Research Article

Sowing Date influences cotton leaf curl disease (CLCuD) incidence and productivity of non-*Bt* cotton cultivars

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Abstract

Disease infestation in crop plants can be reduced by choosing the most suitable sowing date for different cultivars of the same crop. A two-year study was conducted to know the best sowing date for cotton on silt loam soil in a sub-tropical arid climate. Two cotton cultivars i.e. CIM-612 and CIM-573 were sown for two consecutive years. Moreover, CIM-591 was grown in year 1 and Cyto-124 in year 2, at five different dates (April 15, May 01, May 15, June 01 and June 15). By delaying the sowing, plant height, number of bolls per plant and seed cotton yield (kg ha^{-1}) was decreased while cotton leaf curl disease (CLCuD) incidence (%) was increased gradually. All the varieties in general sown earlier showed higher yield and reduced incidence of CLCuD. However, among non-*Bt* cultivars, performance of CIM-612 was overall better when sown on April 15 during both the years with minimum CLCuD incidence and improved seed cotton productivity. Hence non-*Bt* cotton cultivar CIM-612 may be sown on April 15 in cotton core zone of Punjab (Pakistan).

Keywords: CLCuD; *Gossypium hirsutum*; Seed cotton yield; Sowing date

Introduction

Cotton is an important cash crop of Pakistan and is a significant source of foreign exchange earnings. It is also a major oilseed crop of the country [1]. In Pakistan, cotton is grown both for its fiber and extraction of the edible oil from seed cotton. Cotton is grown on 2,699 thousand hectares in Pakistan, with total production of 11.935 million bales and average yield of 752 kg ha^{-1} [2].

Cotton crop now a day is facing some serious threats which altogether have forced the scientists to standardize the production practices and enhance the fiber qualities to meet the international standards at the same time. Changing climate is acting like a precursor for these threats. Abiotic stresses (drought, temperature, salts and water stresses) determine the fate of the cotton crop [3]. Seed rate, spacing, plant protection, nutrient and water management beside

varieties and sowing date are of pivotal significance in this context. Among agronomic factors, sowing date is very important to harvest a profitable final yield [4, 5]. Change in sowing time states change in all the weather elements at the time of sowing. A crop requires specific degree days and heat units along with other weather units throughout the life cycle in a certain proportion for moving from one growth step to the other. An early weather changes in temperature, humidity etc; lower or higher will be incorporated into plant biological system which will last until the end in subsequent growth and developmental stages. Plants normal growth and development will be badly hampered consequently. The early sowing of cotton will make the plant to face different set of conditions in the field while late sowing will provide for a totally different set of growing conditions having different implications on yield, fiber characters and virus abundance. Farmers sow cotton in March and even in February to avoid the cotton leaf curl disease (CLCuD) problem, instead of May-June [6]. Early sowing may aid in reducing the incidence of CLCuD by providing early favorable environment to the crop stand. Early planting of cotton enhances yield components and seed cotton yield, increased growth, reduced flower and boll shedding over late sown crop [4, 6, 7]. Early stand establishment will make crop more vigorous and less prone to damage by virus which ultimately will aid in better outcomes in terms of production. Furthermore, late planting deteriorates quality of seed cotton [8-10]. But these varying reports do not clarify the effect of change in weather conditions and time of cotton sowing on CLCuD incidence, productivity of cotton cultivars. Management approaches (nutrition management, controlling vector, buffer cropping, seed treatment, sowing time etc) can help in reducing CLCuD incidence for

first 40 days. This disease may vary for its severity among abiotic factors like temperature and plant age [11], weed eradication [12], development of resistant varieties along with agronomic and biotechnological methods [13].

Different varieties behave and respond differently in field conditions owing to the differences in structure, stature, leaf angle, leaf orientation, shape, leaf size etc beside crop duration. Cultivars vary for their response to biotic, abiotic stresses and climatic conditions because of differential genetic potential they possess [14]. The yield potential of any cultivar can only be expressed in a best possible way if it is given full chance for expression of its genes by sowing at a suitable time and at ideal space from each other. The rates of photosynthesis, transpiration and respiration also vary depending on varietal characters, environmental factors and management practices which ultimately determine the productivity of cotton. Different cultivars have different yield potential under varying environments [15, 16].

There is always a continuous need and challenge for scientists to acclimatize and standardize the agro-normals of newly evolved cultivars like those under present study. This study was undertaken because the literature available is not enough regarding suitable time when these new cotton cultivars should be sown in core cotton zone of Punjab Pakistan.

Materials and Methods

The field studies were conducted at latitude of 30° 12N 71° 28E and altitude of 123 m for two consecutive years to evaluate the effect of sowing dates on seed cotton yield and CLCuD incidence of non *Bt* cotton cultivars. CIM-612 and CIM-573 were grown for both the years whereas CIM-591 was grown during year 1 and Cyto-124 during year 2, on five dates i.e., April 15, May 01, May 15, June 01 and June 15 having factorial

arrangement under randomized complete block design (RCBD) replicated thrice. Bed-furrows 75 cm apart were prepared and weeds were controlled through pre-emergence application of pendimethalin at 825 g a.i. ha⁻¹. After irrigating furrows, delinted cotton seeds were manually dibbled on respective sowing dates during both the growing seasons.

Phosphorus (P₂O₅) in the form of triple super phosphate (46%) was incorporated in the soil at the time of seedbed preparation at 50 kg ha⁻¹. Nitrogen was applied at 150 kg ha⁻¹ in the form of urea (46%N) in three equal splits at bud formation, flowering and boll formation. Rest practices were maintained uniformly throughout the seasons. Observations on the incidence of CLCuD were recorded at fortnight interval from 30 days after planting and continued until 165 days. Total number of plants showing leaf curl virus disease symptoms (upward curling with thickened veins on underside of the leaf) were counted every time during observations. Plants with even a single leaf showing the symptoms of disease were counted as infected. The disease incidence was counted by using the following formula:

Disease incidence (%) = (total plants - healthy plants / total plants) x 100

Data regarding yield parameters were taken at maturity. For recording parameters like boll weight, number of bolls per plant and plant height ten plants were selected at random from each plot. The seed cotton yield was recorded on per plot basis and converted to kg ha⁻¹.

The collected data were subjected to analysis of variance (ANOVA) using the MSTAT statistical computer package. The differences among the means of the treatments were compared by least significant difference (LSD) test at P≤0.5 [17].

Results and Discussion

Year's effect was significant hence the data has been presented and discussed separately. Sowing dates and cultivars brought

significant differences among each other for most of the yield parameters. Plant height was influenced significantly by different sowing dates (Table 1). The plant height reduced as the sowing was delayed. Crop sown on June 15 showed significantly shorter plants while the early sown crop April 15 produced the maximum plant height. The cultivar CIM-612 produced the taller plants during both the crop seasons. Shorter plants in delayed sowing have also been observed in other studies [5, 7, 18] which can be attributed to less time available for cotton plants to complete the phenological stages in sufficient time for normal growth.

Late seeding can bring reduction in boll weight upto 33.8% due to more prevalence of CLCuD [19]. Significantly higher boll weight was produced from the crop sown on June 15 among all non *Bt* cultivars. Among the sowing dates the boll weight ranged from 2.59 to 2.80g during year 1. However, for year 2 growing season boll weight ranged 2.44 to 2.55 g. Moreover, CIM-573 produced highest boll weight (2.77 g) and Cyto-124 (2.52 g) respectively during year 1 and year 2 (Table 2 & 3). Interactive effect of cultivars and sowing dates revealed significant variation with an overall increase in boll weight as the sowing was delayed in year 1 while boll weight could not vary significantly during growing season of year 2 (Table 3). It might be due to temperature fluctuation and variation in relative humidity (Fig. 1).

Higher bolls per plant in year 2 than the growing season of year 1 could be owing to differences in genetic potential of cultivars and variation in environmental conditions. However, CIM-591, during year 1 performed better than CIM-573, whereas in year 2 cultivars could not differ significantly due to changes in temperature and relative humidity in terms of number of bolls per plant (Table 2). The photosynthates started partitioning by differentiating and plants shifted to reproductive stage to complete their life cycle

successfully. Significant differences during both the years could be due to environmental variation and subsequent insect pressure differences. The number of bolls per plant of three cultivars CIM-591, CIM-612 and CIM-573 were 23, 20 and 22 during the year 1. While the cultivars CIM-612, Cyto-124 and CIM-573 produced number of bolls per plant 24, 24 and 23 during year 2, respectively. The number of bolls per plant of five sowing dates 15th April, 1st May, 15th May, 1st June and 15th June were 27, 25, 22, 19 and 13 respectively during the year 1 and the subsequent figures for the year 2 were 31, 29, 24, 20 and 15 respectively.

The data on seed cotton yield of test cultivars affecting sowing dates (Table 2) indicated that on an overall average of cultivars, crop sown early on April 15 produced significantly higher seed cotton yield ($P < 0.05$) 2604 and 2761 kg ha⁻¹ for year 1 and year 2, respectively than other sowing dates (May 01, May 15, June 01 and June 15). While the late sowing date (June 15) produced the minimum seed cotton yield 1003 kg ha⁻¹ and 1197 kg ha⁻¹ during year 1 and year 2, respectively (Table 2). CIM-591 gave 2088 kg ha⁻¹ and Cyto-124 produced 2184 kg ha⁻¹ seed cotton yield during year 1 and year 2, respectively.

During year 1, CIM-591 performed better for seed cotton yield and bolls per plant when compared with other cultivars under test. Whereas during year 2, Cyto-124 exhibited a greater number of bolls per plant and seed cotton yield and was significantly higher than all the other cultivars under study. Higher seed cotton yield in year 2 than in year 1 could be attributed to more uniformity in rainfall pattern with resultant stable relative humidity prevailed during the 2nd year. It was interesting to observe that CIM-612, reflected an overall marked reduction in CLCuD incidence. It means that this cultivar can also be planted between April 15 to May 01, without compromising much on seed

cotton yield reflecting the wider time window potential of this non-*Bt* cultivar. However, it is also pertinent to state that further delay in sowing CIM-612 resulted in sharp increasing trend in CLCuD occurrence which in turn reduced seed cotton yield as well. Delaying the sowing of seed cotton drastically reduced yield and vice versa [20, 21]. Better seed cotton yield in early sowing could be owing to timely availability of growth resources and less incidence of CLCuD (Table 4 & 5). At optimum time planting of cotton ensured less attack of sucking insects including whitefly which acts as a vector for CLCuD. Reduction in seed cotton yield is not only due to delayed sowing but also because of increased CLCuD infestation [21].

The incidence of disease was 15.53% at day 45 and reached to maximum (49.67%) at 105 days after planting on crop seeded on 1st June. The infection level was 59.14% at day 45 and increased (73.17%) at day 90 after planting on 15th June. Averaged across the cultivars, disease at low level (0.1%) at day 45 after planting with the advancement of age, the incidence increased up to 47.90% at 150 days on that crop planted on 15th April, year 1 (Table 4). The infection level was 2.50% at day 45 and attained its maximum (68.5%) at 150 days after planting on crop seeded on 1st May. However, incidence of CLCuD was 6.20% at day 45 and reached to its maximum level 71.4% at 135th day of planting for crop sown on 15th May. The incidence of disease started from 28.20% at day 45 and reached up to 78.7% at day 120 after planting for crop planted on 1st June.

The expression and progression of CLCuD during the crop seasons of both years of study differed with sowing date. Averaged across the cultivars (no difference for CLCuD incidence) minimum incidence (0.46%) was recorded at 45 days after planting and increased up to 1.39% at day 60 after planting when crop was sown on 15th April, year 2. The disease boosted up to 32.88% till 165

days after sowing for crop seeded on 15th April (Table 5). The infection level was 0.00 % at day 45 and increased (39.52%) at day 150 after sowing for crop planted on 1st May. However, CLCuD incidence was 4.72% at 45 days and reached to its maximum level (52.12%) at 120 days after planting for crop seeded on 15th May (Table 5).

At 45 days after sowing during both the growing seasons, early sowing i.e. 15th April revealed less CLCuD incidence [22]. A gradual and significant rise in CLCuD incidence could be attributed to gradual increase in relative humidity as the growing season advanced. Whereas at 60 days after sowing (DAS), more CLCuD incidence in year 1 can be due to comparatively higher

rainfall than the growing season of Year 2 (Fig. 1). At 105 DAS, the lower CLCuD infestation during year 2 as compared to same stage in year 1 could be owing to less rainfall received with no significant fluctuation in relative humidity. The incidence of CLCu disease increased as sowing was delayed. The crop planted on 15th June start incidence of CLCuD 24.10% after 30 days which increased up to 89.30% at day 105 after planting for crop planted on 15th June [22, 23]. The increased CLCuD incidence can also be attributed to increased whitefly damage at lateral stages. Hence more diseased plants of cotton cultivars were found [22].

Table 1. Interaction effects of Non-Bt cotton cultivars and sowing date on plant height

Sowing Date (SD)	Year 1			Year 2		
	Cultivars			Cultivars		
	CIM-612	CIM-573	CIM-591	CIM-612	Cyto-124	CIM-573
April 15	125a	109b	103c	120a	110b	112b
May 01	116b	106bc	101c	116ab	108b	102c
May 15	112b	103c	101c	108b	101cd	93de
June 01	108b	89d	91d	99cd	96d	89e
June 15	101c	76e	75e	84e	85e	78f
LSD	5% SDxC = 4.82			5% SDxC = 5.08		

Table 2. Boll weight, number of bolls per plant, plant height (cm) and seed cotton yield (kg ha⁻¹) as influenced by Non-Bt cotton cultivars and sowing date

Treatments	Boll weight (g)		Number of bolls plant ⁻¹		Plant height (cm)		Seed cotton yield (kg ha ⁻¹)	
Cultivars	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
CIM-612	2.56 C	2.51 A	20 B	24	112 A	105 A	1825 B	2135 A
CIM-573	2.77 A	2.46 B	22 A	23	97 B	95 C	1994 A	1942 B
CIM-591	2.73 B	-	23 A	-	94 C	-	2088 A	-
Cyto-124	-	2.52 A	-	24	-	100 B	-	2184 A
LSD 5%	0.02	0.02	1.37	NS	2.16	2.27	112.68	111.18
Sowing Date								
April 15	2.59 D	2.44 D	27 A	31 A	112 A	114 A	2604 A	2761 A
May 01	2.65 C	2.47 C	25 A	29 A	108 B	109 B	2431 B	2562 B
May 15	2.69 B	2.50 B	22 B	24 B	105 C	101 C	2161 C	2193 C
June 01	2.71 B	2.53 A	19 C	20 C	96 D	95 D	1646 D	1725 D
June 15	2.80 A	2.55 A	13 D	15 D	84 E	82 E	1003 E	1197 E
LSD 5%	0.02	0.02	2.07	2.04	2.74	3.10	101.00	93.99

NS= Non- significant

Table 3. Interaction effects of Non-Bt cotton cultivars and sowing date on boll weight (g)

Sowing Date (SD)	Year 1			Year 2		
	Cultivars (C)			Cultivars (C)		
	CIM-612	CIM-573	CIM-591	CIM-612	Cyto-124	CIM-573
April 15	2.50f	2.67d	2.60e	2.45ns	2.46	2.43
May 01	2.56e	2.75c	2.83bc	2.49	2.50	2.41
May 15	2.60e	2.82bc	2.99a	2.52	2.51	2.46
June 01	2.57e	2.84b	2.67d	2.55	2.56	2.49
June 15	2.59e	2.79c	2.57e	2.56	2.56	2.53
LSD	5% SDxC = 0.04			5% SDxC = NS		

NS= no significant

Table 4. Cotton leaf curl disease incidence on different Non-Bt cultivars as influenced by sowing date during Year 1

Sowing dates	Cultivars	CLCuD incidence percentage (DAS)									
		30	45	60	75	90	105	120	135	150	165
15 th April	CIM-591	0.0	0.4	2.9	13.5	32.8	43.3	53.3	66.8	80.3	88.0
	CIM-612	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0	2.1
	CIM-573	0.0	0.0	4.1	11.7	31.0	37.2	51.3	57.8	62.3	66.3
	Average	0.0	0.1	2.3	8.4	21.3	27.2	35.2	41.9	47.9	52.1
1 st May	CIM-591	0.0	6.0	18.4	80.2	89.9	94.0	97.6	98.8	100.0	
	CIM-612	0.0	0.0	1.2	5.4	5.4	7.0	7.0	7.7	7.7	
	CIM-573	0.0	1.5	14.7	42.5	54.3	67.8	82.5	91.5	97.9	
	Average	0.0	2.5	11.4	42.7	49.9	56.3	62.4	66.0	68.5	
15 th May	CIM-591	0.6	8.0	55.0	87.3	96.3	97.5	100.0	100.0		
	CIM-612	0.0	2.5	6.3	9.4	12.7	14.1	15.8	16.5		
	CIM-573	0.0	8.0	44.1	73.0	85.9	89.9	96.9	97.8		
	Average	0.20	6.2	35.1	56.6	65.0	67.2	70.9	71.4		
1 st June	CIM-591	0.0	38.8	76.6	100.0	100.0	100.0	100.0			
	CIM-612	0.0	10.3	18.1	28.0	30.6	33.7	36.0			
	CIM-573	0.0	35.6	74.4	94.6	98.9	100.0	100.0			
	Average	0.0	28.2	56.4	74.2	76.5	77.9	78.7			
15 th June	CIM-591	22.6	81.2	100.0	100.0	100.0	100.0				
	CIM-612	18.9	40.1	61.7	63.3	65.5	67.8				
	CIM-573	30.8	59.3	100.0	100.0	100.0	100.0				
	Average	24.1	60.2	87.2	87.8	88.5	89.3				

Table 5. Cotton leaf curl disease incidence on different Non-*Bt* cultivars as influenced by sowing date during Year 2

Sowing dates	Cultivars	CLCuD incidence percentage (DAS)									
		30	45	60	75	90	105	120	135	150	165
15 th April	CIM-573	0.0	1.39	3.72	16.2	48.1	63.85	80.56	87.75	91.03	91.03
	CIM-612	0.0	0.0	0.45	0.89	0.89	1.39	2.35	3.25	3.25	3.25
	Cyto-124	0.0	0.0	0.0	0.45	0.99	1.58	1.58	3.8	4.35	4.35
	Average	0.0	0.46	1.39	5.85	16.66	22.27	28.16	31.6	32.88	32.88
1 st May	CIM-573	0.0	0.0	4.64	29.74	72.48	87.26	92.02	98.53	98.53	
	CIM-612	0.0	0.0	1.96	2.98	5.34	8.29	8.29	8.29	8.29	
	Cyto-124	0.0	0.0	0.0	1.43	4.17	6.71	10.48	11.74	11.74	
	Average	0.0	0.0	2.2	11.38	27.33	34.09	36.93	39.52	39.52	
15 th May	CIM-573	4.57	13.19	51.96	90.47	98.66	99.38	100	100		
	CIM-612	0.0	0.98	5.27	14.48	26.8	28.59	30.46	30.46		
	Cyto-124	0.0	0.0	4.47	14.09	23.72	25.91	25.91	25.91		
	Average	1.52	4.72	20.57	39.68	49.73	51.29	52.12	52.12		
1 st June	CIM-573	2.64	42.0	71.63	90.15	94.19	97.1	97.1			
	CIM-612	0.0	4.6	13.64	27.13	30.80	36.1	36.1			
	Cyto-124	0.0	0.0	5.16	11.37	12.05	15.82	15.82			
	Average	0.88	15.53	30.14	42.88	45.68	49.67	49.67			
15 th June	CIM-573	9.12	87.42	98.72	98.72	100	100				
	CIM-612	14.43	79.35	100	100	100	100				
	Cyto-124	0.7	10.64	16.5	17.89	19.5	19.5				
	Average	8.08	59.14	71.74	72.20	73.17	73.17

Figure 1. Metrological data of two consecutive cotton growing years

Conclusion

CLCuD being a complex disease is affected by many factors including sowing date. All the non *Bt* varieties sown earlier showed higher seed cotton yield and less incidence of CLCuD probably as a result of provision of

improved agri-environmental resources and more time availability. Hence farmers who want to grow non-*Bt* cotton varieties may not delay the cotton sowing. However, it can be suggested that under the prevailing agro-environmental normals; non-*Bt* cotton

variety CIM-612 sown on April 15 in core zone of Punjab (Pakistan) may aid in getting overall improved seed cotton yield with least chances of CLCuD incidence. Planting of suggested non-*Bt* variety is also very important under the backdrop of prevailing constraints and challenges being faced in the productivity of *Bt* cotton varieties.

Authors' contributions

Conceived the idea and designed the experiment: D Muhammad, Performed the experiment: M Ahmad & M Tariq, Analyzed the data: K Mubeen & MW Yonas, Contributed materials/ analysis/ tools: MN Afzal, Wrote the paper: M Shehzad & M Aziz.

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