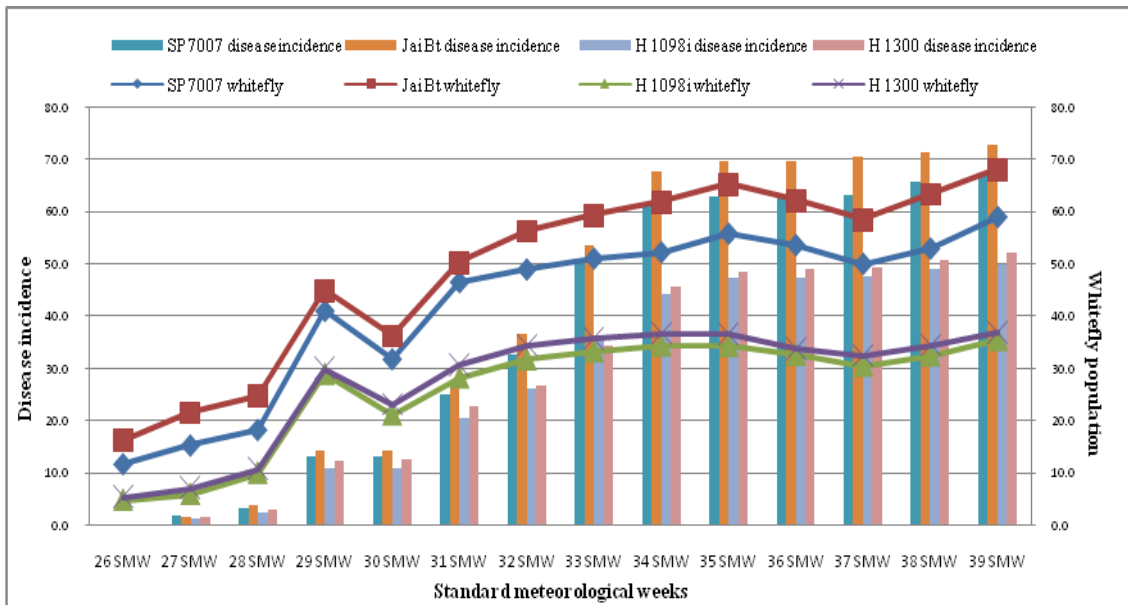Of all the three date of sowing in cultivars

Fig.5 Relative progression of mean per cent CLCuD incidence and mean
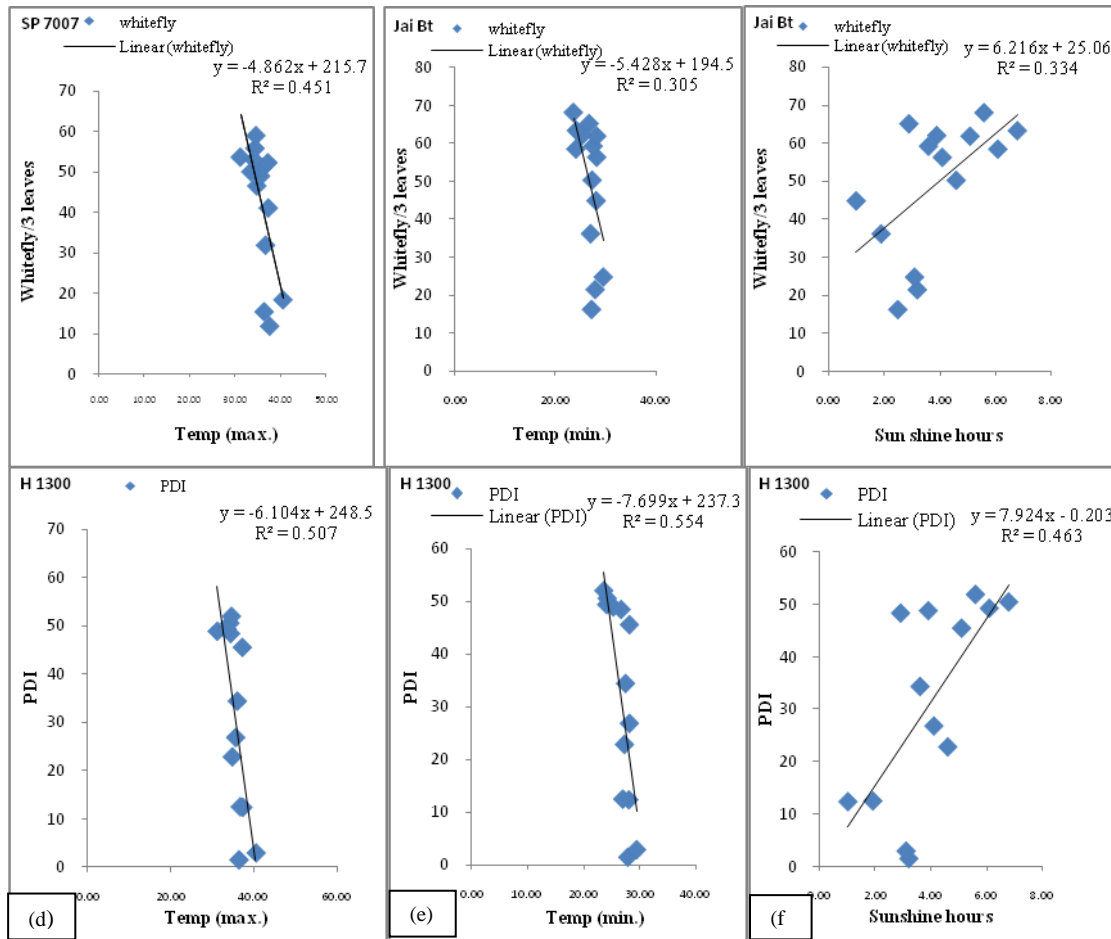Whitefly population in relation to weather parameters

Table.1 Correlation matrix for disease incidence in relation to whitefly
Population in different cotton cultivars at different dates of sowing

Date of Sowing	1st- 29th April	2nd- 14th May	3rd- 27th May	Mean
Cultivars				
SP 7007	0.901[**]	0.900[**]	0.897[**]	0.902[**]
Jai Bt	0.946[**]	0.919[**]	0.924[**]	0.933[**]
H 1098i	0.861[**]	0.860[**]	0.868[**]	0.864[**]
H 1300	0.866[**]	0.836[**]	0.870[**]	0.860[**]

Table.2 Correlation matrix for the per cent CLCuD incidence in relation to weather parameters in different sowing environments

Weather variables	29th April, 2014				14th May, 2014				27th May, 2014				Average			
	SP 7007	JAI Bt	H 1098 i	H 1300	SP 7007	JAI Bt	H 1098 i	H 1300	SP 7007	JAI Bt	H 1098 i	H 1300	SP 7007	JAI Bt	H 1098 i	H 1300
T (maximum)	-0.687**	-0.683*	-0.700**	-0.700**	-0.675*	-0.684**	-0.696**	-0.708**	-0.676*	-0.687**	-0.715**	-0.722**	-.681*	-.685**	-.705**	-.712**
T (minimum)	-0.720**	-0.701**	-0.716**	-0.718**	-0.715**	-0.722**	-0.723**	-0.763**	-0.708**	-0.718**	-0.745**	-0.744**	-.716**	-.714**	-.729**	-.745**
Relative humidity %(M)	0.322	0.320	0.338	0.342	0.301	0.310	0.325	0.337	0.294	0.321	0.343	0.366	0.306	0.317	0.336	0.35
Relative humidity %(E)	0.322	0.317	0.331	0.329	0.289	0.308	0.317	0.316	0.287	0.312	0.334	0.348	0.299	0.312	0.327	0.332
SS(hrs)	0.661*	0.675*	0.674*	0.668*	.679*	0.678*	0.673*	0.700**	0.682*	0.668*	0.671*	0.667*	.676*	.674*	.673*	.681*
RAIN(mm)	0.024	0.006	0.002	-0.015	-0.03	0.007	-0.019	0.006	-0.027	-0.012	-0.003	-0.006	-0.009	0	-0.007	-0.005

Table.3 Correlation matrix for the whitefly population in relation to weather parameters in different sowing environments

Weather variables	29th April, 2014				14th May, 2014				27th May, 2014				Average			
	SP 7007	JAI Bt	H 1098 i	H 1300	SP 7007	JAI Bt	H 1098 i	H 1300	SP 7007	JAI Bt	H 1098 i	H 1300	SP 7007	JAI Bt	H 1098 i	H 1300
T (maximum)	-0.718**	-0.721**	-0.594*	-0.601*	-0.688**	-0.672**	-0.589*	-0.602*	-0.620*	-0.614*	-0.609*	-0.575*	-.672**	-.670**	-.599*	-.593*
T (minimum)	-0.555*	-0.598*	-0.446	-0.450	-0.547*	-0.535*	-0.450	-0.444	-0.504	-0.520	-0.454	-0.413	-.534*	-.552*	-0.451	-0.435
Relative humidity %(M)	0.570*	0.521	0.510	0.531	0.538*	0.497	0.502	0.532	0.454	0.411	0.518	0.504	0.516	0.476	0.511	0.522
Relative humidity %(E)	0.413	0.379	0.302	0.328	0.371	0.347	0.305	0.325	0.258	0.223	0.320	0.301	0.339	0.314	0.31	0.318
SS(hrs)	0.536*	0.599*	0.475	0.457	0.511	0.540*	0.426	0.457	0.542*	0.585*	0.448	0.446	.533*	.578*	0.45	0.454
RAIN(mm)	-0.076	-0.053	-0.199	-0.204	-0.110	-0.108	-0.212	-0.207	-0.200	-0.186	-0.187	-0.204	-0.137	-0.119	-0.199	-0.205

Sunshine hours significant positively correlated with both per cent CLCuD incidence and whitefly population. Rainfall has a negative impact on whitefly population and showed diminution with increased rainfall and negatively correlated (Table 2 and 3). Perveen *et al.,* (2010) also reported negative correlation of maximum and minimum temperatures with cotton leaf curl virus disease.

Regression analysis reveals that maximum variability (54.40%) in percent CLCuD incidence was found due to temperature minimum while temperature maximum and sunshine hours participated 50.70% and 46.30% variability in CLCuD development respectively [Fig. 5(a), 5(b) and 5(c)]. In case of whitefly temperature maximum has a very significant role showed 45.10 % variability in whitefly population progression while temperature minimum and sunshine hours has 30.50% and 33.40% variability in whitefly progression over the time [Fig. 5(d), 5(e) and 5(f)]. Temperature maximum, temperature minimum and sunshine hours ranges between 35-40 °C, 25-30 °C and 4-8 hours respectively showed maximum occurrence of whitefly population leads to severe appearance of CLCuD (Fig. 5).

In conclusion, despite tremendous improvements in technology and crop yield potential, food production remains highly dependent on climate. Plant diseases and pest infestations are influenced by climate. Accurate weather forecasting helps to make more informed daily decision, and to keep out of danger of any biotic factor including CLCuD development. It appears in 27th standard meteorological week while white fly appears in 26th standard meteorological week and positively related to each other. Early sowing is appropriate to avoid CLCuD infestation having very less extent of per cent CLCuD incidence as compare to late sowing.

Bt-cotton hybrids are more prone to CLCuD having higher per cent CLCuD incidence and whitefly population as compare to non-Bt varieties. Per cent CLCuD incidence shows a positive correlation and similar pattern of progression with whitefly population. Temperature maximum and minimum shows a negative correlation with CLCuD incidence and whitefly and maximum variability found due to temperature minimum in CLCuD development. Relative humidity morning and evening and sunshine hours have a positive correlation with per cent CLCuD incidence. Rainfall is the limiting factor for increasing whitefly population. Temperature maximum, temperature minimum and sunshine hours ranges between 35-40 °C, 25-30 °C and 4-8 hours respectively has a significant role in cotton leaf curl disease development. Thus, Cotton leaf curl disease can be escaped or impact can be minimized by modifying management practices such a way that crop susceptible stages does not coincide with CLCuD favourable environmental conditions.

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