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EARLY SOWING REDUCES COTTON LEAF CURL VIRUS OCCURRENCE AND IMPROVES COTTON PRODUCTIVITY

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ABSTRACT. Cotton productivity is severely hampering by various diseases and insect pests especially cotton leaf curl virus (CLCV) worldwide. Losses caused by CLCV are far more than any other factor affecting cotton productivity. Growing of early and resistant genotypes is of vital significance in alleviating the adversities of these pests in crop plants. The current field trial was conducted at Central Cotton Research Institute (CCRI) Multan, Pakistan, to investigate the role of varying sowing dates in managing the CLCV infestation on different elite cotton genotypes. The crop was sown on five different dates i.e. D_1= 15th April, D_2 = 1st May, D_3 = 15th May, D_4 = 1st June and D_5 = 15th June and three different elite cotton genotypes, i.e. V_1= CIM-612, V_2 = CIM-591 and V_3 = CIM-573 to optimize a suitable sowing date and to screen out high productive and tolerant genotype against the CLCV. Seeds were drilled manually on finely crafted seedbed by using single row hand drill keeping seeding density of 20 kg ha^{-1} and inter row spacing of 75cm. CLCV severely hampered the crop performance by delayed planting of cotton from 15th April; while increased the chances of disease incidence. It is concluded that early sowing of all tested genotypes especially CIM-592 reduces the problem of CLCV and enhanced cotton productivity.

Key words: Cotton; Leaf Curl Virus; Sowing dates; Seed cotton yield.

INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is not only the king of fibers and crucial crop used for fiber production all around the world (Killi and Aloğlu, 2000) but also it is a vital source of foreign exchange earnings. Several production, management, policy and marketing factors together are responsible for distant production ranking of the country. These constraints include; hiking prices of seeds, fertilizers, pesticides etc., increasing pest pressure, drought at different important growth phases, pesticide adulteration, poor

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agricultural policies and unavailability of resistant genotypes (Agro News, 2009).

Cotton is summer crop and undue high temperature harms growth and reproduction of cotton plant eventually decreasing overall yield (Bradow and Davidonis, 2000). Fruit setting in upland cotton is severely affected if day temperature remained more than 30^0C for a period of 13 hours or more (Reddy, 1992). Delayed in that period allows various environmental factors to act and effect maturation period (Iqbal *et al*., 2003). Late maturating types are ultimately affected by a later pest pressure and thus fiber quality is degraded severely (Subhan *et al*., 2001). Earliness allows development of crop during period of favorable moisture and timely picking prevent the crop from unfavorable weather (Rauf *et al.,* 2005). Sowing of advanced, early maturing genotypes not only allows timely sowing of wheat in wheat based cropping systems as in Pakistan (Ali *et al*., 2003) but also reduced the cost of pesticides use and enable the plant to use fertilizer and water more efficiently.

Due to late harvesting of wheat crop, cotton sowing become late which poses severe threats of insect pests and diseases attack particularly cotton leaf curl virus (CLCV). Several management options exist to improve the yield of late sown crop in wheat based cropping systems among which increasing planting density is one which may also negatively affect the crop yield (Silvertooth *et al.,* 1994). However, there exist great variation among different cotton cultivars based on quality of fiber (Mohammad, 2001) and ginning out turn (GOT) (Moser *et al*., 2000).

CLCV has become a serious challenge for cotton growers in the recent past decade resulting in very low productivity of cotton. Several CLCV tolerant cotton genotypes such as CIM-1100, CIM-448, CIM-446, CIM-443, MNH-552, MNH-554 were evolved to cope with this threatening challenge in future but in the recent decade situation has become more worse as the genotypes which were initially tolerant to this disease have shown susceptibility to this disease (Shah *et al*., 2010).

Selecting the proper sowing time is of prime importance among the different husbandry practices used to ensure higher output and quality of the produce. Area specific selection of appropriate husbandry practices such as sowing time is a tough challenge as there are many problems associated with too early and too late sowing of the crop as disease cycles and infestation of insect pests is also area specific. The one wrong decision about sowing of the crop may lead to severe losses.

As cotton season starts in summer and temperature is little bit higher which is favorable for cotton establishment and plant growth. If cotton is sown too early in the season when ambient temperature is low; it will hinder the cotton establishment and will lead to stumpy growth. Further, the attack of several seedling diseases will also aggravate the situation (Bange and Milroy, 2004). In the semi-arid countries like Pakistan where climate fluctuates from place to place selection of proper sowing time plays a pivotal role to fetch the maximum crop potential of cotton (Saraz, 2008; Soomro *et al.,* 2000).

In the changing climate scenarios establishment of superior germplasm and its acclimatization is the dire need of the time. It was hypothesized that sowing of newly evolved diverse cotton genotypes at different sowing dates will give best sowing date of each genotype for obtaining higher profitability and productivity.

MATERIALS AND METHODS

The current field trial was conducted at Central Cotton Research Institute (CCRI) Multan, Pakistan. The experiment was laid out in randomized complete block design in split plot provisions with a net plot size of 10 m × 10 m in three replicates. Varying planting intervals and elite cotton cultivars were randomized in main and sub plots respectively. Seeds of elite cotton genotypes CIM-612, CIM-591 and CIM-573 used in this study were collected from Agronomy section, Central Cotton Research Institute (CCRI), Multan. The crop was sown on five different dates *viz.* 15^{th} April, 1^{st} May, 15^{th} May, 1^{st} June and 15^{th} June to optimize the best suited date for crop sowing in order to minimize the infestation of CLCV. After necessary operations of seed bed preparation seeds were drilled manually by using single row hand drill keeping seedling density of 20 kg ha^{-1} and inter row spacing of 75 cm. The experimental soil was sandy loam having pH=8.60, EC=2.42 dS m^{-1} and organic matter=0.84%.

After the plants attained the size of 10 cm thinning was done to maintain the plant spacing of 30 cm. Total 150 kg phosphorus (P) and 250 kg of nitrogen (N) per ha was used to fertilize the crop for entire growing season by using diammonium phosphate (DAP) and urea as source. Whole amount of P and one third of N was applied with seedbed preparation while remaining N was split in two equal doses i.e. at 2^{nd} irrigation and at flowering. Weeds were controlled manually by hoeing throughout the growing season of the crop. Earthening up was done 45 days after sowing in each sowing date treatments to avoid the damages of crop lodging. Insects were controlled chemically by applying different insecticides at different growth stages of the crop after pest scouting to avoid the damages caused by insects. All other agronomic practices were uniformly maintained to assure crop health. Picking was done on different dates according to opening of bolls.

Observations

Various observations regarding plant growth and development, CLCV incidence, seed cotton yield and yield components and fiber characteristics were noted during the entire course of study.

Twenty different plants from each treatment unit were measured for their stature by using measuring scale and were averaged to get plant stature. While total number of nodes present on selected plants for plant height were carefully observed, and averaged to record nodes per plant. Cotton leaf curl virus (CLCV) infestation was calculated by carefully observing the infested plants and disease incidence was then computed by using percentage formula.

Boll population from different locations of each treatment was observed on each plant (20 plants maximum). Then average was computed to record number of bolls per plant. Whereas, thirty bolls at maturity from each experimental unit were chosen at random and weight of individual boll was recorded with the help of electrical balance and then averaged to compute boll weight. On selected twenty plants, total number of bolls present and that of opened were counted to get percent boll opening. Seed cotton picked from each experimental unit was recorded and final yield was calculated by adding all the yields obtained after each picking. Ginning out turn was calculated from weight of lint and total weight of seed cotton by using formula to get percent ginning out turn.

Statistical analysis

Recorded data was subjected to statistical analysis on MSTATC software and ANOVA technique was used to compute the means. The significance among means was tested by LSD test using 5% probability (Steel and Torrie, 1997). Microsoft Excel 2007 computer program was used to present the data in graphical form.

RESULTS

Effect of different sowing dates was significant for cotton leaf curl virus, boll weight, seed cotton yield, seed index, ginning out turn, micronaire, fiber strength, brightness and yellowness; however, it did not affected significantly staple length (*Table 1*). Likewise, various cotton genotypes differed significantly except for ginning out turn (*Table 1*). Interaction of sowing dates with cotton genotypes was also significant except for staple length (*Table 1*).

Maximum CLCV infestation was observed in cotton genotypes CIM-612 and CIM-573 sown on 1st June and 15th June while minimum incidence of disease was recorded in CIM-573 sown on 15th April which showed that late sown crop has more chances of disease infestation (*Table 2*). This not only improved boll weight with maximum value in CIM-612 sown on 15th May while CIM-591 sown on 15th April behaved poor in this regard (*Table 2*). Because of delayed planting boll weight reduced which cause reduction in seed cotton yield. In this regard, CIM-612 sown on 15th April and 1st May resulted in highest seed cotton yield while all genotypes sown on 15th June behaved poor resulted in lowest seed cotton yield compared with all other values (*Table 2*). However, maximum seed index was observed in crop sown 15th May, followed by 1st May sown crop while minimum seed index was computed in CIM-612 sown on 15th June (*Table 3*). All these attributes improved ginning out turn with maximum value from CIM-591 sown on 15th April observed peak ginning out turn compared with CIM-612 and CIM-573 sown on 15th June which resulted in lowest ginning out turn as compared to other plating dates (*Table 3*).

Table 1 - Analysis of variance for CLCV incidence, boll weight, seed cotton yield, seed index, ginning out turn, micronaire, fibre strength, staple length, brightness and yellowness of different cotton genotypes as affected by different sowing dates

SOV	df	CLCV	Boll weight	Seed cotton yield	Seed index	Ginning out turn	Micronaire	Fibre strength	Staple length	Brightness	Yellowness
Swing dates (D)	4	6654.56*	0.075*	5072062.93*	0.800*	2.521*	0.591*	31.55*	0.355^{ns}	51.358*	18.708*
Genotypes (V)	2	23297.49*	0.248*	355997.86*	4.928*	4.057^{ns}	0.439*	251.33*	6.028*	14.150*	9.017*
D × V	8	678.93*	0.037*	45084.53*	0.058*	0.174*	0.047*	2.614*	0.215^{ns}	2.983*	0.496*

SOV = source of variation, df = degree of freedom, * = significant at P ≤ 0.05, ns = non significant, CLCV= cotton leaf curl virus

Table 2 - Influence of different sowing dates on CLCV incidence, boll weight and seed cotton yield of different cotton genotypes

	CLCV (%)					Boll weight (g)					Seed cotton yield (kg ha^{-1})				
Sowing dates / Genotypes	15th April	1st May	15th May	1st June	15th June	15th April	1st May	15th May	1st June	15th June	15th April	1st May	15th May	1st June	15th June
CIM-612	43.3 e	94.0b	97.5 a	100.0 a	100.0 a	2.99 a	2.83 b	2.67 d	2.60 e	2.57 e	2740 a	2687 a	2290 bc	1642 d	1081 e
CIM-591	1.0 j	7.0 i	14.1 h	33.7 g	65.5 d	2.60 e	2.56 e	2.57 e	2.50 f	2.59 e	2334 b	2235 bc	2024 c	1598 d	933 e
CIM-573	37.2 f	67.8 d	89.9 c	100.0 a	100.0 a	2.82 b	2.75 c	2.84 b	2.67 d	2.79 bc	2737 a	2372 b	2169 bc	1699 d	995 e
LSD (P ≤ 0.05)			3.29					0.051					284.5		

Figures sharing same letter 'for interaction' did not differ significantly at P ≤ 0.05.

Table 3 - Influence of different sowing dates on seed index, ginning out turn and micronaire of different cotton genotypes

	Seed index					Ginning out turn (%)					Micronaire (Ug inch^{-1})				
Sowing dates / Genotypes	15th April	1st May	15th May	1st June	15th June	15th April	1st May	15th May	1st June	15th June	15th April	1st May	15th May	1st June	15th June
CIM-612	7.45 efg	7.47 efg	7.75 de	7.34 fg	7.15 g	41.07 ab	40.39 abc	40.27 bc	39.75 c	39.58 c	4.01 d	4.12 cd	4.06 d	4.32 a-d	4.43 a-d
CIM-591	8.17 bc	8.48 ab	8.81 a	8.34 bc	8.29 bc	41.64 a	41.31 ab	40.74 abc	40.56 abc	40.71 abc	4.20 bcd	4.38 a-d	4.40 a-d	4.73 a	4.66 a
CIM-573	7.95 cd	8.20 bc	8.51 ab	7.73 def	7.68 def	40.64 abc	40.44 abc	40.27 bc	40.17 bc	39.60 c	4.00 d	4.19 bcd	4.53 abc	4.56 ab	4.75 a
LSD ($P \leq 0.05$)	0.27					1.297					0.44				

Figures sharing same letter 'for interaction' did not differ significantly at $P \leq 0.05$.

Table 4 - Influence of different sowing dates on fiber strength, brightness and yellowness of different cotton genotypes

	Fiber strength (tppsi)					Brightness (R)					Yellowness (+b)				
Sowing Dates / Genotypes	15th April	1st May	15th May	1st June	15th June	15th April	1st May	15th May	1st June	15th June	15th April	1st May	15th May	1st June	15th June
CIM-612	102.7 a	102.2 a	102.8 a	99.51 b	98.10 d	72.00 de	75.50 abc	76.50 ab	77.75 a	76.25 ab	9.00 ab	9.00 ab	7.25 cd	6.25 d	6.25 d
CIM-591	95.78 e	94.85 ef	93.82 fg	92.75 g	92.78 g	73.50 cd	75.50 abc	77.00 a	76.50 ab	77.25 a	9.00 ab	8.25 bc	7.25 cd	6.25 d	6.00 d
CIM-573	99.36 bc	99.41 bc	98.35 cd	97.90 d	95.22 e	70.25 e	73.50 cd	74.50 bc	76.50 ab	77.00 a	10.25 a	9.25 ab	8.00 bc	8.25 bc	7.25 cd
LSD ($P \leq 0.05$)	1.02					2.34					1.41				

Figures sharing same letter 'for interaction' did not differ significantly at $P \leq 0.05$.

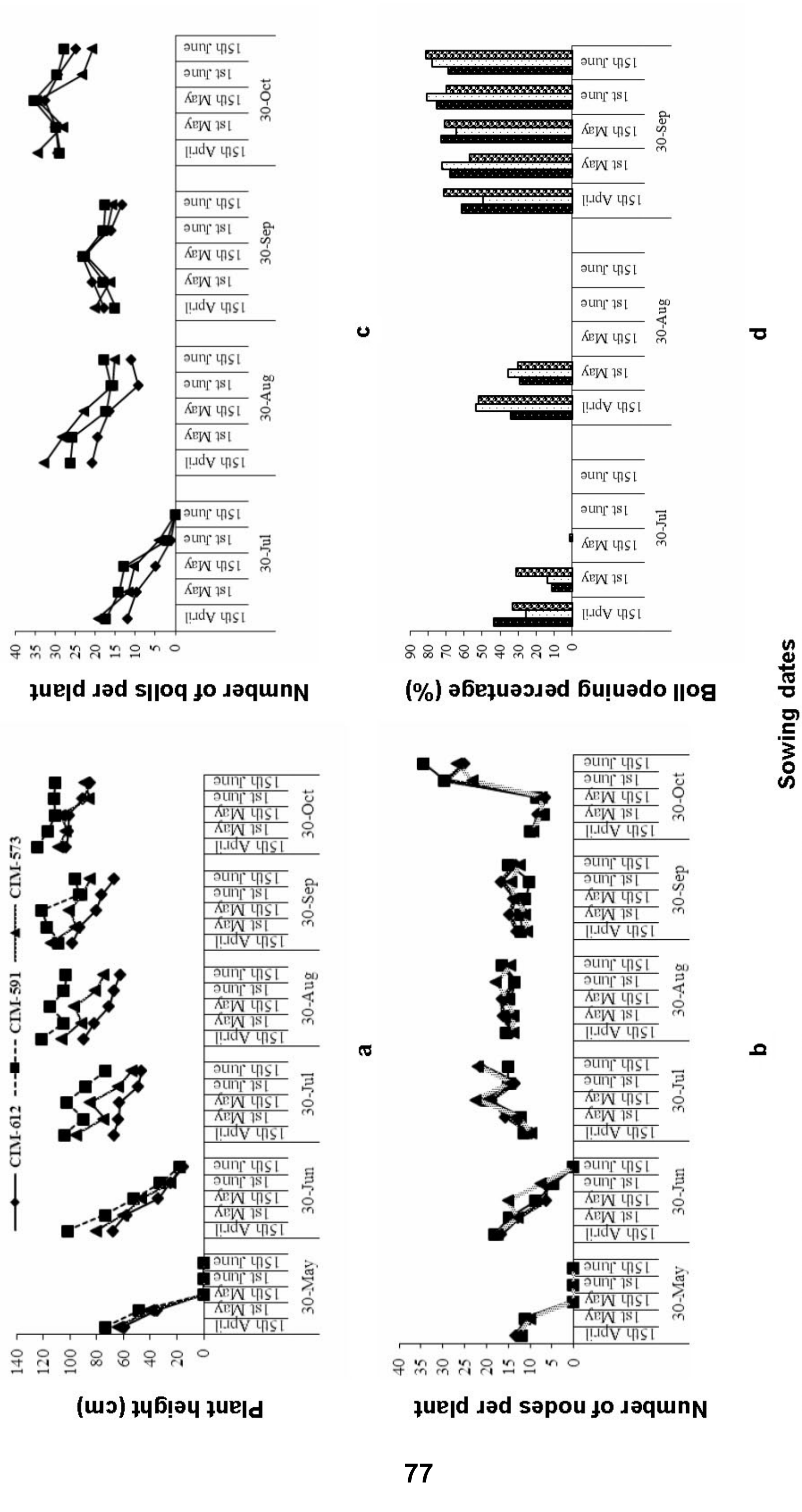

Figure 1 - Effect of different planting dates on (a) plant height, (b) number of nodes per plant, (c) number of bolls per plant and (d) boll opening percentage of newly evolved cotton genotypes

Due to less infestation of disease on early sown genotypes the quality of seed cotton was improved in terms of micronaire, fiber strength, brightness and yellowness as compared to delayed planting. Narrating for micronaire, CIM-591 sown on 1st and 15th June and CIM-573 sown on 15th June resulted in peak micronaire while CIM-612 sown on 1st April and 15th May and CIM-573 sown on 15th April resulted in minimum micronaire (*Table 3*). Similarly, fiber strength was maximal in CIM-612 sown on 1st April, 1st and 15th May while CIM-591 sown on 1st and 15th June remained poor in this regard (*Table 4*). Brightness and yellowness were more in CIM-612 sown on 1st June and CIM-591 sown on 15th May and 15th June and CIM-573 sown on 15th June while, CIM-573 sown on 15th April behaved poor (*Table 4*).

Crop sown on 15th April observed maximum plant height at all intervals of data collection while performance of crop sown on 15th June remained poor in this regard and minimum plant height was noted in crop sown on 15th June (*Fig. 1a*). Similarly among different genotypes tested during the course of investigation; CIM-591 remained superior and taller plants were noted in it compared with all other genotypes included on the study. However, minimum plant height was observed in genotype CIM-612 compared with all other genotypes tested (*Fig. 1a*).

The data indicated that crop sown on 15th April produced maximum number of nodes per plant during early in the season while later on maximum number of nodes per plant were observed in 15th May sown crop. However, at final stage 15th June sown crop recorded peak number of nodes per plant compared with all other sowing dated included in the study. Similarly, different genotypes also differed for number of nodes per plant at different intervals of crop growth. Cotton genotype CIM-591 outperformed with maximum number of nodes per plant at all sowing dates included in the study while performance of CIM-612 remained poor for number of nodes per plant at all sowing dates tested during the field trial (*Fig. 1b*).

Initially 15th April planted crop peak number of bolls per plant up till midseason while; afterwards, 15th May sown crop outperformed with maximum number of bolls per plant up till harvesting of the crop. Similarly, amid different genotypes included in the study CIM-591 outpaced with maximum number of bolls per plant compared with other genotypes included in the trial (*Fig. 1c*).

In case of boll percentage , maximum boll opening percentage was recorded in 15th April sown crop while against the minimum in 1st May sown crop while not even single opened boll was observed in all other sowing dates up to mid of the season. However, at the end of growing season maximum boll opening percentage was recorded in 15th June sown crop compared with remaining sowing dates tested during the course of study. Among genotypes, CIM-612 observed higher boll opening % age against the minimum in CIM-573 (*Fig. 1d*).

DISCUSSION

The results of the study clearly indicated that delayed planting severely hampered the productivity of different cotton genotypes. Maximum seed cotton yield was observed in 15th April sown crop while, 15th June planted crop remained poor for seed cotton yield and productivity. Higher seed cotton yield in early sown crop is the direct result of optimum temperature required for germination, growth and also the longer season to complete plant growth compared with delayed sown crop. Early sowing resulted in maximum plant height, number of nodes per plant, more number of bolls per plant, higher boll opening %age and finally more yield (*Fig.1a-d, Table 2*).

Moreover delayed sown crop observed higher incidence of cotton leaf curl virus disease which severely affected the crop yield particularly in late sown crop. 15th April sowing remained superior in this regard due to more vigorous and tolerant plants (*Table 1*). Similarly, different genotypes also behaved differently for disease incidence which is purely the inherent genetic character of different cotton genotypes.

Planting time has significant effect on seed cotton yield and its components. Among the yield components, number of bolls per plant reduced from 1st April to 15th June of planting, respectively. Earlier, decline in boll weight was also observed due to delay planting (Annual summary progress report Central Cotton Research Institute (OIC center of excellence in Asia) Multan, 2008-‘09 pp.17). The cause of reduction in seed cotton yield and its components is only due to planting time but also due to CLCV has significant impact on it. Incidence of CLCV was recorded maximum (100%) on 30th June’s planting, followed by 15th June at 30 days after planting, while 88% disease incidence was recorded after 120 days of 1st May of planted cotton (Annual summary progress report Central Cotton Research Institute (OIC center of excellence in Asia) Multan, 2008-‘09).

The genotypes that were severely affected by CLCV can be managed with increasing plant population and nitrogen fertilizer to achieve optimum seed cotton yield (Iqbal *et al.*, 2005). The variability in the natural incidence of disease depends upon the genetic makeup of the cultivar, concentration of inoculum of the disease and cultural management at different sites. Furthermore, the pressure of whitefly with concurrent presence of inoculum in the area affects the incidence of the disease.

The results of this study corroborates with those of Tahir *et al.* (2005). They reported that natural incidence of the disease varied from 14.4 to 70.24 % in various districts of the Punjab during 2004-‘05. Similarly the varieties planted in these districts had great variability in their reaction to the disease.

CONCLUSION

From the results of the field trial it is concluded that delayed planting of cotton from 15th April severely decreases the seed cotton yield along with its components while increase the chances of disease incidence which also reduces the seed cotton yield. Among different advanced cotton genotypes, CIM-592 reduces the problem of CLCV and enhanced cotton productivity.

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