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INFLUENCE OF WEATHER VARIABLES AND AGE OF PLANT ON COTTON LEAF CURL DISEASE (CLCuD)

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A B S T R A C T

The behaviour of cotton leaf curl disease (CLCuD) and weather variables were studied using three genotypes, planted each year at15 days intervals during 15th to 23rd standard (std.), week of 2010-2012. Three genotypes viz. CIM-573, CIM-496 and CIM-608 (2010) and CIM-554, CIM-591 and CIM-608 (2011) and CIM-591, CIM-612 and CIM-573 (2012) respectively, were planted in split plot. Weather parameters such as maximum, minimum temperatures and relative humidity were recorded. On an average basis of cultivars, the 15thstd. week planting showed significantly less disease incidence than all other sowing dates. The incidence increased as the sowing was delayed up to 23rdstd. week. Among the sowing dates, regardless of genotypes, disease incidence differed significantly. The CLCuD boost up during 25th to 27thstd. (2010) and 27th to 31st std. (2011& 2012) weeks of the year, regardless of sowing date and genotypes. Averaged across sowing dates, minimum disease incidence was observed in CIM-608 (2010 & 2011) and CIM-612 (2012) which was lower than all other strains. All other interactions were non-significant statistically. The disease increased sharply during 2010 and gradually during 2011 and 2012. Disease incidence was low during 2011 and 2012 as compared to 2010. Average maximum, (34.8~39.8°C), minimum (27.7~28.9°C) temperature and relative humidity (51~79%) favored CLCuD progression.

Keywords: Cotton leaf curl disease; CLCuD; cotton cultivars; environmental conditions.

INTRODUCTION

Cotton is one of the major industrial crops in many countries of the world including Pakistan accounting for over 60% of foreign exchange earnings (Imran *et al*., 2012). Low productivity of cottonis due to heavy attack by a number of insect-pests and diseases starting from germination upto the harvest of crop. Among the diseases; cotton leaf curl disease (CLCuD) is the major reason for the decline in production and productivity in Pakistan, especially in the Punjab. This disease is caused by cotton leaf curl virus (CLCuV) which belongs to begomovirus, family germiniviridae, transmitted in persistent manner by the vector, whitefly (*Bemisiatabaci* Genn.). Characteristic symptom of the disease is upward or downward curling with thickened veins which is more pronounced on under side of the leave. The disease results in stunted plant growth with loss in yield.

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First time in Pakistan during 1967 CLCuD was observed near Multan. At that time disease was of minor importance and it did not get much attention. After 1988, the disease appeared in an epidemic form and damaged the crop on about sixty thousand hectares with a loss of 0.3 billion bales in production (Mahmood *et al.,* 1999). The geographic spread of CLCuD has increased tremendously and more than 7.7 million bales of cotton has been lost due to CLCuD from 1986 to 2002 (Akhtar*et al.,* 2004).

Low cotton yield is due to this disease depend upon the variety and sowing time of crop (Tahir *et al*., 2004). Weather factors (individual and collectively) particularly temperature and relative humidity and rain fall, influence the disease and vector (whitefly) population to great extent in host pathogen system (Sharma *et al*., 2006). However, meager information is available on the role of climatic factors affecting vector population and disease development. The percent studies were therefore carried out to understand the role of

environmental factors on the development of CLCuD. The information thus generates will be utilized in formulating the suitable integrated disease management.

MATERIALS AND METHODS

The field experiments were conducted at research area of Central Cotton Research Institute (CCRI), Multan to determine effect of planting period on promising cotton varieties during three consecutive cotton growing seasons.

Three varieties/lines viz., CIM-573, CIM-496 and CIM-608 (2010) and CIM-554, CIM-591 and CIM-608 (2011) and CIM-591, CIM-612 and CIM-573 (2012) were planted at 15 days interval during 15th to 23rd standard (std.), week of 2010 to 2012 in split plot design with three replications. Keeping planting period as main plots and varieties as sub plots. The crop was planted at a spacing of 75 x 30 cm by dibbler. All other agronomic practices were maintained uniformly in the field through the crop season.

Data for CLCuD infection were recorded at 15 days interval starting from 30 days after planting and continued up to 35thstd. week. Total numbers of plants showing leaf curl virus disease symptoms were counted every time during observations. Plant with even a single leaf showing the symptoms of disease were continued as infected. The percentage of disease incidence was calculated by the following formula.

Disease Incidence =Number of diseased plants/Total Plants x 100

At the end of the season (35thstd. week) hundred plants were examined in the field and different grades/scale were allotted to them according to the level of infection in disease plants as described by Akhtar & Khan (2002). The rating scales are given in Table 1.

Table 1. Disease rating scales to used intensity of CLCuD for its Index.

Symptoms	Rating Scale	Symptoms	Rating Scale
Complete absence of symptoms	0	Large groups of veins involved and curling OR top of the plant affected	4
Few small scattered vein thickening	1	All veins involved and severe curling OR half of the plant affected	5
Small scattered vein thickening	2	All veins involved and severe curling and stunted plant OR whole of the plant affected and stunting	6
Vein thickening involving small groups of veins	3	Enations	E

The disease severity and percentage of disease index were calculated by using the following formulas

Disease Severity = a* (0#) + a (1) + a (2) + a (3) + a (4) + a (5) + a (6) / Total Diseased Plants

Whereas *= Number of plants, # = Rating scale

Disease Index = Disease %age x Disease Severity/ Maximum Severity Value (6).

The data on environmental variables was obtained from Meteorological Department, Central Cotton Research Institute, Multan. Data for fortnightly progression of disease incidence was calculated and compared with environmental parameter (Maximum, minimum temperature & relative humidity) of that period of each year separately. The pooled data for three years were first analyzed by simple regression. The disease index were subjected toanalysis of variance Split Plot Design (Steel *et al*., 1996) and the means were compared using DMR/LSD test (P=005).

RESULTS AND DISCUSSION

The Results of incidence of CLCuD monitored (fortnightly interval) right from 30 days after planting for all planting dates in each year are given in Figure 1a, b &c.

Progression of Disease: Results reveal the expression of CLCuD and its progression during the crop season (2010) differed greatly with planting dates. Averaged across varieties, minimum incidence (11.9%) of CLCuD was recorded at day 60 after planting. With the advancement of age, the incidence progressed sharply to 82% within 60 days on that crop planted on 15th std. week of the year. Averages across cultivation, minimum disease incidence was recorded on 17th std. week sown i.e. 9.5% at day 45 and it progressing to its maximal level 98.2 % at day 105 after planting. The incidence of CLCuD started at 30 DAP which sharply increased to 39.5 % at day 45 and progressed up to 99.5% at 75 DAP on crop which was sown during19thstd. week of the year. The incidence of the disease was 41.5% at day 30 and reached to maximum (99%) at day 45 after planting on crop planted on 21 std. week of the year.

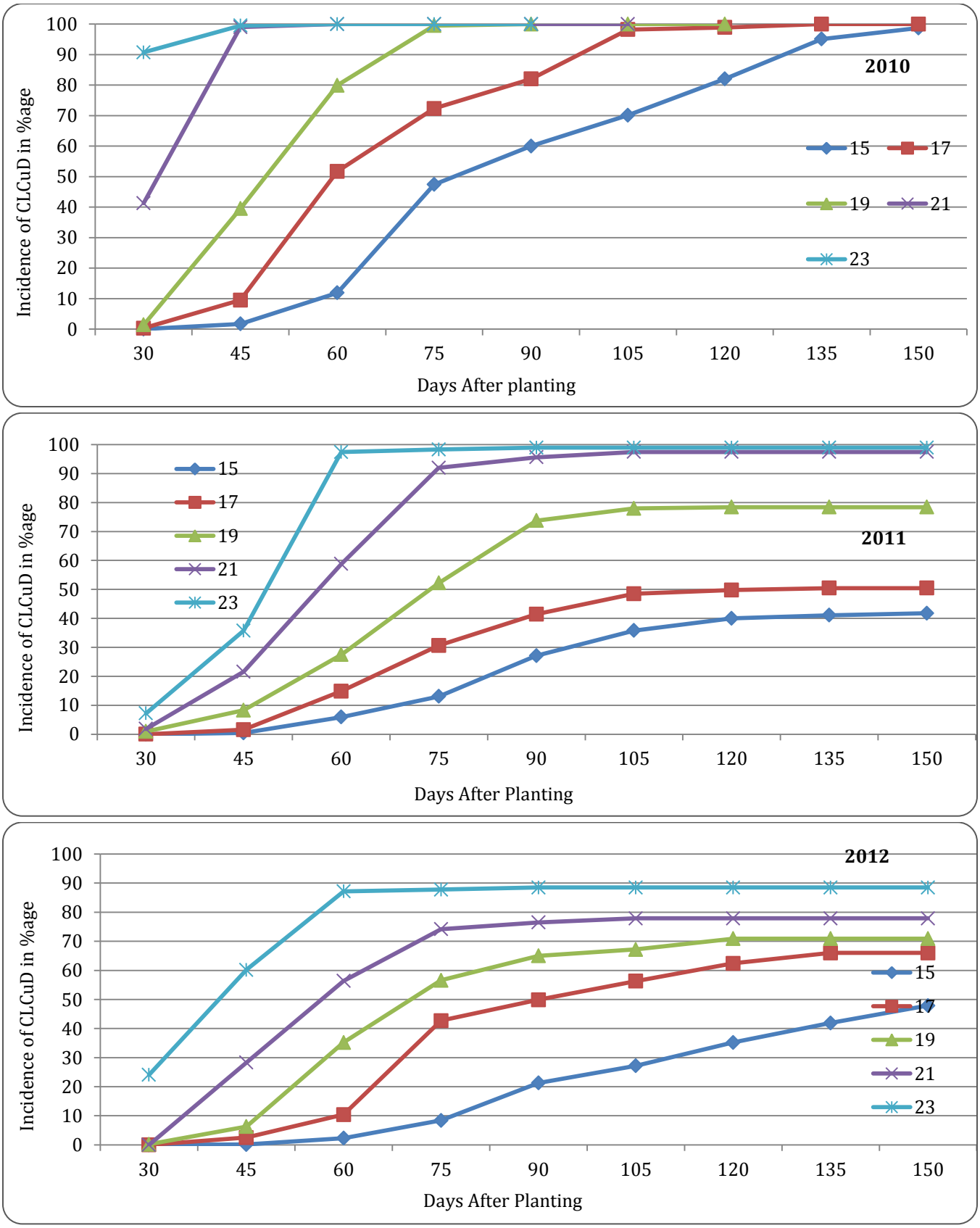

Figure 1. Incidence of CLCuD as influenced by planting Dates during 2010 (A), 2011 (B) and 2012 (C).

Furthermore, crops planted on 23rdstd. week of the year fell prey to CLCuD to 90% within 30 days after planting and to maximal (99%) with in next 15 days (Figure 1a). Data reveals that in early planting (15thstd week) the infection was less and took more period to reach its maximum level where as it was vice versa in the late planting (23rdstd week).

The pattern of appearance of CLCuD and it progression during the crop season (2011) differed greatly with the planting dates and less than crop season 2010.

Averaged across varieties, disease started low level (0.41%) at day 45 after planting and reached upto(5.9%) at day 60 after planting. With the advancement of age, the incidence progressed gradually to 40% with in next 60 days, on that crop planted on 15thstd. week of the year. The infection level was 14.8% at day 60 and attained it maximum (48.4%) at day 105 after planting on crop planted on 17thstd. week of the year. However, incidence of CLCuD was 8.28% at day 45 and reached to its maximum level 78.4% with in rest days as crop planted 19 std. week of the year. The incidence of disease start from 1.82% at day 30 and reached upto (91.9%) at day 75 after planting on crop planted 21ststd. week of the year. Furthermore, the crop planted on 23rdstd. week of the year fell prey to CLCuD to 97.4% within 60 days after planting, which is 50% period is less and incidence double than those crop planted on 17thstd. week of the year (Figure 1b).

The expression of CLCuD and its progression during the crop season (2012) was less than to crop season 2010 but slightly greater than 2011 upto crop planted 19thstd. week of the year. Averaged across varieties, minimum incidence (2.3%) of CLCuD was recorded at day 60 after planting. With the advancement of age, the incidence progressed sharply to 47.9% within 90 days on that crop planted on 15th std. week of the year (Figure 1c).

The infection level was 2.5% at day 45 and attained its maximum (66%) at day 150 after planting on crop planted on 17th std. week of the year. However, incidence of CLCuD (6.3%) of day 45 and reached to its maximum level (70.9%) at day 120 after planting on crop planted on 19th std. week of the year. The incidence of the disease was 28.3% at day 45 and reached to maximum (77.9%) at day 105 after planting on crop planted on 21st std. week of the year. Furthermore, crops planted on 23rd std. week of the year showed 24.1 % disease incidence within 30 days after planting and to maximal (87.2%) with in next 30 days (Figure 1c). Data reveals that the incidence of disease increased & period decreased (days after planting) as we delay the planting time.

Similar findings were made by Khan *et al*., 1988 & Tahir *et al.,* 2004, both concluded that maximum incidence was recorded in the June planting (21ststd. week) and increase rapidly in the first week of August (29thstd. week) in all planting dates.

Effect of Date of Planting: One of the most important agronomic considerations for growers to optimize yield and quality is to select an appropriate planting time for cotton crop. Choosing the best time for planting in a particular region can often be difficult as it is a decision that must strike a balance between planting too early and too late and enduring problems of different pest and diseases. Planting too early and too late makes the crop susceptible to different diseases, like CLCuD.

The effect of planting dates on the disease incidence of CLCuD and their disease index are given in Figure 1a, b & c and Figure 2a, b & c respectively.

Data revealed that among sowing dates regardless of genotypes, disease incidence differed significantly. The CLCuD boost up during 25th to 27thstd. (2010) and 27th to 31ststd. (2011& 2012) week of the year regardless of sowing dates and varieties/lines.

Averaged across cultivars, minimum disease index of CLCuD was recorded on 35th std. week of the year (150 days after planting) on crop planted on 15thstd. week of the year (2010). Whereas in other planting, data showed that no difference in disease index was observed (Figure 2a). Averaged across cultivars, minimum disease index of CLCuD was recorded on crop planted on 15thstd.& 17thstd. week compared with crop planted on 19thstd. week of the year (2011). A little difference of disease index was recorded on crop planted during 21st & 23rd std. week of the year (Figure 2b). The same results were recorded during the crop season 2012 (Figure 2c). According to Sharma *et al*., (2006), the disease incidence increases rapidly between the mid of June to the last week of July (25th-31ststd. week). Ghazanfar *et al*. (2007) also stated that sowing even earlier to 15th May (19thstd. week) may have more effect on reduction in disease incidence which needs to be tested.

The data were analyzed statistically and reveled that averages across cultivars the disease index was highly significant in 15th std. week planting as compared to other planting period in all three years studies (annexure-I).

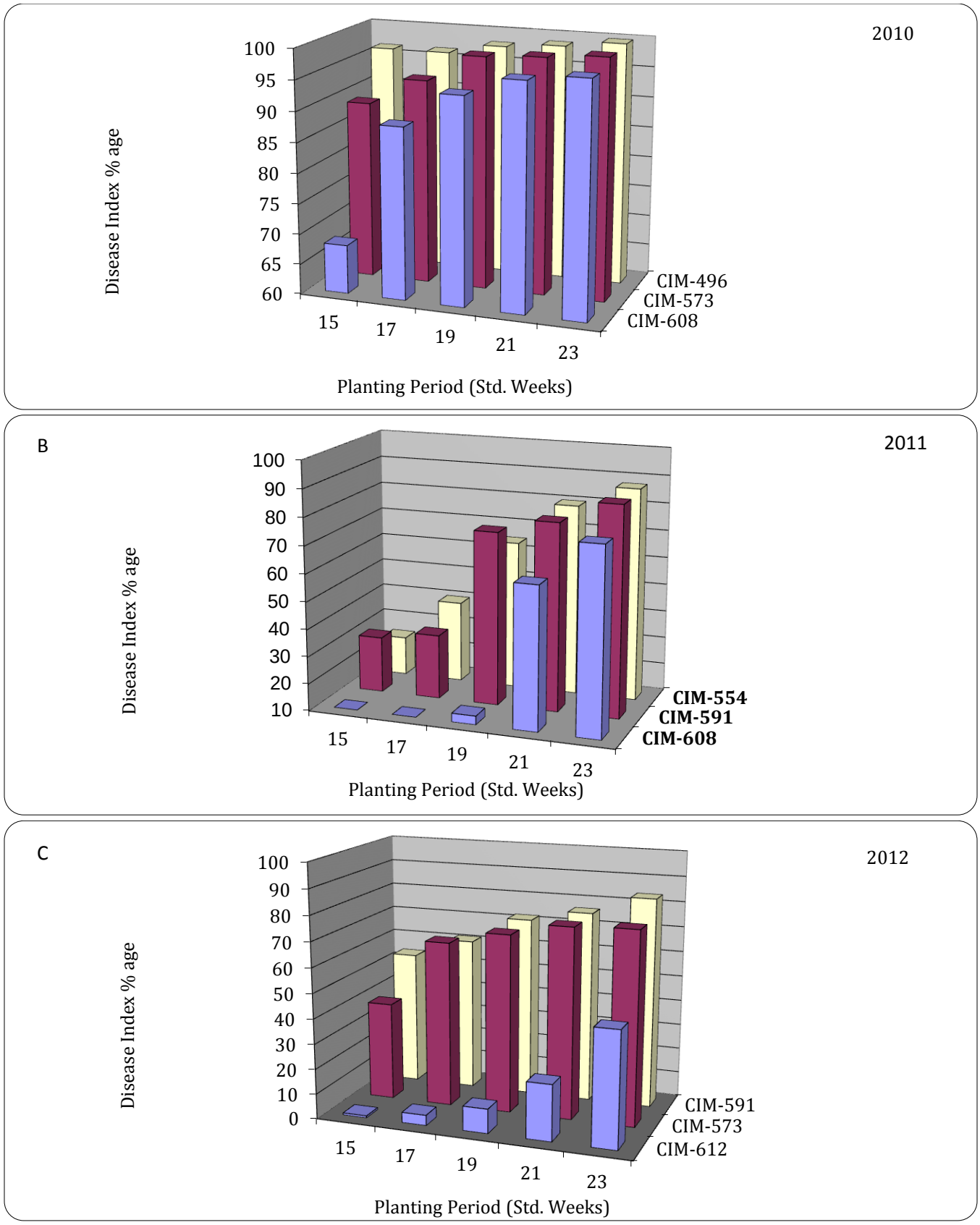

Figure 2. Cotton Leaf Curl Disease Index as affected by different planting period during 2010 to 2012.

Varietal Effects: The response of different varieties/strains of cotton crop toward the attack of its different pathogens is different. Some varieties/strains display tolerant and others exhibit susceptible response. The maximum disease index of CLCuD recorded on variety CIM-496 (97%), followed by CIM-573 (95%) and CIM-608 (89%) irrespective the planting dates for the year 2010 (Figure 2a). On the basis of disease incidence (Figure 3) and disease index (Figure 2a), the line CIM-608 showed some tolerance against CLCuD as compared to other variety/lines when planted on 15th std. week of the year. Whereas this line showed a little better performance upto on crop planted on 17thstd. week of the year as compared to crop planted on 19th to 23rdstd. week of the year.

Averaged cross planting dates, minimum disease index (33%) was recorded on line CIM-608 followed by CIM-496 (59%) and CIM-573 (60%) respectively on crop planted during the year 2011 (Figure 2b). On the basis of disease incidence (Figure 4) and CLCuD index (Figure 2b), the line CIM-608 showed some tolerance against the disease when planted on 15th- 19thstd. week of the year. However, there was little difference of incidence and disease index when planted on 21st to 23rdstd. week of the year as well as with the comparison of other varieties/lines. The varieties CIM-573 and CIM-496 showed no effect on the reduction of disease index on any planting dates.

Averaged across planting dates, minimum disease index (16.51%) was recorded on liner CIM-612 followed by CIM-573 (65.67%) and CIM-591 (69.3%) respectively on crop planted during the year 2012 (Figure 2c). On the basis of disease incidence (Figure 5) and CLCuD index (Figure 2c), the line CIM-612 showed some tolerance against the disease when planted on 15th - 19th std. week of the year. However, incidence and disease index increased when planted on 21st to 23rd std. week of the year as well as with the comparison of other /varieties. The variety/line CIM-573 and CIM-591 showed no effect on the reduction of disease index on any planting dates.

Averages across planting period the disease index was low statistically in line CIM-608 in both the years i.e. 2010 & 2011. The line CIM-612 also showed significantly low disease index during the year 2012 (Annexure-I). The interaction between planting period and varieties/liness was found statistically significant in 2010, whereas it was none-significant in the year 2011 & 2012.

These findings are similar to that of Tahir *et al*. (2004) who found that of cotton cultivars under trial, the incidence was more on CIM-496 as compared to others. Akhtar*et al*. (2004) found that the age related to susceptibility to CLCuD was more apparent in late planting. Maximum increase in disease incidence was occurred at 6 week after sowing. The incidence of the different viral and fungal diseases is also influenced by altering the date of sowing as reported by Mirza (1992).

Effect of weather parameters: The fortnightly increase in the disease of each year along with the environmental parameters of that period is given in Figure 6a, b & c. On an average basis of planting dates the fortnightly increase of the maximum disease started from 25th-29thstd. week of the year (2010) during that period the range of maximum temperature was 35.5 to 39.8°C with R.H from 62.5 to 79.6%. The fortnightly increase of the disease remains negligible or low before 25thstd. week because during those days the temperature remained high with low R.H and after 29thstd week due to low temperature with high Relative humidity, irrespective to planting dates Where as the incidence was remained low (during 25th – 29thstd, weeks of the year) on that crop planted on 15th- 17thstd week of the year as compare to other planting dates (Figure 6a).

On an averaged basis of planting dates the maximum fortnightly increase of the disease start from 27th-31ststd. week of the years(2011).Among environmental parameters the maximum temperature range were 34.8-36.6°C, minimum temperature,28.5- 28.8°C with relative humidity 72-76.1% during the above mentioned period. The fortnightly increase of the disease remained low up to 25thstd. week of the year and same conditions was found after 31ststd. week of the year (Figure 6b)

On an averaged basis of planting dates the maximum fortnightly increase of the disease start from 27th - 31st std. week of the years (2012). Among environmental parameters the maximum temperature range were 37.3- 39.8°C, minimum temperature, 27.7-28.6°C with relative humidity 51-57.5% during the above mentioned period. The fortnightly increase of the disease remained low before 27th and after 31st std. week of the year (Figure 6c).

It is clear from that CLCuD increased rapidly during the period 25thto 27thstd. week of the year 2010, whereas the disease was gradually increased during the 29th to 31thstd. week of the year 2011. If that was compared with the weather parameters that indicate the maximum temperature was high, minimum temperature remained constant with R.H 62-79% in the year 2010 as compare to 2011 during 25th to 31thstd. week of the year.

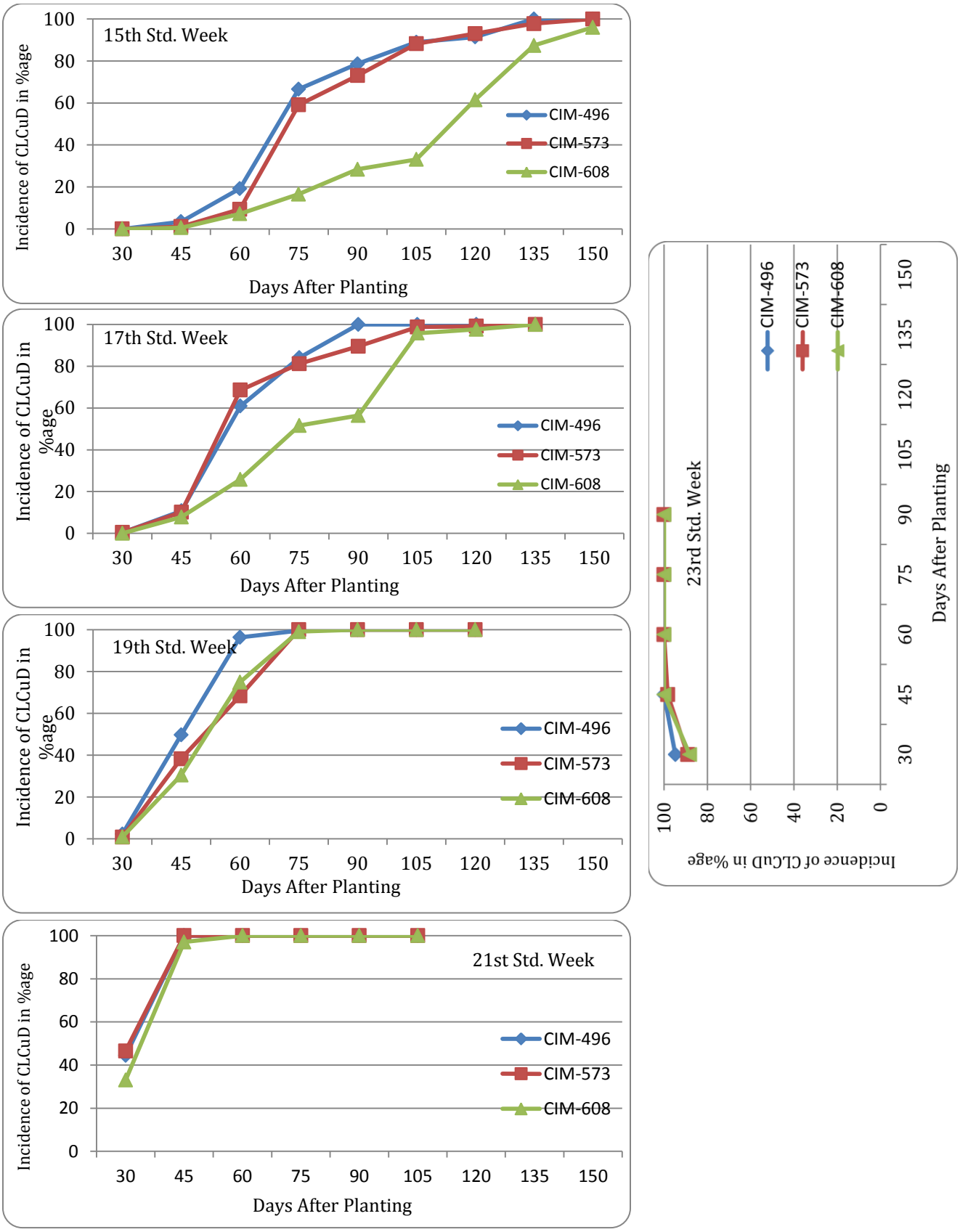

Figure 3. Incidence of CLCuD as influenced by planting Dates and strain during 2010.

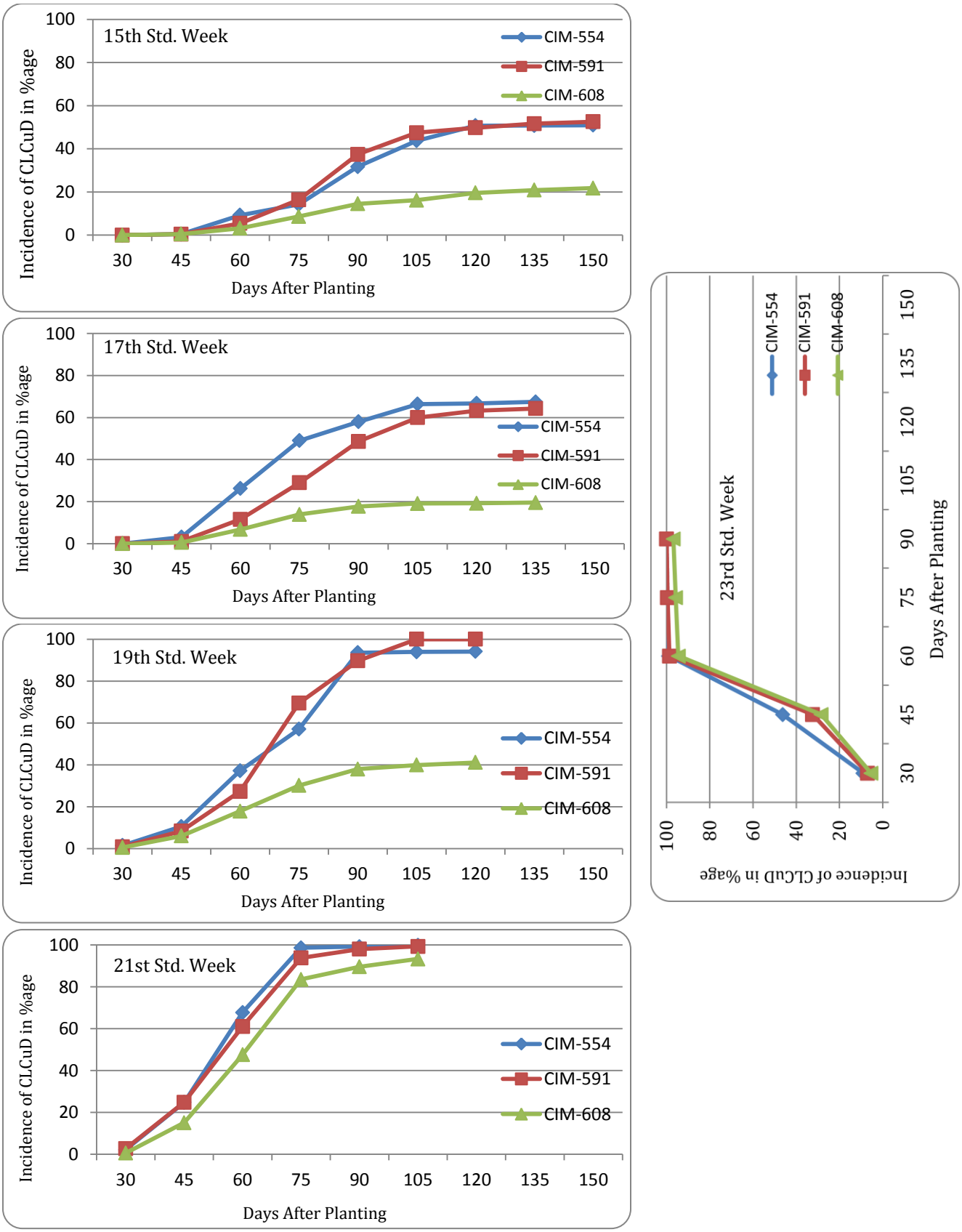

Figure 4. Incidence of CLCuD as influenced by planting Dates and strain during 2011.

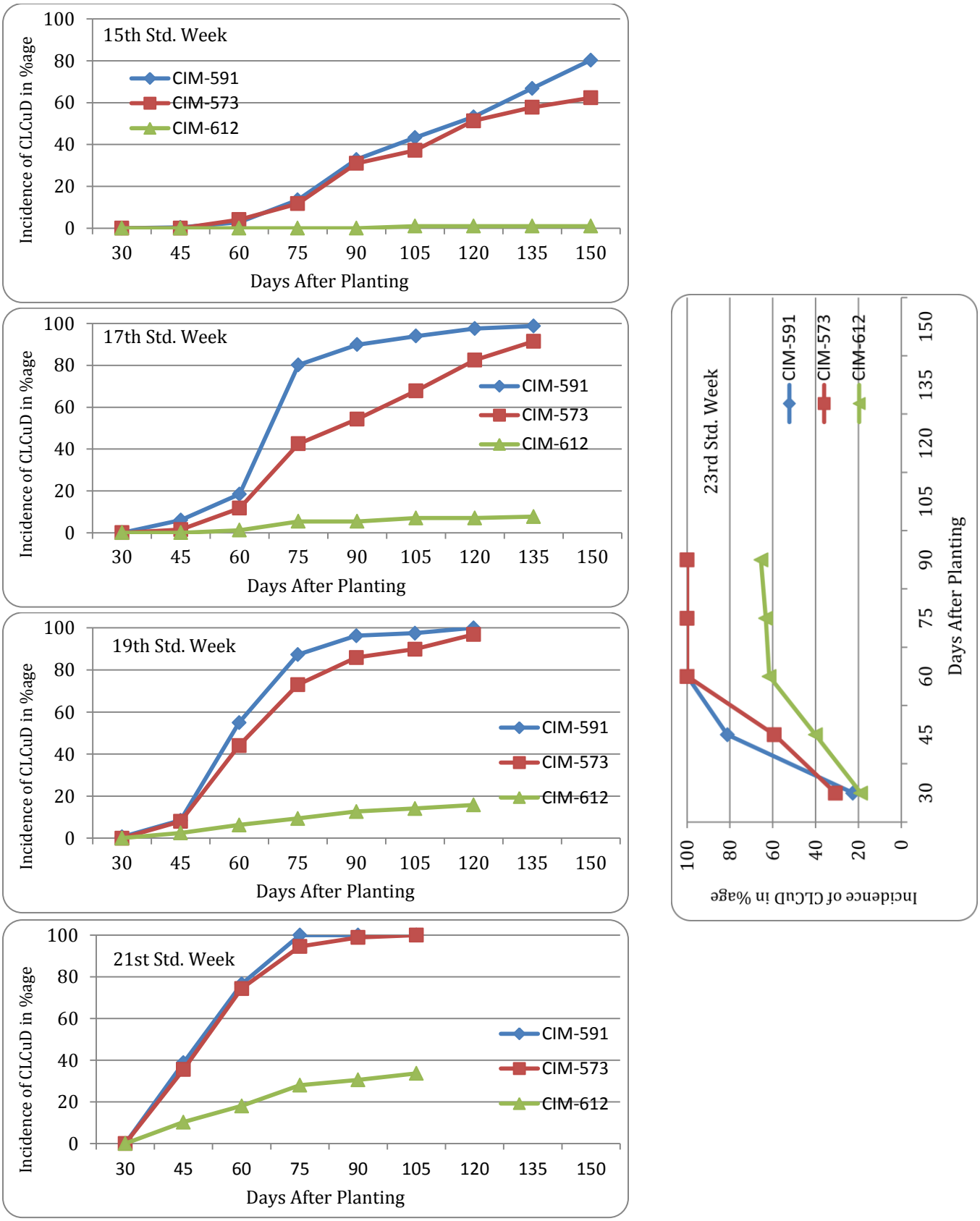

Figure 5. Incidence of CLCuD as influenced by planting Dates and strain during 2012.

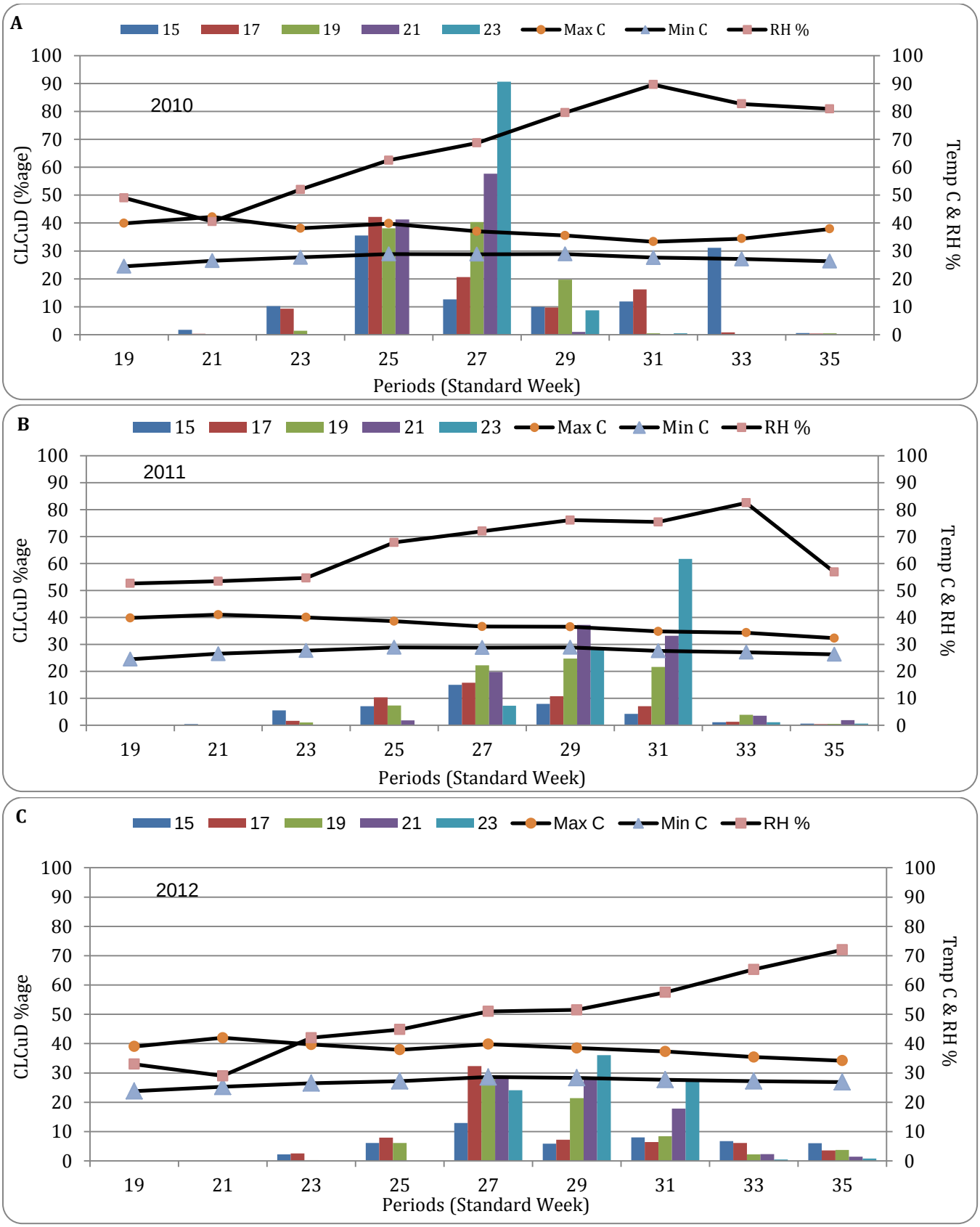

Figure 6. Relationship between fortnightly increases in CLCuD with weather parameters during 2010 to 2012.

During the third year (2012) study, on an average basis the incidence remained low as compare to year 2010. Whereas the maximum temperature was same as in 2010 but relative humidity was low. So that the relative humidity is one of the factor which is responsible to increase the disease incidence of cotton leaf curl virus.

It concluded that the disease does not express its symptoms if the temperature is greater than 40°C and less than 50% of Relative humidity during the early season of the crop. During the end of the season the disease also does not exhibit its symptoms if temperature is less than 34°C with greater than 80% Relative humidity. The results are in according with the finding of Sherma *et al*. (2006). In this study, it was concluded that disease was highly influenced by mean temperature and morning humidity. The morning Relative Humidity and mean temperature explained the variability in disease incidence.

It concluded that the disease expresses its symptoms during 25th-31ststd week but the incidence was low in earlier planting (15th– 17thstd week as compared to late planting (21st– 23rdstd week of the year. In early planting the plant had strongly completed their vegetative growth while in late planting disease vigor come earlier when the plants are tender.

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Annexure I. Analysis of Variance of Disease Index affected by Sowing dates and varieties for the year 2010 to 2012.

A: ANOVA for the year 2010

SOV	d.f	SS	MS	F-Ratio	S.E	C.D 5%	C.D 1%
Rep	3	29.744813	9.914938	1.29^{NS}			
Main (M)	4	1609.1647	402.2912	52.49**	1.130	2.46	3.45
Error (I)	12	91.977342	7.664779				
S. Plot (S)	2	827.24133	413.6207	108.56**	0.617	1.26	1.70
M x S	8	1122.7788	140.3473	36.84**	1.380	2.82	3.80
Error (II)	30	114.30431	3.810144	M*S (II)	1.381	2.92	4.01
	59	3795.2113					

C.V (I)= 2.94% C.V (II)= 2.07%

Averages

Main Plot		**Sub Plot**	
M1= 15th April	84.65a	S1= CIM-608	89.05a
M2= 1st May	92.76b	S2= CIM-573	95.26b
M3= 15th May	95.84c	S3= CIM-496	97.91b
M4= 1st June	98.11cd		
M5= 15th June	99.00d		

B: ANOVA for the year 2011

SOV	d.f	SS	MS	F-Ratio	S.E	C.D 5%	C.D 1%
Rep	3	6504.898	2168.28	6.13^{ns}			
Main (M)	4	36075.018	9018.75	25.48**	7.680	16.73	23.46
Error (I)	12	4247.555	353.96				
S. Plot (S)	2	9163.321	4581.66	52.49**	2.954	6.03	8.12
M x S	8	2590.233	323.779	3.71^{ns}	6.606	13.49	18.17
Error (II)	30	2618.667	87.28	M*S (II)	7.654	16.33	22.61
	59	61199.634					

C.V (I)= 38.19% C.V (II)= 18.96%

Averages

Main Plot		**Sub Plot**	
M1= 15th April	21.08a	S1= CIM-608	31.81a
M2= 1st May	25.28a	S2= CIM-554	57.36b
M3= 15th May	45.58b	S3= CIM-591	58.64b
M4= 1st June	71.67c		
M5= 15th June	82.74c		

C: ANOVA for the year 2012

SOV	d.f	SS	MS	F-Ratio	S.E	C.D 5%	C.D 1%
Rep	638.675	212.891	3.05^{ns}				638.675
Main (M)	8500.945	2125.236	30.41**	3.413	7.44	10.43	8500.945
Error (I)	838.756	69.896					838.756
S. Plot (S)	36443.538	18221.770	235.7**	2.780	6.68	7.65	36443.538
M x S	1558.311	194.789	2.52^{ns}	6.217	12.70	17.10	1558.311
Error (II)	2319.301	77.310	2319.301	M*S (II)	5.620	11.72	15.99
	50299.528		50299.528				

C.V (I)= 16.29% C.V (II)= 17.13%

Averages

Main Plot		**Sub Plot**	
M1= 15th April	33.86a	S1= CIM-612	16.51a
M2= 1st May	43.76b	S2= CIM-573	70.15b
M3= 15th May	52.79c	S3= CIM-591	67.32b
M4= 1st June	58.12d		
M5= 15th June	68.62d		

Note: For Two subplot means at the same main-plot treatment use MxS CD

For Two main-plot means at the same or different subplot treatment use MxS (II) C.D