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Association of Weather Variable with Pest Outbreak in Bt-Cotton in the Cotton Belt of North India

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A B S T R A C T

Major threat to highly productive cotton belt of North India is Cotton Leaf Curl Disease exclusively transmitted by whitefly (*Bemisia tabaci*). The present investigation was carried out at Research farm of department of Agricultural Meteorology, CCS HAU, Hisar Haryana, to evaluate progression of CLCuD and whitefly (*Bemisia tabaci*) in relation to weather parameters. Three Bt -cotton hybrids were sown at three different dates. 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. 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

The mammoth pressure on planet Earth to cater to the never ending demands of the human population has already started to show its effect on the environment through various manifestations. Climate change the inevitable consequence of human existence on this world, has some far reaching consequences on the ability of Earth to produce food. Weather is inevitably the major and avoidable component of primary productivity. It is evident after Karnatka has become the first state to witness to record failure of winter crop the estimated crop loss was more than 33% the state qualifies for aid from the Union governments National Disaster Relief Funds (NDRF) this all was happened because of an unusual dry and warm winter. As we know meteorological parameters have direct relevance to agriculture. Weather parameters play a major role in production aspect of the

agricultural crops both as a factor in food production as well as affecting many disease and pests which are responsible for bringing down the quantum of production. Cotton is a major fiber crop of world popularly known as "white gold". Besides fiber it also contains 15-20% oil. India ranks third in area and production of the cotton. Cotton (*Gossypium spp.*) plays a dominant role in India's agrarian and industrial economy. It provides food, feed and fuel, and is considered as a major agricultural commodity sustaining Indian economy with 20 percent of industrial production and 30 percent of export. The raw material mainly used in textile industry, accounts for 70 per cent of total fiber. Cotton occupies a unique position in textile world with millions of people engaged in its cultivation, processing and marketing etc. therefore cotton is rightly called as the lifeline of economy all over Asia. Cotton seems to be specifically designed by nature to insect attacks. It has succulent leaves, attractive flowers, nectarines on every flower and a number of fruits. It suffers from insect ravages throughout its growth period. A number of insect- pests have been reported to cause up to 57.9 per cent reduction in seed cotton yield (Sharma, 1998).Among major threats to production of cotton a disease called cotton leaf curl disease plays a major role specifically in South east Asian countries name like Pakistan, India, Bangladesh etc. The disease caused by a whitefly transmitted Gemini virus was first noticed in Nigeria on *Gossypium peruvianum* and *G. Vitifolia* (Farquharson, 1912). In India the disease was first reported on *G. barbadense* at Indian Agriculture Research Institute, New Delhi in 1989 then after reported on American cotton (*G hirsutum*) in Sriganganagar area of Rajasthan state during 1993 (Ajmera, 1994) and during 1994 it appeared in Haryana and Punjab (Rishi and Chauhan, 1994; Singh *et al.,* 1994) states on *hirsutum* cotton and posed a major threat to its cultivation in northern India (Verma *et al.,* 1995). The disease has appeared in an epidemic form during 1997 in the Rajasthan affecting an area of 0.1 million hectares (Anonymous, 1998). The major area (more than 90%) has now come under Bt-cotton hybrids.

Cotton is best adapted to sub-tropical climates. The latitudinal limits of commercial production of cotton coincide with areas having an average summer temperature of 21^0C. The development rate is maximum when temperature of 25 to 30^0C. High humidity favors many pests and diseases. The cotton yield reduces when weather remains cloudy frequently. The meteorological factors play a vital role in the development and population build-up of insect species. Among the weather parameters, temperature and relative humidity are the most important to build up the insect and diseases. A positive relationship was found between daily temperature, relative humidity etc. with the cotton whitefly population. Temperature was found positively associated with whitefly population and relative humidity was negatively associated (Rote and Puri, 1991). Jayanthi *et al.,* (1993) reported a positive association of temperature and evening relative humidity with the population of whitefly and a negative bearing of morning relative humidity on the whitefly population. For the first time in its history, the India Meteorological Department-best known for its summer monsoon forecasts- will issue a summer forecast for April, May and June. This forecast will surely help to forecast to help the farmer to know whether the disease will appear or not based on the prevailing weather conditions. Our current study is to forecast the disease based on the correlation between the weather variables and disease. The present study includes the occurrence of disease with the weather conditions.

The study was carried out with the following objectives:

Correlation of weather variables with the occurrence of Cotton Leaf Curl Disease in Bt-cotton.

Relationship between weather variables and outbreak of white fly.

Materials and Methods

The present investigation on "Studies on physical environment in relation to cotton leaf curl disease in Bt-cotton" was carried out during the *kharif* season, 2013. The study was conducted at research farm of department of agricultural meteorology, Chaudhary Charan Singh Haryana Agricultural University, Hisar. Hisar is situated in the semi-arid zone at an elevation of 215.2 m with a longitude of 75° 46' E and latitude of 29°10'N.

The climate of Hisar region owes to its continental location on the outer margins of the monsoon region i.e. 1600 Km away from the ocean. It has arid subtropical monsoonal climate. South westerly monsoon current in the summer brings rain generally from last week of June to middle of September. From October to the end of June next, the weather remains mainly dry, except for a few light showers received due to western disturbances. About 80 per cent of annual precipitation is received in the south-west monsoon season. Summers are very hot (maximum temperature touches 45°C or sometimes more) and winters are fairly cool (minimum temperature around 1 to 2°C or sometimes less). Some time temperature falls below 0°C in the month of December and January. The average annual rainfall is 460 mm.

Methods for raising crop

Delinted and certified seeds of recommended SP 7007, Pancham 541 and RCH 791 of Bt-cotton cultivars were sown in three growing environments by hand plough, keeping a distance of 67.5_cm from row to row. Thinning was done one month after sowing maintaining a plant to plant distance of 30 cm. All the agronomic practices were followed as per the recommended package of practices by the University for raising the crop under irrigated conditions (Anonymous, 2014).

Crop field data

A field experiment was conducted on Bt-cotton with following treatments:

Main plot treatments: Sowing environments-Three

S_1	:	Sowing on 1st fortnight of May
S_2	:	Sowing on 2nd fortnight of May
S_3	:	Sowing on 1st fortnight of June
Sub plot treatments:		Cotton cultivars-Three
C1	:	SP-7007
C2	:	Pancham-541 (Susceptible)
C3	:	RCH-791 (Moderately Resistant)
Replications	:	Three
Plot size	:	6.75m × 6.00m
Spacing	:	67.5cm×60 cm
Design	:	Split plot

Observations recorded

Crop observations

The following phenological observations were observed:

Square initiation
Flower initiation
Boll formation
Boll opening

Plant height, LAI and dry matter were recorded on above mentioned phenophases.

Yield parameter (boll weight, boll number, seed cotton yield).

Quality parameter (ginning out turn, seed index, lint index).

Disease observation

Tagging on ten infected plants and ten healthy plants at previously mentioned stages.

PDI will be recorded and calculated as per the disease scale (0-6) of All India Coordinated Cotton Improvement Project (AICCIP).

$$PDI = \frac{\text{Sum of all diseased ratings}}{\text{Total no. of plants} \times \text{Maximum grade}} \times 100$$

White fly population will be observed on tagged plants at previously mentioned stages.

Meteorological observation

Temperature and humidity were measured using Psychrometer in crop canopy at all phenophases

PAR were measured in crop canopy using Quantum sensor at all phenophases.

Daily meteorological data was taken from meteorological observatory.

Statistical analysis

The data used in the study are the mean values of replicated observations. Correlation Coefficients were computed between the leaf curl virus disease in cotton and agro meteorological parameters. Regression analysis was carried out to develop the relationship of leaf curl virus disease with significant weather parameters temperature viz. relative humidity, vapour pressure deficit, wind speed, sunshine etc. and agro meteorological parameters. Multiple regression equations were developed by taking two or more significant agro meteorological parameters together using stepwise regression technique. Online computer programme OPSTAT was used for all the statistical analysis (http://hau.ernet.in/sheoranop/) of the research field data.

Results and Discussion

Disease observations

Disease intensity and whitefly population were recorded in three cotton cultivars grown in three different environments were recorded and their graphical representations with weather parameters are presented:

Per cent disease intensity

Among the three different sowing dates, in plants sown on 9th June PDI was highest (49.9%) at 50% boll opening stage whereas, plants sown on 10th May showed lowest PDI (18.3%) at 50% flowering stage. Among three Bt-cotton cultivars plants 541 plants showed highest PDI (55.9%) at 50% boll opening stage while lowest was recorded in RCH 791, at 50% flowering stage (Table 1).

Whitefly population

Whitefly population was observed at different phenophases of all the cotton cultivars and presented in table 2. Among the different sowing dates, 9th June sown crop plants had highest whitefly population (138) at 50% boll opening stage, while plants sown on 10th May showed lowest whitefly population (107.55) at 50% square formation stage. Among Bt-cotton cultivars plants of Pancham 541

showed highest whitefly population (95.44) at 50% boll opening stage whereas lowest (39.33) was recorded in RCH 791 at 50% square formation stage.

Correlation

The correlation of disease intensity with weather parameters are presented in table 3. Leaf curl disease showed a negative and significant correlation with maximum temperature. Relative humidity morning showed positive and significant correlation while relative humidity evening showed non-significant correlation with leaf curl disease. Wind speed and evaporation showed positive and significant correlation with leaf curl disease whereas sun-shine hours had positive correlation but non-significant. Rainfall showed negative non-significant correlation with leaf curl disease.

Multiple regression

The best regression models were developed for prediction of leaf curl disease with weather parameters using step-wise multiple regression technique which is shown in table 4. Maximum variability in leaf curl disease can be explained up to 88 per cent by temperature minimum and relative humidity morning in Pancham 541 and SP 7007 cultivar in 25th May sown crop whereas lowest variability (39%) showed by wind speed in RCH 791 cultivar also from 25th May sown crop. Highest variability in leaf curl disease was found in Pancham 541 by temperature minimum and relative humidity morning in all the sowing environments while lowest variability in leaf curl disease was found in RCH 791.

Relationship of whitefly population with weather parameters

The correlation and regression analysis were carried out to establish the relationship between whitefly population in various cotton cultivars and weather parameters: maximum temperature, minimum temperature, relative humidity (M), relative humidity (E), wind speed, sun-shine hours, evaporation and rainfall.

Table.1 Percent disease intensity progression in different Bt-cotton cultivars under different sowing environments

Treatment	50% Flowering	50% Boll Formation	50% Boll Opening
Date of sowing			
10th May	18.2	23.6	33.5
25th May	21.1	30.06	44.6
9th Jun	31.2	41.6	49.9
SE(m)	0.08	0.40	0.13
CD at 5%	0.34	1.60	0.51
Cultivars			
SP7007	24.4	31.8	42.7
Pancham-541	27.1	39.4	55.9
RCH-791	18.9	23.9	29.3
SE(m)	0.15	0.44	0.30
CD at 5%	0.50	1.40	0.93

Table.2 Whitefly population progression in different Bt-cotton cultivars under different sowing environments

Treatment	50% Square Formation	50% Flowering	50% Boll Formation	50% Boll Opening
Date of sowing				
10th May	25.33	61.55	93.11	107.55
25th May	45.66	89	103.33	114.11
9th Jun	75.33	101.66	111.77	138
SE(m)	0.61	0.85	0.76	2.77
CD at 5%	2.45	3.43	3.05	11.16
Cultivars				
SP7007	43	78.66	104.33	121.22
Pancham-541	64	108	124	143
RCH-791	39.33	65.55	79.88	95.44
SE(m)	1.59	2.07	2.82	2.48
CD at 5%	4.95	6.44	8.79	7.73

Table.3 Correlation coefficient for the percent disease intensity of CLCuD of Bt-cotton hybrids in relation to weather parameters in different sowing environments

Weather variables	1st DOS (10-05-2014)			2nd DOS (25-05-2014)			3rd DOS (09-06-2014)		
	Hybrids			Hybrids			Hybrids		
	SP 7007	Pancham 541	RCH 791	SP 7007	Pancham 541	RCH 791	SP 7007	Pancham 541	RCH 791
T (maximum)	-0.741**	-0.692*	-0.688*	-0.677*	-0.655*	-0.673*	-0.757**	-0.658*	-0.711**
T (minimum)	-0.706*	-0.793**	-0.563	-0.822**	-0.836**	-0.610*	-0.654*	-0.799**	-0.599*
Relative humidity %(M)	0.628*	0.554	0.616*	0.530	0.502	0.593*	0.642*	0.521	0.638*
Relative humidity %(E)	0.175	0.075	0.207	0.045	0.018	0.168	0.201	0.066	0.228
WS(km/hr)	-0.688*	-0.694*	-0.610*	-0.702*	-0.657*	-0.624*	-0.657*	-0.675*	-0.601*
SS(hrs)	0.195	0.248	0.171	0.277	0.315	0.209	0.126	0.286	0.194
EVAP(mm)	-0.868**	-0.830**	-0.798**	-0.817**	-0.776**	-0.791**	-0.867**	-0.798**	-0.817**
RAIN(mm)	-0.277	-0.315	-0.259	-0.325	-0.327	-0.267	-0.276	-0.276	-0.219

DOS - Date of sowing

Table.4 Stepwise regression equation for the percent disease intensity of CLCuD on Bt-cotton hybrids in relation to weather parameters under different date of sowing

Hybrids	Regression Equations	R^2
1st DOS (10-05-2014)		
SP 7007	$Y= 61.41 - 3.49 X_1 + .67 X_2$	0.82
Pancham 541	$Y = 100.79 - 4.96 X_1 + .717 X_2$	0.86
RCH 791	$Y = 33.36 + .571 X_2 – 2.30 X_1$	0.64
2nd DOS (25-05-2014)		
SP 7007	$Y = 108.61 - 5.17 X_1 + .67 X_2$	0.88
Pancham 541	$Y =136.51 - 6.31 X_1 + .75 X_2$	0.88
RCH 791	$Y = 46.96 - 4.01 X_3$	0.39
3rd DOS (09-06-2014)		
SP 7007	$Y = 71.96 - 2.12 X_3 + .78 X_2 - 3.22 X_1$	0.81
Pancham 541	$Y = 158.37 - 7.68 X_1 + 1.02 X_2$	0.84
RCH 791	$Y = 44.96 + 0.75 X_2 + 3.15 X_1$	0.70

X_1 = Temperature minimum (°C) **DOS** - Date of sowing
X_2 = Relative humidity (M)
X_3 = Wind speed (km/hr)

Table.5 Stepwise Regression equation for the whitefly population on Bt-cotton hybrids in relation to weather parameters under different date of sowing

Hybrids	Regression Equations	R^2
1st DOS (10-05-2014)		
SP 7007	$Y= 202.97 – 11.97 X_1 + 2.17 X_2$	0.81
Pancham 541	$Y = 208.30 -10.97 X_1 + 2.31 X_2$	0.74
RCH 791	$Y = 156.35 – 7.78 X_1 + 1.43 X_2$	0.80
2nd DOS (25-05-2014)		
SP 7007	$Y = 196.62 – 11.02 X_1 + 2.28 X_2$	0.85
Pancham 541	$Y = 271.27 – 12.49 X_1 + 2.14 X_2$	0.81
RCH 791	$Y = 158.08 – 7.76 X_1 + 1.36 X_2$	0.78
3rd DOS (09-06-2014)		
SP 7007	$Y = 235.30 – 11.42 X_1 + 1.99 X_2$	0.88
Pancham 541	$Y = 273.01 – 11.95 X_1 + 1.98 X_2$	0.82
RCH 791	$Y = 177.54 – 8.24 X_1 + 1.47 X_2$	0.85

X_1 = Temperature minimum (°C) **DOS** - Date of sowing
X_2 = Relative humidity (M)

Table.6 Correlation coefficient for the whitefly population in Bt-cotton hybrids in relation to Weather parameters in different sowing environments

Weather variables	1st DOS (10-05-2014)			2nd DOS (25-05-2014)			3rd DOS (09-06-2014)		
	Hybrids			Hybrids			Hybrids		
	SP 7007	Pancham 541	RCH 791	SP 7007	Pancham 541	RCH 791	SP 7007	Pancham 541	RCH 791
T (maximum)	-0.718**	-0.704*	-0.703*	-0.755**	-0.697*	-0.696*	-0.737**	-0.703*	-0.717**
T (minimum)	-0.701*	-0.647*	-0.710**	-0.701*	-0.730**	-0.703*	-0.758**	-0.745**	-0.739**
Relative humidity %(M)	0.623*	0.619*	0.606*	0.659*	0.588*	0.594*	0.619*	0.582*	0.614*
Relative humidity %(E)	0.180	0.181	0.147	0.225	0.124	0.143	0.159	0.114	0.161
WS(km/hr)	-0.646*	-0.626*	-0.651*	-0.598*	-0.649*	-0.644*	-0.615*	-0.659*	-0.625*
SS(hrs)	0.243	0.236	0.264	0.203	0.272	0.255	0.249	0.261	0.268
EVAP(mm)	-0.836**	-0.823**	-0.828**	-0.845**	-0.818**	-0.818**	-0.834**	-0.824**	-0.831**
RAIN(mm)	-0.228	-0.269	-0.274	-0.156	-0.283	-0.255	-0.216	-0.285	-0.227

DOS - Date of sowing

Fig.1 Relative progression of PDI with relation to whitefly population in 10th May sown crop

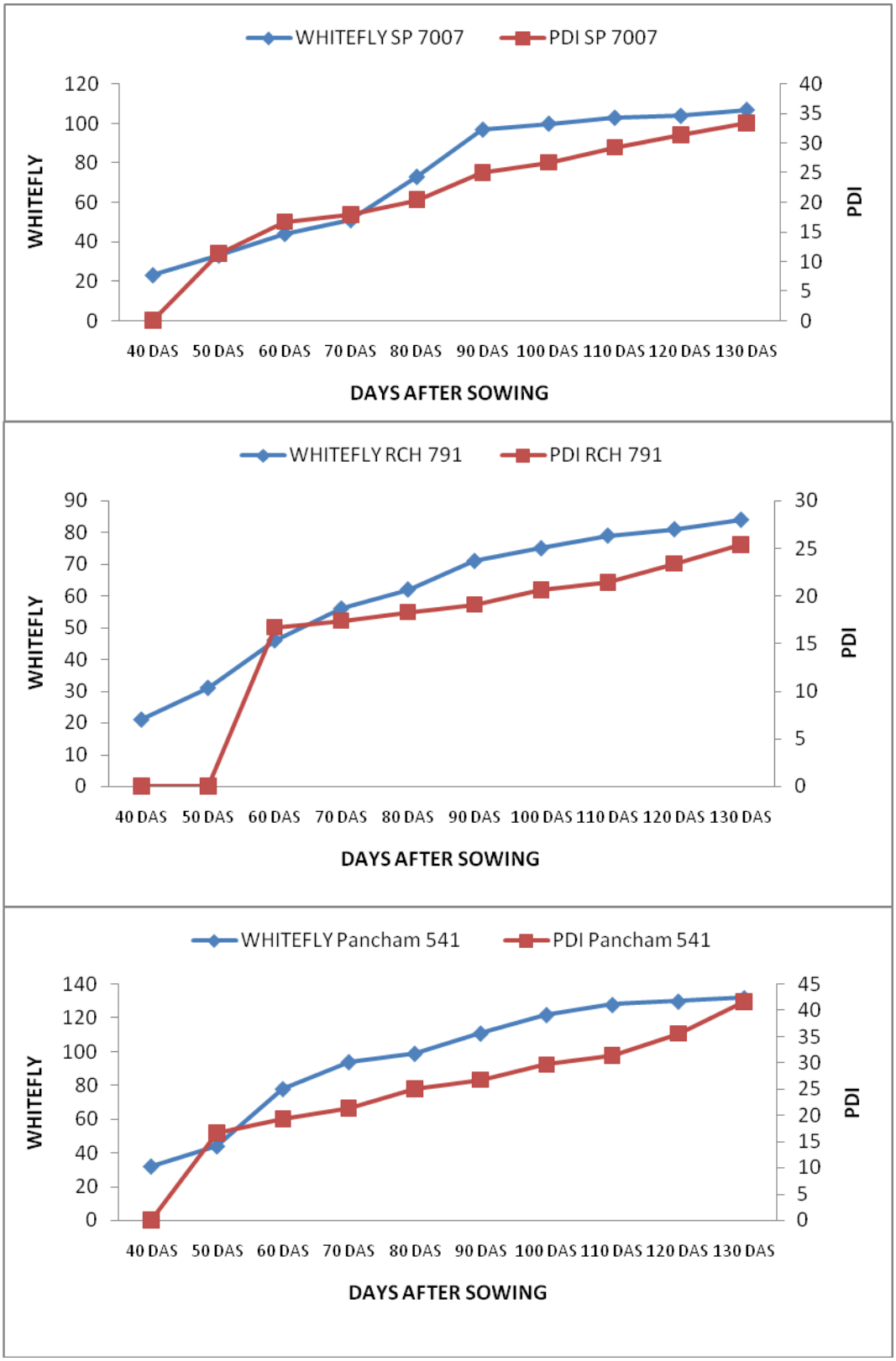


Fig.2 Relative progression of PDI with relation to whitefly population in 25th May sown crop

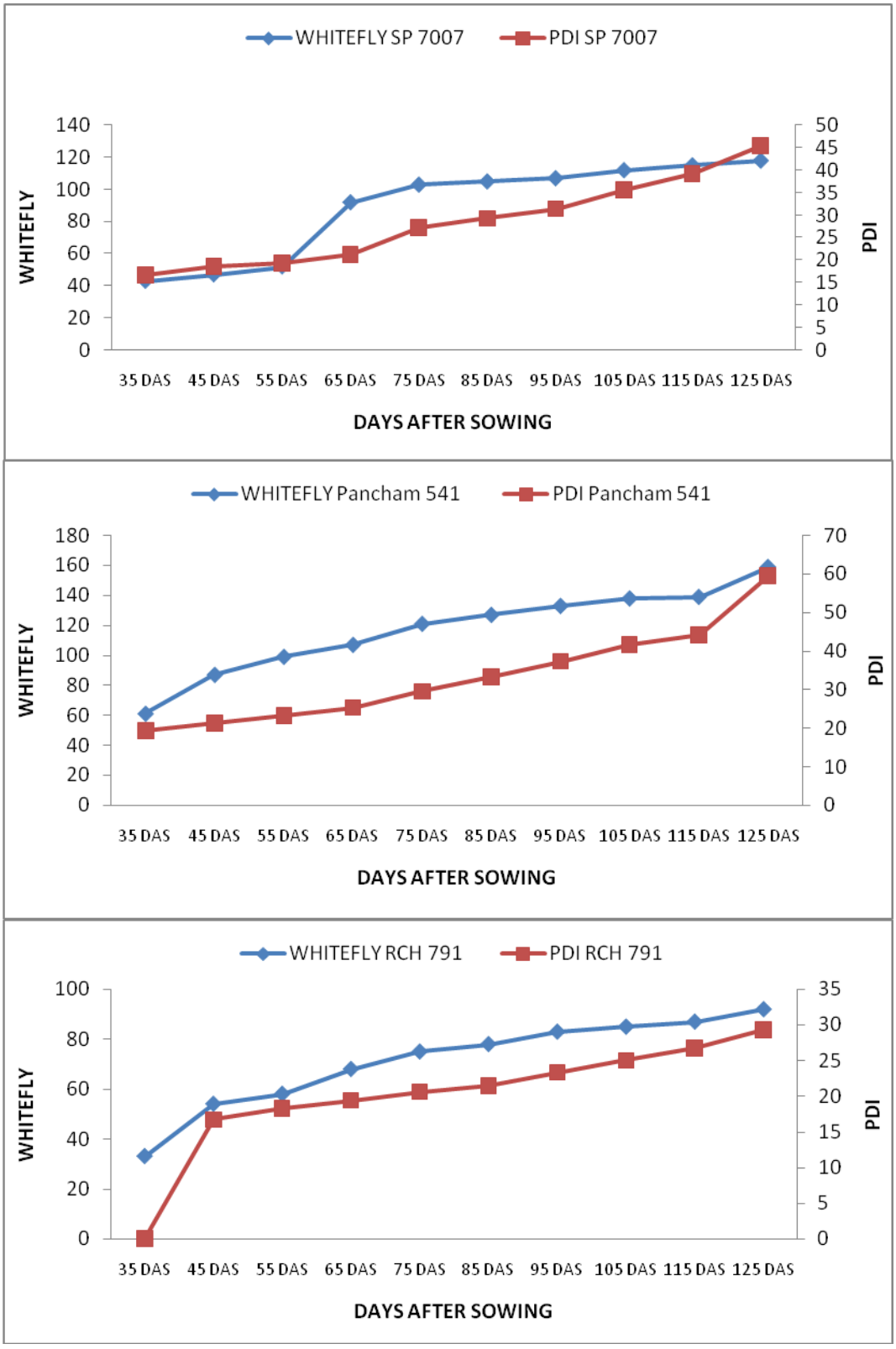
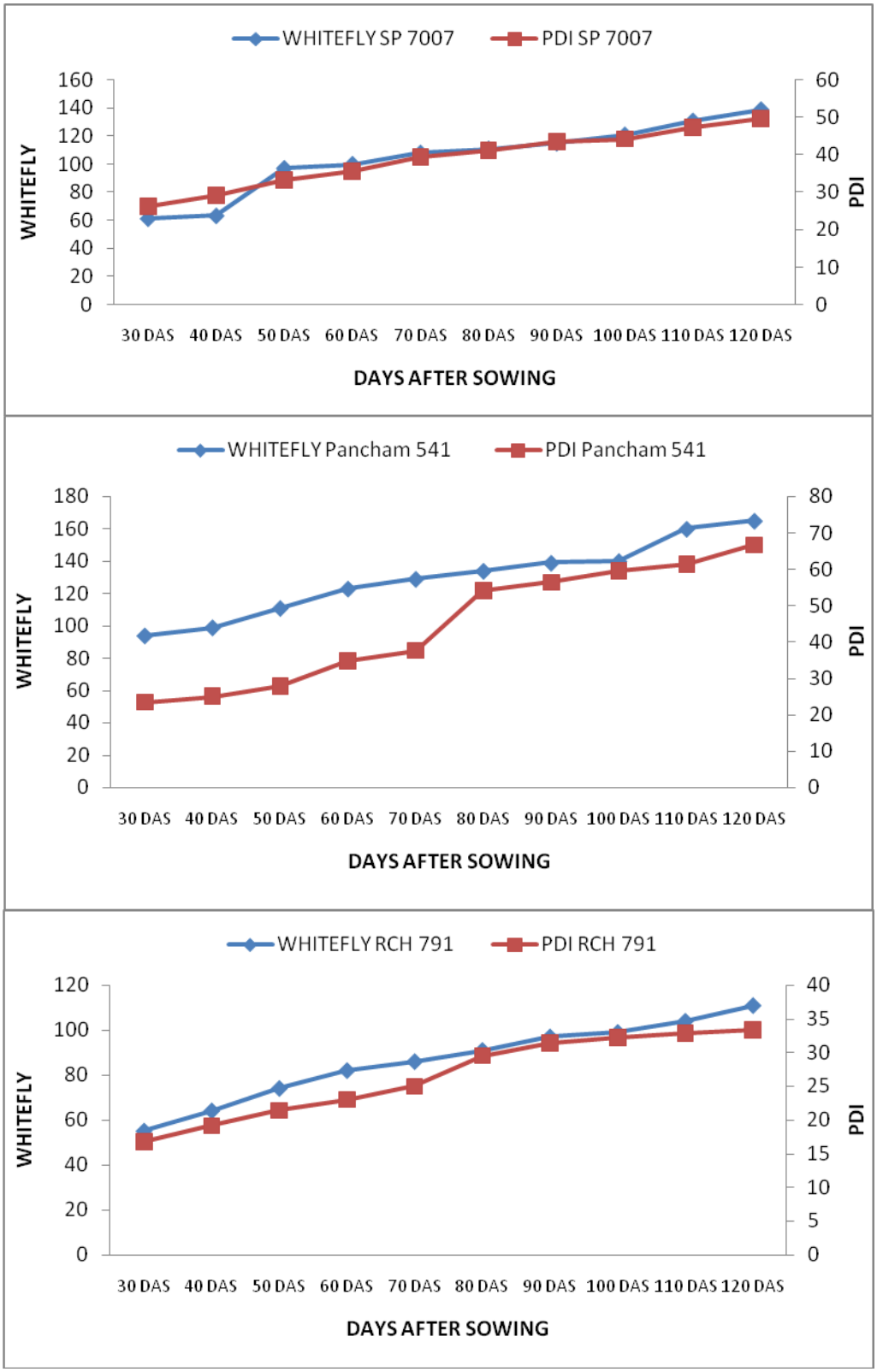


Fig.3 Relative progression of PDI with relation to whitefly population in 9th June sown crop



Correlation

Whitefly population negatively and significantly correlated with maximum temperature, minimum temperature, wind speed and evaporation. Rain fall also had negative but non-significant correlation with whitefly population. In case of relative humidity, whitefly population was positive and significant correlation with relative humidity morning while relative humidity evening was positive and non-significant correlation with whitefly population. Whitefly population had positive and non-significant correlation with sun-shine hours (Table 5).

Multiple regression

On the basis of significant weather parameters best fit simple and multiple regression models for prediction of whitefly population are presented in table 6.

Maximum variability in whitefly population was by minimum temperature and relative humidity morning in SP 7007 cultivar sown on 9th June, whereas lowest variability (74%) was explained in Pancham 541 cultivar sown on 25th May. These best fit models are location and cultivar specific and could be used for prediction of whitefly build up.

Relative progression of CLCuD intensity with respect of whitefly population

Relative progression of CLCuD intensity with whitefly population for all the three cotton cultivars in three different sowing environments was presented in figure 1 to 3 showed that intensity of the leaf curl disease increases with increased population of whitefly. In all the sowing environments same pattern was found for all the Bt-cotton cultivars. Positive relation between leaf curl disease intensity was highest in 9th June sown crop whereas among three cultivars SP7007 showed highest positive relationship between disease intensity and whitefly population.

Per cent disease intensity (PDI) and white fly population were more in late sown crop as compared to early sown crop. Maximum variability in whitefly population can be explained upto 88 per cent by minimum temperature and morning relative humidity in SP 7007 cultivar whereas lowest variability (74%) explained by minimum temperature and morning relative humidity in Pancham 541 cultivar.

PDI showed negative correlation with minimum temperature while positive with morning relative humidity.

Whitefly showed negative correlation with minimum temperature while positive with morning relative humidity. Wind speed also showed a negative significant correlation with whitefly population.

Highest variability in intensity of leaf curl disease in Pancham 541 was explained by minimum temperature and morning relative humidity.

Maximum variability in whitefly population build up in SP 7007 was explained by minimum temperature and morning relative humidity. A positive relationship of leaf curl disease with whitefly population was observed and which was maximum in SP 7007 cultivar.

Farmers are advised to sow the crop early to avoid infestation and major losses to the crop.

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