Correlation of meteorological parameters and remotely sensed normalized difference vegetation index (NDVI) with cotton leaf curl virus (CLCV) in Multan

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Abstract. Climate change and weather has a profound effect on the spread of Cotton Leaf Curl Virus (CLCV) which is transmitted by whitefly. Climate change is altering temperature and precipitation patterns, resulting in the shift of some insect/pest from small population to large population thus effecting crops yield. To find out the relationship between the weather conditions, outburst of CLCV and changes in Normalized Difference Vegetation Index (NDVI) values due to the outburst of CLCV, a study was carried out for tehsil Multan. Data was acquired for the months of June, July, August and September for the year 2010. Regression analysis between CLCV and meteorological conditions as well as between CLCV and NDVI was performed. Meteorological parameters included temperature, humidity, precipitation, cloud cover, wind direction, pan evaporation and sunshine hours. NDVI values were calculated from SPOT satellite imagery (1km) using ArcMap10 and WinDisp v5.1. Correlation coefficients obtained in most of the cases were acceptable however the significance F and P-value were higher than their critical value at 95% level of significance. Therefore significant correlation was found only between CLCV and temperature and between CLCV and PAN evaporation during the month of July.

1. Introduction
Multan district is situated in the southern part of the Punjab province. The district of Multan consists of four tehsils which include Multan Cantonment, Multan Sadar, Shujabad and Jalalpur Pirwala. Multan district has an extreme climate. In summers the temperature reaches to 49°C while in winter it drops to 1°C. The average rainfall in Multan district is 127 mm. Multan tehsil has a very fertile soil. Agriculture of Multan consists of crops, fruits, vegetables etc. Wheat, cotton and sugarcane are the main crops grown here while important fruits grown here include mangoes and citrus [1]. Mangoes and cotton crop grown here play an important role in foreign exchange earnings of Pakistan.

Cotton crop is one of the main crops of Pakistan which is grown in the Kharif season and plays very significant role in the development of Pakistan’s economy [2]. Cotton crop contributes to about 2% of GDP and it is considered to be the life line of Pakistan’s economy [3]. Cotton crop provide oil, fibre, fuel and animal feed etc. It supplies raw material to 1200 ginning units, 180 spinning units, about 470 textile mills and 50 vegetable oil mills [4].

Although this cash crop is very important however yields are still very low and stagnant in Pakistan for the last several years as compared to other cotton growing countries. Factors which are responsible for the stagnant cotton production includes excessive precipitation at sowing time, high temperature...
and its variations at the flowering stage [5]. In Pakistan, annual mean surface temperature has been rising consistently since the start of 20th century [6]. This is altering optimum weather conditions required for crop growth for instance many crops are under heat stress like wheat, sugarcane and cotton [7]. Alteration in weather conditions affects the insects/pests populations, thus affecting crop yields. One of the most significant reasons of low production of cotton in Pakistan is due to the presence of number of insects/pests and diseases at different periods of its growth and development which results in vast economic losses [8]. Amongst the sucking insect pests, whitefly, jassid and thrips are considered very dangerous for crops in Pakistan [9].

Whitefly is the main cause of Cotton Leaf Curl Virus (CLCV). CLCV was reported for the first time in Nigeria in 1912 [10]. After that it was reported in 1926 in Tanzania [11] and in 1934 in Sudan [12]. In Pakistan CLCV was observed for the first time near Multan on cotton plants in 1967 [13]. The emergence of the disease at seedling phase badly affect flowering, development of boll, growth and maturation, yield of cotton seed and quality of fibre [14]; [15]. It reduces length, strength and elongation of fiber up to 3.44%, 10% and 10% respectively [16].

As insects and pests damage crops these damages can be detected through remote sensing. Satellite imagery is useful to detect alterations in plant development. Therefore to detect changes in the study area, SPOT satellite imagery was used (1km resolution). SPOT satellite images were used to calculate NDVI (Normalized Difference Vegetation Index) values of cotton crops. NDVI is a widely used measurement method to determine the density of vegetation. Therefore this study was carried out with the following scope:

- To find out the relationship of weather conditions and development of CLCV in Multan sadar and Multan cantonment cotton field areas (Multan tehsil).
- To calculate NDVI values of cotton crop in Multan tehsil in order to find out changes in NDVI values with CLCV development.

2. Materials and Methods

2.1. Data acquisition

1. Relevant literature was acquired from International Islamic University Islamabad (IIUI) digital library.
2. Four months meteorological data i.e. June, July, August and September (2010) was acquired from Pakistan Meteorological Department (PMD). The data included daily temperature, humidity, precipitation, cloud cover, wind direction, PAN evaporation and sunshine hours for the selected four months.
3. Per month three images (Twelve images) of SPOT 1km resolution satellite imagery were acquired from PMD for the year 2010.
4. CLCV data for the selected months i.e. June, July, August and September (2010) was acquired from Pakistan Cotton Research Institute (PCRI), Multan.

2.2. Methods

Relevant literature was reviewed. Hundred points were taken from Multan cantonment and Multan sadar cotton field areas (Multan tehsil) using software Google earth. Meteorological and CLCV data for Multan tehsil was acquired from PMD and PCRI respectively.

SPOT satellite imagery was used to calculate NDVI values of cotton crops with the help of software ArcMap 10 and WINDISP 5.1. For this the selected hundred points were plotted on a map, converted to shape file format using software ArcMap 10. Then shape file was converted to .bna format. After that NDVI values were extracted using .bna file and SPOT satellite images with the help of WINDISP 5.1 software.

After that regression analysis was performed and for this separate spread sheets were used. Every spread sheet contained spots of CLCV and one parameter for a month. Each month was divided into ten days interval and average was calculated for each interval, except for precipitation (sum was taken for precipitation) and then regression analysis was performed using Microsoft excel 2010. Thus
correlation was calculated between spots of CLCV and meteorological parameters and as well as between CLCV and NDVI.

Figure 1. Map of Pakistan highlighting the study area. 
Source: Pakistan Meteorological Department

3. Results and discussion
It is predicted that about 20-40% losses of cotton crop take place annually as a result of different insects and pests of cotton [17]. Among different diseases CLCV is a dangerous disease of cotton crop which is transmitted by whitefly. It affects the quality and yields of cotton crop. Climate change is altering weather conditions and changing pest/insects population thus affecting crop growth. Therefore finding out this relationship was very important. Thus regression analysis was performed to find relationship between CLCV and weather conditions and as well as between CLCV and NDVI. The results obtained in this research study shows that CLCV is being affected by weather. Results acquired are discussed in subsequent section.

| Table 1. Regression analysis of CLCV with meteorological parameters and NDVI. |
|---------------------------------------------|----------------|----------------|----------------|----------------|
|                                | June | July | August | September |
| CLCV and mean air Temperature | R Square | 0.93 | 0.99 | 0.49 | 0.20 |
|                                | Significance F | 0.15 | 0.03 | 0.50 | 0.70 |
|                                | P Value | 0.15 | 0.03 | 0.50 | 0.70 |
| CLCV and PAN Evaporation       | R Square | 0.82 | 0.99 | 0.01 | 0.95 |
|                                | Significance F | 0.27 | 0 | 0.97 | 0.13 |
|                                | P Value | 0.27 | 0.03 | 0.97 | 0.13 |
| CLCV and Cloud Cover           | R Square | 0.54 | 0.91 | 0.14 | 0.27 |
|                                | Significance F | 0.47 | 0.18 | 0.75 | 0.64 |
|                                | P Value | 0.47 | 0.18 | 0.75 | 0.64 |
In this research, the relationship between temperature and CLCV was found significant in Multan station during the month of July. In Africa, CLCV was affected by temperature [18]. According to [19], CLCV increased in the range of maximum and minimum temperatures of 33-45 °C and 25-30 °C respectively. However, during June, August, and September (2010) insignificant relationship was obtained between CLCV and air temperature. According to [20], there exists non-significant correlation between weekly maximum air temperature and whitefly (cause of CLCV).

The relationship between CLCV and PAN evaporation was found significant in Multan during July. However, insignificant relationship between CLCV and PAN evaporation was found in June, August and September in Multan due to high significance F and P value as mentioned in table 1.

A study was carried out in five districts of Punjab and found that the correlation between rainfall and whitefly population was non-significant [20]. Similarly poor correlation was found between weekly rainfall and CLCV development [19]. Likewise the relationship obtained in this research between CLCV and cloud cover and between CLCV and precipitation during June, July, August and September (2010) in Multan was insignificant because significance F and P value were greater than critical value 0.05.

A poor correlation of humidity with CLCV development was found [19] and non-significant correlation was obtained between relative humidity and whitefly population [20]. We also found similar trends in our research. No significant relationship was established between CLCV and relative humidity in Multan during all selected four months.

Wind speed is a significant aspect which governed the activity of whitefly population [21]. However a non-significant correlation between wind and whitefly population was found according to a study carried out in five districts of Punjab [20]. Similarly in this research, the relationship between CLCV and wind was found insignificant in Multan during June, July, August and September because significance F and P value were greater than critical value 0.05.

During 2000, significant positive correlation was found between sunshine hours and CLCV [8]. However [20] observed that there was non-significant correlation between whitefly and sunshine. Similarly results obtained between CLCV and sunshine hours in this research were insignificant due to high significance F and P value, both were greater than critical value 0.05 during June, July, August and September (2010) in Multan station.
Normalized Difference Vegetation Index (NDVI) has been widely used for the estimation of biomass of plant [22], growth, development, spatial density distribution [23]. In this research the relationship between CLCV and NDVI in selected area was found to be insignificant during June, July, August and September (2010).

4. Conclusion
The objective of this study was to determine the relationship of meteorological parameters and NDVI with CLCV. For this regression analysis was performed to find the relationship of meteorological parameters and NDVI with CLCV. Value of correlation coefficient obtained was acceptable in most cases however values of significance F and P were mostly greater than their critical value i.e. 0.05. These variations in the results might have occurred due to lesser amount of data. Since the data was available only for four months i.e. June, July, August and September (2010) and only three observations within a month. Therefore significant relationship was only obtained between:

- CLCV and air temperature during July 2010.
- CLCV and PAN evaporation during July 2010.

If long term CLCV data and high resolution imagery is available then results would be much better than the present one. Therefore more research should be done with complete data set.

Appendix

Figure 1. CLCV and Temperature Variations in June, July, August and September, 2010.

Figure 2. CLCV and PAN Evaporation Variations in June, July, August and September, 2010.

Figure 3. CLCV and Cloud Cover Variations in June, July, August and September, 2010.

Figure 4. CLCV and Wind Variations in June, July, August and September, 2010.
Figure 5. CLCV and Precipitation Variations in June, July, August and September, 2010.

Figure 6. CLCV and Sunshine Hours Variations in June, July, August and September, 2010.

Figure 7. CLCV and Relative Humidity Variations in June, July, August and September, 2010.

Figure 8. CLCV and NDVI Variations in June, July, August and September, 2010.

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