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Differential Effect of Planting Time on Cotton Leaf Curl Disease (Clcud) and Yield of Cotton Variety Cim-598 (*Gossypium Hirsutum* L.)

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Abstract: **A biotic and biotic factors like temperature and planting time influence cotton leaf curl virus disease epidemiology. The objective of the present study was to determine the factors that affect the of cotton leaf curl disease on seed cotton yield of Bt CIM-598, for three years 2010.2011 and 2012. Significant difference exited for seed cotton yield and CLCuV infestation due to planting time in every year. There was less disease incidence on early planted crop as compare to late planting. Maximum CLCuV incidence was recorded within 30-45 days in late planting as compared to 105 days of early planted cotton. This trend was common in three years but CLCuV incidence percentage was increased every year. The three year results revealed that CIM-598 cotton variety at early plantation performed better and produced higher seed cotton yield as compared to late plantation. It was found that cotton planted on May 15th gave highest CLCuV disease incidence followed by May 1st, April15th, April 1st and March 15th planting. Whereas on 15th March planted cotton gave highest seed cotton yield followed by April 1st, April 15th, May 1st and May 15th planting. Delay in sowing cotton crop reduced seed cotton yield progressively. Other factors affecting the incidence of cotton leaf curl virus are investigated. 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.**

Keywords: **Gossypium sp., Cotton Leaf Curl Disease, Disease Index, Seed cotton Yield, Temperatures, Relative Humidity.**

1. INTRODUCTION

Cotton is one of the major industrial crops in many countries of the world including Pakistan (*Imran et al., 2012*) accounting for over 60% of foreign exchange earnings. It is grown in most of the warmer regions of the country (*Riaz et al., 2013*) Cotton Leaf Curl Virus (CLCuV) is a single stranded DNA virus and also a member of "Begomovirus" and family "Geminiviridae". This virus is neither seed born nor soil borne. It has some alternate hosts where it survives these alternate hosts are Tomato, Tobacco, Lehli, Dhatura, Okra, China Rose etc. The most important means of virus transmission is whitefly (*Bemisia tabaci*),. This whitefly acquires the virus from infected plant and transmits it to the healthy ones. Ones the virus is acquired by the whitefly it remains in it throughout its life. Whitefly requires 30 minutes of feeding on infected plant to acquire the virus and a latent period of 24 hours and then 30 minutes of feeding on healthy plant to transmit the virus leading to unnoticeable changes at the initial stage to remarkable variations in growth patterns at later stages of cotton plant development. Cotton leaf curl disease (CLCuD) complex is a debilitating disease of cotton that results in leaf curling, darkened veins, vein swelling and enations that frequently develop into cup-shaped, leaf like structures on the undersides of leaves. Overall the plant becomes stunted and reduced yield and quality.

The effects of the disease on production, during 1991-1999, proved to be disastrous. By 1994-1995, the epidemic reduced yields to 7.9 million bales (Anonymous, 1997). The most recent epidemic resulted from the emergence of a resistance breaking strains in varieties developed to combat the first outbreak that occurred in about 1990 (*Zafar and*

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Brown,2011;Zafar et al.,2003) Breeding efforts were undertaken to develop resistance varieties to combat the disease, and production return to pre epidemic levels. However during 2001-2002, a second outbreak began in the Burewala virus in the Punjab Province where the disease affected those cotton varieties that had been developed to combat infection by CLCuV of Multan, the pre dominant causal agent of the 1994-95 epidemics. As reported by *Mahmood et al., 2003; Mansoor et al., 2003* Sequencing of viral associated with the burewala out break revealed the predominance of an emergent new strain, referred to as cotton leaf curl Burewala virus (CLCuBV).

Currently, no disease resistance is available to CLCuD in cultivated cotton or any other cultivated host species (Vegetable or ornamentals). Even so the reliance on genetic resistance for disease management has been the primary means considered in Pakistan. Losses due to this disease depend upon variety and planting time of cotton crop (*Tahir et al., 2004*). *Khan and Khan (1992*) reported that planting date of 20th April to 5th May gave better seed cotton yield than late sown crop. The present studies were therefore, carried out to find out the factors influences the change in resistance with the passage of time due to CLCuV.

2. MATERIAL AND METHOD

The studies were undertaken with variety Bt-CIM-598 for three consecutive years i.e. 2011, 2012 and 2013 at Central Cotton Research Institute (CCRI) Multan, Pakistan. The crop was planted under natural epiphytotic conditions. The crop was planted on 15th March, 1st April, 15th April, 1st May and 15th May of each year by dibbling method. The plants were spaced 75cm row to row and 30 cm plant to plant distance. Experiment was arranged in split-split design keeping the planting years in main plot and sowing time in sub plot with 4 replicates. All other cultural practices were performed in standard fashion to optimize the seed cotton yield.

Data on CLCuV incidence were collected at 15 days interval starting from 30 days after planting and continued upto180 days. Total numbers of plants showing leaf curl virus disease symptoms (upward curling with thickened vein on underside of leaf) were counted every time during observations. Plants with even a single leaf showing the symptoms of disease were counted as infected. The percentage of disease incidence was counted by simple percentage formula. CLCuV disease index was recorded on 15th August in different grades as described by *Akhter and Khan (2002*). The percentage of disease index was calculated by using the following formula.

Disease Severity = a* (0$^{\#}$) + a (1) + a (2) + a (3) + a (4) / Total Diseased Plants

Where as *= Number of plants, # = Rating scale

Disease Index = Disease %age x Disease Severity/ Maximum Severity Value (4).

The Data of weather parameters were obtained from Metrological Department, (CCRI) Multan, Pakistan. Fortnightly progression of disease incidence were calculated and correlated with weather parameters (Maximum, minimum Temperature and Relative Humidity. The Data were subjected to analysis of variance Split Plot Design (Steel *et. al.* 1996). Significance difference test (LSD) were compared at P =0.005.

3. RESULTS AND DISCUSSION

The results of disease incidence monitored (fortnightly interval) 30 days after planting for all sowing dates in each year are given in Table- 1. Data showed different expression of CLCuD during the crop seasons of 2011, 2012 and 2013 with planting dates. Minimum incidence of disease 0.2% was recorded at day 75 after planting and increased very slowly up to 2.1% at day 150 after planting on crop planted on 15th March of 2011. The disease infestation was 0.3% at day 75 and reached its maximum level 3.8% on 165 days after planting on crop planted on 1st April. However, incidence of CLCuD 2.2% at day 75 and attained its maximum level 13.2% at day 135 after planting on 15th April. The disease incidence was 1.1% at day 45 and trapped up to 60.6% at day 135 after planted on 1st May. The crop planted on 15th May had 8.4% CLCuD incidence at day 45 and boot up to 93.5% at day 105 after planting during 2011. During the crop seasons 2012, Minimum incidence of disease 0.5% was recorded at day 90 after planting and increased up to 4.7% at day 180 after planting on crop planted on 15th March of 2012. The disease infestation was 1.8% at day 60 and reached its maximum level 24.1% on 165 days after planting on crop planted on 1st April. However, incidence of CLCuD 4.2% of day 60 and

attained its maximum level 65.4 % at day 150 after planting on 15th April. The disease incidence was 2.6 % at day 45 and trapped up to 97.0 % at day 150 after planted on 1st May. The crop planted on 15th May had 10.1 % CLCuD incidence at day 45 and boot up to 98.8 % at day 120 after planting during 2012. There was more disease in all sowing dates of 2012 as compare to 2011.

In 2013 disease incidence started at high level as compared to 2011 and 2012 in all sowing dates. It was 0.5% at day 75 after planting and reached up to 45.3% at its maximum level on crop planted on 15th March Similarly the crop planted on 1st April attained 1.2% at day 60 and progressed rapidly 95.7% at day 165. The infestation level was 0.6% after 45 days and prey fell 100% within 120 days in 1st May plantation. Whereas in 15th May planting disease incidence started at day 30 and maximum increase was 100% at day 105.I t was found that CLCuD percentage rapidly increased in the first week of august in all the planting dates. Selection of optimum sowing time for cotton crop in any area should be according to its weather condition. Too early and too late planting makes the crop susceptible to CLCuD and its vector due to weather fluctuation.

Table-1 Incidence of CLCuD on Different planting dates during 2011-2013

		CLCuD Incidence in %age										
Year	**Sowing Date**	**30***	**45**	**60**	**75**	**90**	**105**	**120**	**135**	**150**	**165**	**180**
2011	15th March	0	0	0	0.2	1.2	1.6	1.6	1.9	2.1	2.1	2.12
	1st April	0	0	0	0.3	0.3	0.5	1.4	2.3	3.0	3.8	3.8
	15th April	0	0	0	2.24	4.53	8.26	13.13	13.2	13.2	13.2	13.2
	1st May	0	1.1	11.8	32.9	40.3	41.5	58.5	60.6	60.6	60.6	60.6
	15th May	0	8.4	36.8	70.4	92.2	93.5	93.5	93.5	93.5	93.5	93.5
	Average	**0.0**	**1.9**	**9.7**	**21.2**	**27.7**	**29.0**	**33.6**	**34.3**	**34.4**	**34.6**	**34.6**
2012	15th March	0	0	0	0	0.53	0.44	2.05	2.59	2.59	3.56	4.7
	1st April	0	0	1.8	6.7	10.0	14.5	17.6	19.6	21.9	24.1	27.9
	15th April	0	0	4.2	16.0	34.3	44.7	51.3	56.1	65.4	65.4	65.4
	1st May	0	2.6	32.6	61.0	77.3	84.1	88.6	90.8	97	97	97
	15th May	0	10.1	59.8	74.1	81.4	90.9	98.8	98.8	98.8	98.8	98.8
	Average	**0.0**	**2.5**	**19.6**	**31.5**	**40.7**	**46.9**	**51.6**	**52.5**	**57.1**	**57.7**	**57.7**
2013	15th March	0	0	0	1.5	2.3	5.0	8.9	16.8	31.8	40.1	45.3
	1st April	0	0	1.2	9.4	18.8	57.4	69.3	80.2	94.5	95.7	95.7
	15th April	0	0.6	4.5	34.3	82.0	90.5	99.5	100	100	100	100
	1st May	0	2.6	12.1	42.3	84.5	86.6	100	100	100	100	100
	15th May	4.18	6.2	37.6	76.0	87.6	100	100	100	100	100	100
	Average	**0.8**	**1.8**	**11.0**	**32.7**	**54.9**	**67.9**	**75.5**	**79.4**	**85.2**	**87.1**	**88.2**

**= Days After Planting*

Data on the effect on planting on the disease index of CLCuD revealed that among sowing dates disease index differ significantly. Average across sowing dates CLCuD increased during 105-120 days (2011) and 120-135 days (2012 and 2013). Averaged across the years, minimum disease index of CLCuD was recorded on crop planted 15th March followed by 1st April and maximum recorded on crop planted 15th May of each year. Averaged across the sowing dates minimum

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disease index as well as maximum seed cotton yield was recorded on crop planted during 2011 as compared to 2012 and 2013 (Table-2).

Table-2 Effect of disease index on seed cotton yield during 2011-2013

Sowing Dates	2011		2012		2013		Average	
	SCY	D. I	SCY	D. I	SCY	D. I	SCY	DI
15th March	2629	0.12	2810	2.38	2550	34.81	2663.0	12.4
1st April	3149	0.38	2511	15.80	2334	65.49	2664.7	27.2
15th April	2578	1.58	2465	40.80	2122	68.72	2388.3	37.0
1st May	2523	22.90	2198	59.38	1895	72.83	2205.3	51.7
15th May	2187	65.83	1809	70.41	1575	75.00	1857.0	70.4
Average	2613	18.16	2358	37.75	2095	63.37		

SCY = Seed Cotton Yield (kg .ha^{-1}) D.I.= Disease Index

The respond of cultivar towards the CLCuD was different in each year. On the basis of disease incidence and disease index this cultivar showed some tolerance against the disease during 2011. It was also observed CLCuD percentage increased every next year (Table-3)

Table-3 Analysis of Variance Disease Index of CIM-598 planted during 2011-2103.

SOV	d.f	SS	MS	F-Ratio	S.E	C.D 5%	C.D 1%
Rep	3	146.681	48.893	0.54ns			
Year (Y)	2	20558.986	10279.490	113.49**	3.009	6.95	10.11
Error (I)	6	543.480	90.580				
Sowing Dates (S)	4	23920.465	5980.116	107.57**	3.043	6.36	8.68
Y x S	8	6324.185	790.523	14.22**	5.272	11.02	15.03
Error (II)	36	2001.324	55.592				
Total	59	53495.124		M*S (II)	5.173	11.14	15.51

CV(I) =13.94 CV(II) =18.75

Cotton cultivar tested in different environments showed variable response for seed cotton yield and CLCuD symptoms. CLCuD had significant and negative impact on seed cotton yield. 15th March sowing gave maximum seed cotton yield as compare to other sowing dates except April 1st plantation in 2011. In 2012 and 2013, 15th March planting cotton crop had maximum seed cotton yield as compare to all other sowing dates. In 2013 seed cotton yield decreased in all sowing dates as compare to 2012 and similar trend was found in 2012. CLCuD has a significant impact on seed cotton yield and its components as the plant is stunted, number of balls/plant and ball weight reduced significantly (Mahmood *et. al*., 1996; Brown 2001). The higher level of CLCuV infestation at early stage of cotton growth reduces plant vigor which ultimately reduce seed cotton yield. An analysis between disease index and seed cotton yield of all thee years presented a significant negative correlation (Fig-1). Correlation between yield & disease index was recorded negatively, y = -0.065x 193.8, r = -0.875. With the increased of disease index seed cotton yield decreased. As the disease index increased every next year so seed cotton yield decreased respectively. The findings were also in accordance with those of Khan and Khan (1992), Tahir *et. al.* (2004) and Ali *et al*. (2009).

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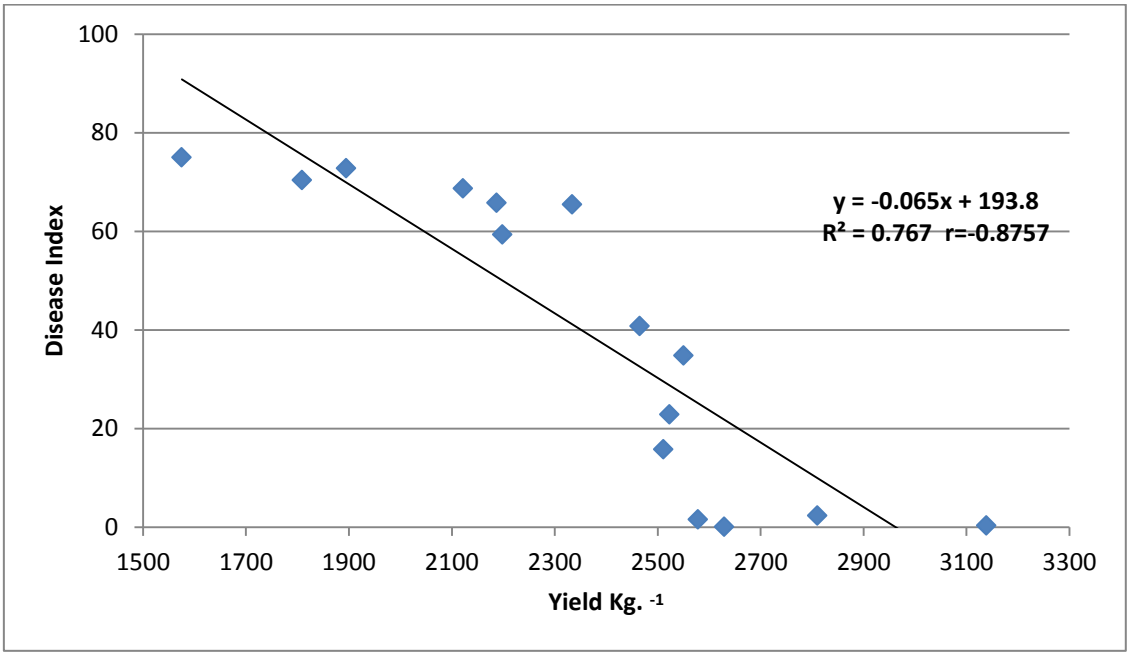

Fig: 1 Relationship between disease index and seed cotton yield during 2011 to 2013 with respect to date of planting.

The fortnightly increase in the disease and the weather conditions of all three years are given in Table-4. On an average basis of sowing dates the fortnightly increase of the maximum CLCuD appeared in mid July of 2011 after sowing at average minimum temperature 28.5°C maximum temperature 36.6 °C with difference in maximum and minimum temperature 8.1°C and maximum relative Humidity was 72 %. Where as in the end of July 2012 average minimum temperature 28.8°C, maximum temperature 38.9 C with difference in maximum and minimum temperature-10.7°C and maximum relative Humidity of 71.7 % favored the appearance of disease. In 2013 minimum temperature 30°C maximum temperature 37.7°C with difference in maximum and minimum temperature 7.7°C and maximum Relative Humidity of 70.7 % favored the appearance of disease) These results are in confirmatory with *Singh et al.* (2003) who found that CLCuD (%) were significantly correlated with minimum. maximum, mean temperature; minimum, maximum, mean relative humidity, rainfall and whitefly population in particular seasons. *Monga et al*. (2004) made prediction equations for the appearance of CLCuD. They found that maximum temperature between 35-42 °C, minimum temperature between 26-29 °C and maximum relative humidity 71-95% in the month of July in 2002 and 2003 favored the maximum disease development. It is clear that when difference in maximum and minimum temperature was less but relative humidity was more cotton leaf curl disease was highest. We can be assumed that these are the optimum weather conditions when CLCuV multiply rapidly as long as these weather conditions exist disease percentage prevail quickly and with the passage of time resistance of cultivar gradually decrease against CLCuV.

4. CONCLUSIONS

It is concluded from the present study that maximum CLCuD was recorded 15th May followed by 1st May at 45 and 60 days after planting respectively. In all years cotton crop fell pray to disease during last week of July. However there was less disease incidence on March planted cotton compared to other planting dates. Significant differences for CLCuD existed for planting time. Early planting had low infestation as compared to late sown cotton. CLCuD infestation percentage reached maximum within 30-45 days in late sown cotton while the maximum infestation in early sown cotton was recorded after 135 days of sowing .It is recommended that transgenic cultivar should be early planted to compensate the destructive affects of CLCuD on vegetative and reproductive parts of plants. Many environmental factors are responsible for the establishment of cotton leaf curl virus. Temperature range of 28 – 40^{o}C, relative humidity of 60 – 70%, is suitable for the development of cotton leaf curl virus It is concluded that major factors which played very important role in the increase of the disease percentage every year may be persistency of "difference in maximum and minimum temperature was less and relative humidity was more." During 2013 as compare to 2012 and 2011.

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Table-4 Relationship between fortnightly increases in CLCuD with weather parameters during 2011-2013

Year	Planting dates	1-15 April	16-30 April	1-15 May	16-31 May	1-15 Jun	16-30 Jun	1-15 July	16-31 July	1-15 Aug	16-31 Aug	1-15 Sep
2011	15th March	0	0	0	0.2	0.9	0.5	0	0.2	0.2	0.03	0
	1st April	0	0	0	0.3	0.0	0.2	0.9	0.9	0.7	0.9	0
	15th April	0	0	0	2.2	2.3	3.7	4.9	0.1	0	0	0
	1st May	0	1.1	10.7	21.2	7.4	1.2	17.0	2.1	0	0	0
	!5th May	0	8.4	28.4	33.6	21.7	1.3	0	0	0	0	0
	Average	**0**	**1.9**	**7.8**	**11.5**	**6.5**	**1.4**	**4.6**	**0.6**	**0.18**	**0.18**	**0**
	Temp.C (Max.)	30.2	36.2	39.8	41	40	38.6	36.6	36.5	34.8	34.3	32.2
	TempC (Mini)	17.6	20.7	25.3	28.4	28.4	30.2	28.5	28.8	28.8	27.4	26.7
	Difference	12.6	15.5	14.5	12.6	11.6	8.4	8.1	7.7	6	6.9	5.6
	RH%	62.5	55	52.6	53.4	54.6	67.8	72	76.1	75.4	82.5	86.6
2012	15th March	0	0	0	0.5	0.1	1.4	0.5	0.0	1.0	1.1	0
	1st April	0	0	1.8	4.9	3.3	4.5	3.1	1.9	2.3	2.3	0
	15th April	0	0	4.2	11.7	18.3	10.4	6.6	4.8	9.3	0	0
	1st May	0	2.6	30.1	28.4	16.3	6.8	4.5	2.2	6.2	0	0
	!5th May	0	10.1	49.6	14.4	7.3	9.5	7.9	0	0	0	0
	Average	**0**	**2.5**	**17.1**	**12.0**	**9.0**	**6.5**	**4.5**	**1.78**	**3.76**	**0.68**	**0**
	Temp Max C	34.4	31.4	38.0	40.7	39.8	38.9	38.9	37.5	36.4	34.8	32.8
	Temp Min C	20.7	20.5	24.9	26.2	27.6	29.7	28.8	28.9	28.4	27.6	27.6
	Difference	15.6	14.9	13.6	15.3	16.7	13.4	10.7	11.2	10.3	7.2	5.2
	RH %age	65.0	78.0	64.0	49.5	59.2	69.3	71.7	73.5	74.2	78.7	85.3
2013	15th March	0	0	1.5	0.7	2.7	4.0	7.9	15.0	8.3	5.3	0
	1st April	0	0	1.2	8.2	9.4	38.6	11.9	10.9	14.3	1.2	0
	15th April	0	0.6	4.0	29.8	47.7	8.5	9.0	0.5	0	0	0
	1st May	0	2.6	9.5	30.2	42.2	2.0	13.4	0	0	0	0
	!5th May	4.8	2.0	31.4	38.4	11.6	12.4	0	0	0	0	0
	Average	0,8	**1.0**	**9.5**	**21.5**	**22.7**	**13.1**	**8.4**	**5.3**	**4.5**	**1.3**	**0**
	Temp Max C	32.3	34.4	37.9	42.5	39.5	38.2	38.6	37.7	34.9	35.2	34.8
	Temp Min C	19.5	21.3	23.8	26.9	29.1	29.4	30.4	30.0	27	27.2	24.9
	Difference	12.5	13.1	14.1	15.6	10.4	8.8	8.2	7.7	7.9	8.0	9.35
	RH %age8am	66.6	60.0	59.1	57.5	69.9	73.0	73.1	70.7	76.2	77.8	82.4

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