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Research Article
Growth and yield of two cotton varieties as affected by various planting dates

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Keywords

Cotton,
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Abstract

Planting date considerably affects seed cotton yield. Being responsive crop to its surrounding environment it is imperative for growers to view appropriate planting date to ensure highest yield potential. The present studies were carried out to determine optimum planting date for two cotton varieties in an arid sub-tropical climate on clay loam soils during the year 2011 and 2012 at Adaptive Research Farm, Vehari, Pakistan. Seven planting dates commencing from March 01 to May 30 with 15 days interval were tested for two cotton varieties i.e. Ali Akbar-703 and MNH-886 arranged according to split plot design replicated thrice. Data regarding growth and yield contributing parameters were recorded. The two year results revealed that both the cotton varieties produced maximum seed cotton yield at early plantation as compared to late plantation. It was concluded that both the cotton varieties produced highest seed cotton yield on March 01 followed by progressively reduced yield when sown on March 15, April 01, April 15, May 01, May 15 and May 30 during both the experimental years. Both cotton varieties varied significantly in growth and yield performance and MNH-886 exhibited supremacy over Ali Akbar-703 at each planting date by producing seed cotton yield of 2046 and 2009 over 1726 and 1696 kg ha^{-1} during 2011 and 2012, respectively. It is recommended that cotton variety MNH-886 may be planted early in the season during the month of March in Vehari zone to attain maximum seed cotton yield.

Introduction

Global warming is the major abiotic stress that occurs due to increase in temperature that severely affects the plant germination, vegetative and reproductive growth. High temperature can increase the rate of reproductive development, which shortens the time for photosynthesis to contribute to fruit or seed production. Cotton is a soft, fluffy staple fiber crop plant of the genus *Gossypium* and belongs to family *Malvaceae* (Dorothy and Stolton, 1999). It occupies a key position in the world's trade and economy particularly in Pakistan. It is grown in about 76 countries, covering more than 32 million ha, under different environmental conditions world wide and world cotton commerce is about US$20 billion annually (Saranga *et al*., 2001). Cotton growth and maturity are altered by cultivars, seasonal management and environmental conditions (Gwathmey and Craig, 2003).

Optimum sowing date for a cultivar in a region is considered to be the most important manageable factor in cotton crop, (Bozbek *et al*., 2006Sekloka *et al*., 2008). Cultivar selection is also a key management component in any cropping system even more critical in plant spacing and sowing date for cotton production. Hodges *et al*.,(1993) observed that initiation of first square and its development was temperature and cultivar dependant. A group of scientists in the country have opinion with their findings that early sown cotton produces taller plants with higher boll number, seed index and seed cotton yield (Arain *et al*., 2001). Similarly Bange, *et al*., 2008reported that higher seed cotton yield due to early sowing was mainly attributed to higher boll number and seed index. Cotton yield declines with delay in sowing due to the shorter time available to initiate and mature an adequate number

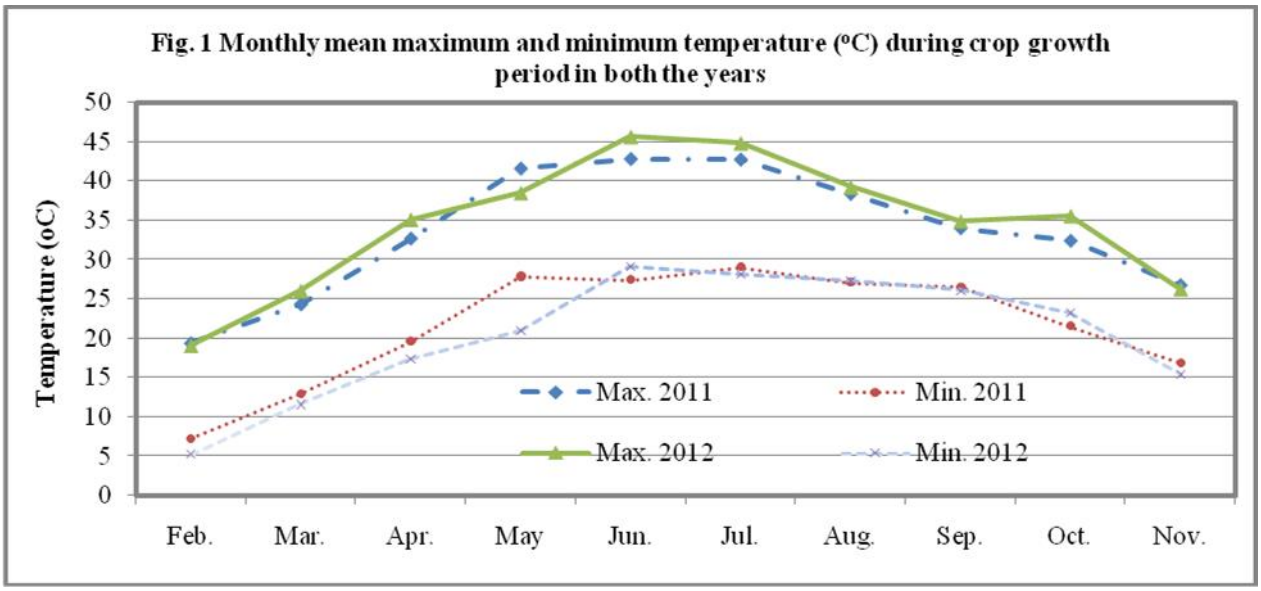
of bolls. Pettigrew, (2002a) reported that early planting increased the cotton yield by shifting the flowering period earlier.

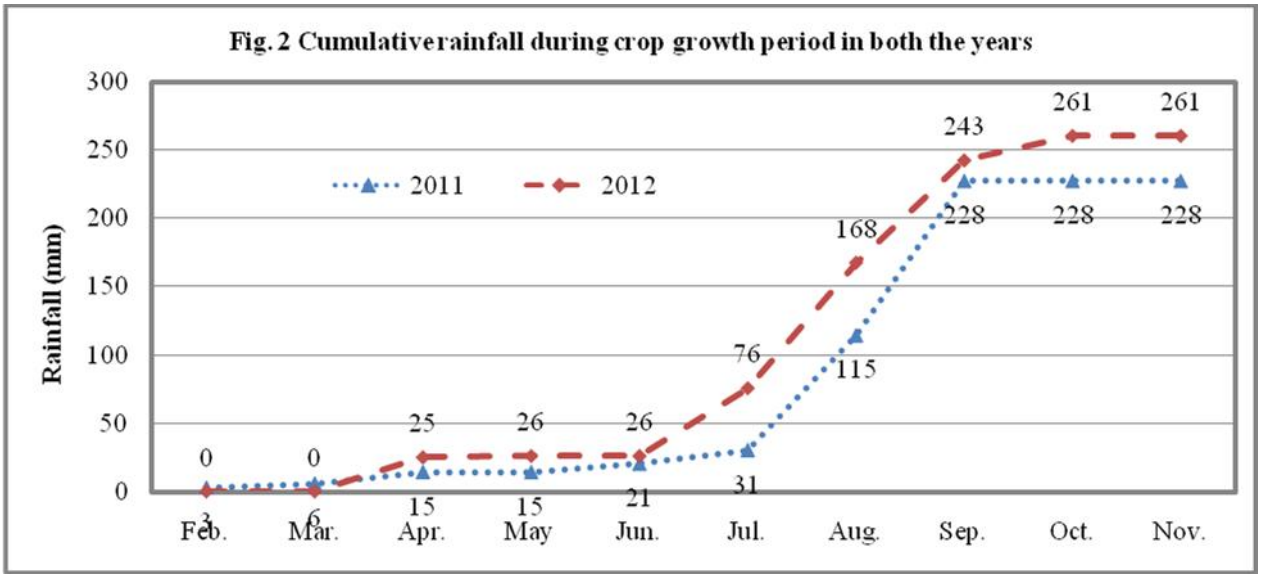
One of the most important agronomic considerations for growers to optimize yield and quality is to select an appropriate sowing time for cotton crop. Earliness in a cotton cultivar is important to minimize exposure of the primary fruiting cycle to the hot, humid monsoon weather which increases fruit loss and abortion resulted in lower yield potential. Sowing too early when the weather is cold can predominantly slow crop growth, often leading to poor establishment and poor early growth. Furthermore, the crop is exposed to many seedling diseases (Bange and Milroy, 2004). Sowing time has very important role in realizing maximum seed cotton yield in a country like Pakistan where the climatic conditions differ from province to province (Saraz, 2008; Soomro *et al*., 2000). Yield of cotton can be sufficiently increased if the optimum time for sowing in particular zone is well known. Hosny and Shahine (1995) reported decreased survival of cotton plant due to delayed sowing. Reddy *et al*., (1991) observed a 50% decline in total shoot biomass for upland cotton plants grown under a 40/30°C day/night temperature regime relative to plants grown under the optimal day/night temperature condition (30/20°C). Reddy *et al.,* (1996) reported that young bolls shed when grown at average daily temperatures of 32°C or higher. The yield of cotton is mostly associated with sowing dates as boll weight and formation of bolls which are inter linked with the yield (Hassan *et al*., 2003). Cultivar selection is also a very important component in any cropping system even more critical in sowing date for cotton production. Although higher yield potential is a predominant consideration, however plant height, number of bolls per plant etc. are also major factors to consider (Nichols *et al*., 2004). Yucel and Gormus (2002) reported that possible reasons of reduced plant growth and yield with late plantation were the unfavorable weather conditions that increased insect-pest incidence. Due to this fact, early planted cotton crop had more intact fruits that resulted in higher number of bolls plant^{-1} with less percentage of cotton leaf curl virus infestation. CLCV damage differs on various plant parts and ultimately results in reduction of yield. It can reduce boll weight 33.8%, 73.5% in bolls per plant, seed index 17.0% and yield per plant 64.5% (Ahmed, 1999).In Punjab early sowing in March or April produced significantly higher yield of cotton due to more boll size and more number of bolls per plant as compared tolate sowing in the month of May (Buttar *et al.,* 2005). In another study sowing of cotton from 15th February to 15th April at fortnight intervals showed that early sowing on 15thFebruary registered the highest number of bolls per plant and it was comparable with 1stMarch. There was decline in number of bolls due to delayed sowing. Similar trend in seed cotton yield was also noted by Srinivasan, 2001.

Materials and Methods

Field experiments and experimental site*:*

The field experiments were carried out at Adaptive Research Farm, Vehari, Pakistan at 29^{o}36'N, 71^{o}44'E at an altitude of 135 m during 2011 and 2012 to determine optimum sowing period of new Bt cotton varieties during two crop seasons on clay loam soils in an arid climate. The data regarding soil characteristics are presented in Table 1. The monthly maximum and minimum temperature(°C), cumulative rain fall (mm) and relative humidity (%) of two crop season are shown in Fig. 1, 2 and 3.





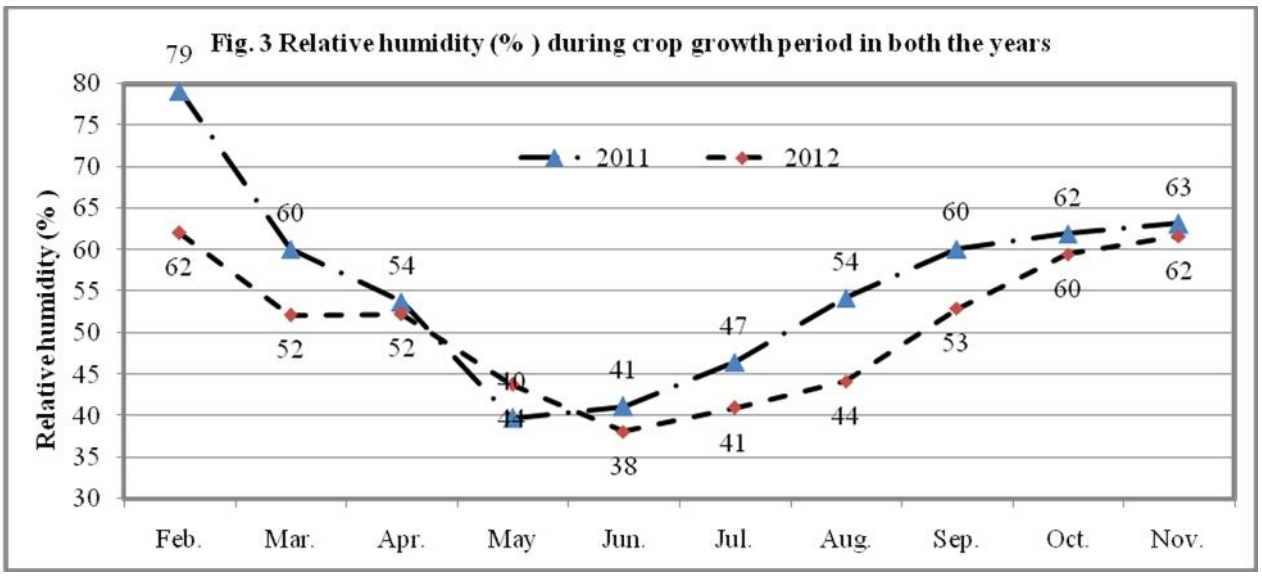


Table 1:Physico-chemical analysis of the experimental site

Depth (cm)	EC (dSm^{-1})	pH	OM (%)	Available P (ppm)	Available K (ppm)	Saturation %age	Sand (%)	Silt (%)	Clay (%)
0-15	1.19	8.2	0.61	6.9	152	45	15	20	65
15-30	1.15	8.3	0.23	2.3	88	46	16	17	67

Treatments and Agronomy*:*

Two cotton varieties Ali Akbar -703 and MNH-886 were planted at seven sowing dates, viz., D_1 (March 01), D_2 (March 15), D_3 (April 01), D_4 (April 15) D_5 (May 01),D_6 (May 15) and D_7 (May 30) during 2011 and 2012according to split plot design with three replications. Sowing dates were set in main plots and varieties in sub plots in net plot size of 7x15 m^2. Bed and furrows were made after land preparation with row-to-row distance of 75 cm. The furrows were irrigated properly and delinted cotton seeds of both cotton varieties were dibbled manually on respective sowing dates during both the years. Weedicides viz;Acetachlore 50EC and pendimethaline330E were applied within 24 hours of sowing at the rate of 1000 ml and 2000 ml ha^{-1}, respectively to control weeds in the field. A light irrigation was again applied after dibbling the seeds to achieve maximum seed germination. Gap filling was carried out and the subsequent irrigations were applied depending upon the weather conditions up till crop maturity.

Plant to plant distance was maintained at 30 cm and four weeks after planting, the crop was thinned keeping one plant per hole. All other agronomic practices were managed uniformly according to the requirement of the crop throughout the crop season. Ten plants from each treatment were selected at random for measuring height of plant in cm. Number of bolls per plant and boll weight were recorded from ten randomly selected plants from each treatment atmaturity. The seed cotton was harvested treatment- wise and finally calculated as kg per hectare. The 100 seed was taken from each treatment and measured in gram. Data for cotton leaf curl virus infestation were also recorded at its peak. Leaves showing small vein thickness, main vein thickness, curling and small 'enation' were considered infected. All the plants showing disease symptoms were counted as infested plants in each plot and percentage of infected plants was calculated.

Data collected on different parameters were analyzed statistically by using MSTAT-C programme (Freed and Scott, 1986) for analysis of variance and means were separated using Fisher's protected least significant difference (LSD) test at 5% probability level (Steel *et al*., 1997).

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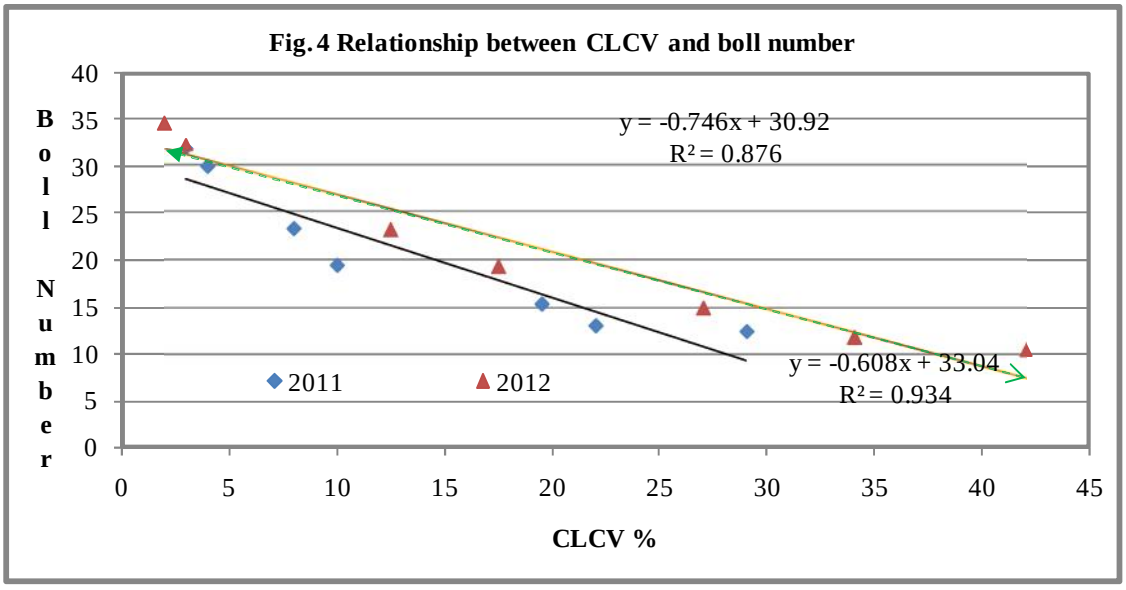
Results and Discussion

Number of bolls (plant^{-1}):

The data presented in Table 2 showed that the number of bolls plant^{-1} decreased significantly ($P \leq 0.05$) with each delay in plantation from March 01 to May 30 for both cotton varieties during both years of study. The average number of bolls plant^{-1} of seven planting dates of March 01, March 15, April 01, April 15, May 01, May 15 and May 30were 31.9, 29.9, 26.9, 20.9,15.3,13 and 12.4 respectively, during the year 2011 and number of bolls for the year 2012 were 34.8,32.4,23.3,19.4,15,11.9, and 10.6, respectively. Overall results revealed that number of bolls plant^{-1} was somewhat higher (34.8,32.4)during the year 2012 during first fortnight of March as compared to number of bolls (31.9, 29.9) in the year 2011. Cotton variety MNH-886 performed better than Ali Akbar-703 in terms of number of bolls plant^{-1} during both the years of study. The number of bolls plant^{-1} of two varieties i.e. Ali Akbar-703 and MNH-886 were19.66 and 23.34, respectively during the year 2011 and subsequent values for year 2012 were 19.57 and 22.46, respectively. It is evident from the results that boll number declined after first fortnight of March till May, 30 and found greater during 2011 than 2012might be due to heavy rains received during 2012 and maximum temperature of 45.63 C^o during the month of June which caused flower shedding. The results are in accordance with Bibi *et al*., 2010;Bange, *et al.,* 2008 and Buttar *et al.,* 2005. Cotton variety MNH-886 performed better than Ali Akbar-703 with respect to number of bolls plant^{-1} which might be due to genetic makeup of the varieties and less cotton leaf curl virus infestation at all the planting dates during both the years of study. Negative significant relationship (R^2=0.87, 0.93) was exhibited between number of bolls and CLCV infestation with respect to planting dates for both years, respectively (Fig. 4). The results are also in line with Ahmed, 1999,who reported that CLCV reduced 73.5% in bolls per plant.

Table 2: Number of bolls (plant^{-1}) of two cotton varieties as affected by various planting dates

Variety	March 01	March 15	April 01	April 15	May01	May 15	May 30	Mean
	Number of bolls (plant^{-1})							
	2011							
Ali Akbar-703	32.2 b	30.2bc	22.4 d	18.6 e	14.2 f	10.2g	9.8g	19.66 B
MNH-886	34.4 a	32.6 a	28.6 c	21.6 d	16.2 f	15.4 f	14.6 f	23.34 A
Mean	33.3 A	31.4 B	25.5 C	20.1 D	15.2 E	12.8 F	12.2 F	
LSD $_{0.05}$	Sowing date=1.51; Interaction=2.18							
	2012							
Ali Akbar-703	29.2 c	27.2 d	25.2 e	20.2 f	14.4 gh	10.6 i	10.2 i	19.57 B
MNH-886	37.4 a	34.6 b	24.2e	20.2f	15.8g	13.6h	11.4i	22.46 A
Mean	33.3 A	30.9 B	24.7C	20.2 D	15.1 E	12.1 F	10.8 F	
LSD $_{0.05}$	Sowing date=1.74; Interaction=1.86							



Boll weight (g plant^{-1}):

Data presented in Table 3 showed the response of both varieties on boll weight to seven sowing dates. It revealed that boll weight ranged from 3.20to 3.29 g boll^{-1}forcultivar Ali Akbar-703 and MNH-886, respectively during 2011, and the subsequent figures for the year 2012 were 3.19 and 3.27 gboll^{-1}, respectively. Among sowing dates the boll weight varied from 3.03 to 3.43 g boll^{-1}during 2011 and subsequent values for 2012 were 2.97 to 3.46 gboll^{-1}.The results are consonant with Hassan *et al.*, 2003. Fig. 5indicated that there is significant negative relationship(R^2= 0.976,0.979) between CLCV and boll weight with respect to sowing dates for both years, respectively. It is observed that with increasing CLCV infestation, the boll weight of both cotton varieties declined progressively causing decrease in seed cotton yield. The results are also in line with Ahmed, 1999who reported that CLCV reduced boll weight 33.8%.

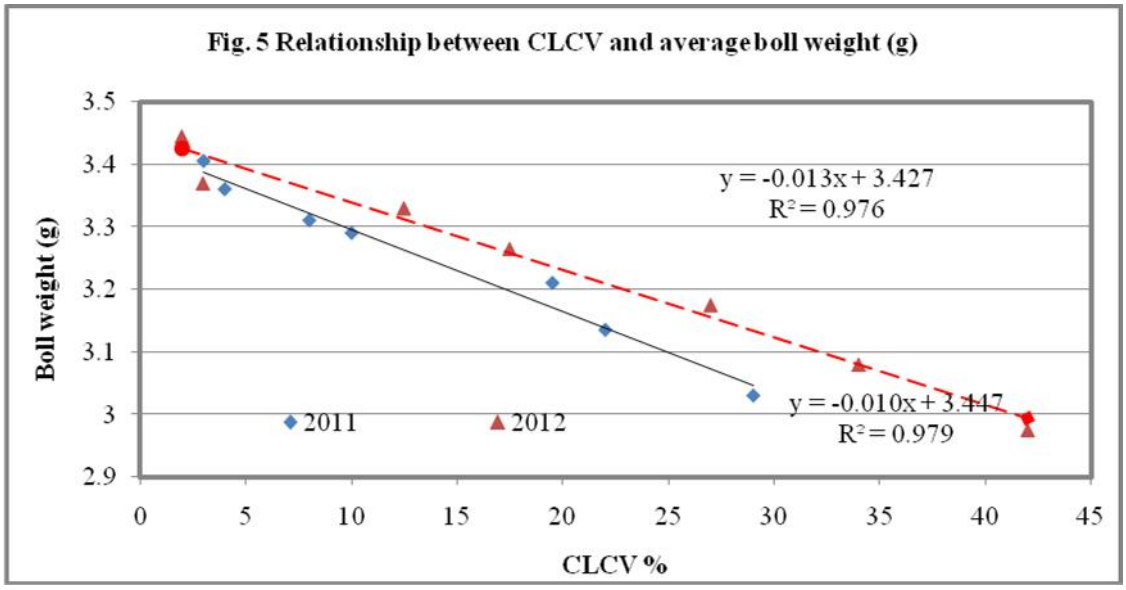


Table 3:Boll weight (g boll^{-1})of two cotton varieties as affected by various planting dates

Variety	March 01	March 15	April 01	April 15	May 01	May 15	May 30	Mean
				Boll weight				
				2011				
Ali Akbar-703	3.41 b	3.32 d	3.26 f	3.21 g	3.16 h	3.07 j	2.95 k	3.20 B
MNH-886	3.45 a	3.40 b	3.36 c	3.29 e	3.22 g	3.20 g	3.11i	3.29 A
Mean	3.43 A	3.36 B	3.31 C	3.25 D	3.19 E	3.13 F	3.03 G	
$LSD_{0.05}$	Sowing date=0.042; Interaction=0.029							
				2012				
Ali Akbar-703	3.45 b	3.39 d	3.29 e	3.19 g	3.11i	3.01k	2.91l	3.19 B
MNH-886	3.48 a	3.42 c	3.30 e	3.28 e	3.24 f	3.15 h	3.04 j	3.27 A
Mean	3.46 A	3.40 B	3.29 C	3.23 D	3.18 D	3.08 E	2.97 F	
$LSD_{0.05}$	Sowing date=0.051; Interaction=0.026							

Seed index (g)*:*

Seed index of two cotton varieties Ali Akbar-703 and MNH-886was 7.77 and 8.18 g, respectively during 2011 and subsequent values in 2012 were 7.63 and 8.06 g, respectively (Table 4).Main effect of sowing dates obviously influenced seed index significantly ($p \leq 0.05$).The range of seed index during year 2011 was 6.96 to 9.01g and seed index was decreased with each delay in cotton plantation and vice versa, and subsequent figures for the year 2012 were 6.64to 9.59 g, respectively. The same trend was noted during year 2012.Bange, *et al.*, 2008 reported that higher seed cotton yield due to early sowing was mainly attributed to higher boll number and seed index. Similarly, cotton yield declined with delay in sowing due to the shorter time available to initiate and mature an adequate number of bolls.

Table 4:Seed index (100 seed weight g)of two cotton varieties as affected by various planting dates

Variety	March 01	March 15	April 01	April 15	May 01	May 15	May 30	Mean
				Seed index (g)				
				2011				
Ali Akbar-703	8.96 a	8.74 b	8.15d	7.58f	7.14g	7.11g	6.72h	7.77 B
MNH-886	9.05 a	8.86 a	8.62c	8.13d	7.89e	7.51f	7.21g	8.18 A
Mean	9.01 A	8.80 A	8.38B	7.85 C	7.51D	7.31D	6.96E	
$LSD_{0.05}$	Sowing date=0.31; Interaction=0.11							
				2012				
Ali Akbar-703	9.06c	8.84d	7.70f	7.45fg	6.98gh	6.91h	6.45i	7.63 B
MNH-886	10.12a	9.58b	7.93e	7.66f	7.25g	7.05g	6.84h	8.06 A
Mean	9.59A	9.21B	7.81 C	7.55C	7.11D	6.98D	6.64E	
$LSD_{0.05}$	Sowing date=0.33; Interaction=0.21							

Plant height (cm)

Data presented in Table 5 depicted that plant height varied significantly ($P < 0.05$) with different planting dates during both the experimental years. The early planted crop on March 01 exhibited maximum plant height which decreased progressively with each delay in plantation during both the years. Average plant height for both cotton varieties ranged from 91.30 cm to 118.60 cm during 2011 and subsequent values for 2012 were 102.25 cm to 128.40 cm. Among cotton varieties, non significant average plant height ranged from 107.06 cm to 109.59 cm for Ali Akbar-703 and MNH-886, respectively during 2011 and the subsequent significant figures for the year 2012 were 114.04 cm to 117.79 cm for Ali Akbar-703 and MNH-886, respectively. The results are in line with the findings of Arain *et al.*, 2001 who has the opinion that early sown cotton produces taller plants.

Table 5:Plant height(cm)of two cotton varieties as affected by various planting dates

Variety	March 01	March 15	April 01	April 15	May 01	May 15	May 30	Mean
	Plant height (cm)							
	2011							
Ali Akbar-703	118.4b	116.8c	113.4d	110.2e	101.7g	98.7h	90.2j	107.06B
MNH-886	120.4a	118.7b	116.9c	112.9d	104.6f	101.2g	92.4i	109.59 A
Mean	118.60A	117.75A	115.15B	111.55C	103.15D	99.95E	91.30F	
$LSD_{0.05}$	Sowing date=1.91; Interaction=1.17							
	2012							
Ali Akbar-703	126.2b	122.4c	115.2e	111.6f	111.2d	106.4f	100.3g	114.04B
MNH-886	130.6a	125.3b	121.5c	118.2d	114.5e	110.2d	104.2f	117.79A
Mean	128.40A	123.85B	119.35C	116.4D	112.85E	108.30F	102.25G	
$LSD_{0.05}$	Sowing date=2.07; Interaction=1.98							

Seed cotton yield (kg ha^{-1})

The data regarding seed cotton yield of two cotton varieties planted atvarious dates during the year 2011 and 2012 were depicted in Table 6. The data revealed that the variation in seed cotton yield due to main effects of planting dates as well as varieties were highly significant ($P \leq 0.01$). Average seed cotton yield at various planting dates varied from 1284 kg ha^{-1} to 2412 kg ha^{-1} during the year 2011 and subsequent values for the year 2012 ranged from 1226 kg ha^{-1} to 2477 kg ha$^{-1.}$. It was evident from the yield data that planting done on March 01 produced the highest seed cotton yield against the lowest when late planting was done. Varieties had also significant ($P \leq 0.05$) differences in seed cotton yield during both the years of study. The seed cotton yield of cotton varietiesAli Akbar-703 and MNH-886 were 1727 kg ha^{-1}and 2046 kg ha^{-1},respectively during the year 2011 and subsequent values for the year 2012 were 1696 kg ha^{-1}, and 2009 kg ha^{-1}, respectively. Cotton variety MNH-786 produced higher seed cotton yield as compared toAli Akbar-703 during both the experimental years. The interaction of planting dates and varieties was also found highly significant ($P \leq 0.01$) indicating that both the varieties recorded highest seed cotton yield when plantation was done on March 01 followed by March 15, April 01, April 15, May 01, May 15 and May 30. The results are in line with Arain *et al*., 2001 and Hassan *et al*., 2003. Negative and significant (R^2=0.97and 0.98) relationship was found between seed cotton yield and CLCV infestation for both years, respectively (Fig.6). It suggested that highest CLCV infestation caused decline in seed cotton yield. The results are also in accordance with Ahmed, 1999who reported that CLCV reduced yield per plant 64.5%.

Table 6:Seed cotton yield (kg ha^{-1})of two cotton varieties as affected by various planting dates

Variety	March 01	March 15	April 01	April 15	May 01	May 15	May 30	Mean
	Seed cotton yield (kg ha^{-1})							
	2011							
Ali Akbar-703	2360b	2200d	2147f	1966h	1431j	1028l	956n	1727B
MNH-886	2464a	2310c	2280e	2072g	1811i	1775k	1612m	2046A
Mean	2412A	2255B	2213B	2019C	1621D	1401E	1284F	
$LSD_{0.05}$	Sowing date=115.51; Interaction=9.88							
	2012							
Ali Akbar-703	2413b	2302c	2054e	1794g	1344k	1027l	937m	1696B
MNH-886	2541a	2407b	2207d	1990f	1714h	1690i	1516j	2009A
Mean	2477A	2354B	2130C	1892D	1529E	1358F	1226G	
$LSD_{0.05}$	Sowing date=110.36; Interaction=6.62							

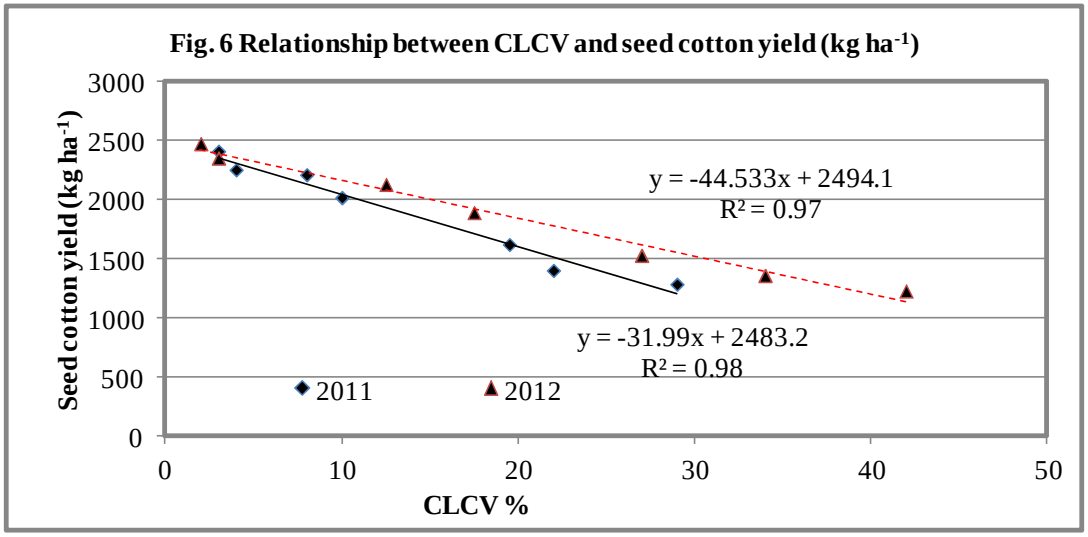
Cotton leaf curl virus infestation (%)

From the results of the study, it was observed that both cotton varieties varied significantly for cotton leaf curl virus when planted at different planting dates. Data presented in Table 7 depicted that incidence of cotton leaf curl virus was more in late planting and least on early plantation. Minimum average cotton leaf curl virus infestations (3% to 4% and 2% to 3%) were recorded on planting date of March 01 to March 15 during 2011 and 2012, respectively.

The average cotton leaf curl virus infestations on both cotton varieties at seven planting dates i.e. March 01,March 15, April 01, April 15, May 01, May 15 and May 30were3%, 4%, 8%, 10%, 19.5%, 22.0% and 29.0% respectively during the year 2011 and the subsequent figures for the year 2012 were 2%, 3%, 12.5%, 17.5%,27.0,34% and 42% respectively. Both the cotton varieties varied significantly with respect to CLCV incidence, however cotton variety MNH-886responded least incidence than Ali Akbar-703 at all the planting dates during both the years of study. Cotton variety MNH-886 performed better than Ali Akbar-703 with respect to yield and yield components which might be due to genetic makeup of the variety and less cotton leaf curl virus infestation at all the planting dates during both the years of study. The results are in accordance with Srinivasan, 2001 who found that there was decline in seed cotton yield due to delayed sowing and more incidence of cotton leaf curl virus. Negative and significant (R^2=0.97 and 0.98) relationship was found between seed cotton yield and CLCV infestation for both years, respectively (Fig.6).

Table 7: Leaf curl virus infestation (%) of two cotton varieties as affected by various planting dates

Variety	March 01	March 15	April 01	April 15	May 01	May 15	May 30	Mean
	Leaf curl virus infestation (%)							
	2011							
Ali Akbar-703	5eg	7ef	10de	12d	30c	33b	46a	20.43 A
MNH-886	1h	1h	6ef	8e	9e	11d	12d	6.85B
Mean	3E	4E	8D	10D	19.5C	22.0B	29.0A	
LSD $_{0.05}$	Sowing date=2.01; Interaction=1.54							
	2012							
Ali Akbar-703	3j	5j	17g	25e	42c	48b	54a	27.71A
MNH-886	1jk	1jk	8.0i	10h	12h	20f	30d	11.71B
Mean	2F	3F	12.5E	17.5D	27.0C	34.0B	42.0A	
LSD $_{0.05}$	Sowing date=2.31; Interaction=2.62							



Time of sowing plays an important role in productivity of cotton through its effect on duration for vegetative and reproductive phases and thus total duration of crop. The acceleration of reproductive development by high temperatures may affect and create problem in flower / boll dropping and boll bursting but not opening causing severely reduction in yield. Late planting causes the crop to flower later and pushes boll development into the cooler weather, resulting in reduced yields. Temperature plays a critical and complicated role in the growth and development of cotton. Much of the understanding of the impacts of low temperature on cotton crop growth and development is based on experimental work undertaken in the past with technology and cultivars quite different than those used commercially today (Siddiqui *et al*., 2004). Data presented in Fig.1 showed that the maximum temperature of 42.83 ^{o}C and 45.63 ^{o}C remained high in the month of June during the year 2011and2012, respectively which caused flower shedding in cotton and increased pest population. Therefore, the crop remained under stress. Reddy *et al.* (1991)

observed that temperatures in excess of a 30/20°C day/night temperature regime resulted in significantly lower boll retention due to enhanced abortion of squares and young bolls. Leaf extension growth declined significantly at temperatures above 35°C (Bibi *et al*., 2010). High humidity of 62-63% and60-62%were observed in the months of October and November in year 2011 and 2012, respectively which caused low cotton seed maturity and viability (Fig.3). Unexpected rains received during the month of August and September (114.5 mm and 227.5 mm) during 2011 and (168 mm and 243) received during 2012 damaged cotton crop near maturity when the crop was ready for picking; hence caused heavy losses in seed cotton yield. Early plantation of cotton in Pakistan was benefited by the favorable environmental conditions before the commencement of monsoon and high temperature during flowering and fruit development (Ali *et al*., 2009). Our results depicted a significant reduction in cotton growth and yield due to its late plantation than March 01 which might be due to reduced crop growth period, high CLCV infestation and vulnerability of cotton crop to insects. These results were in line with the findings of Yucel and Gormus (2002) who reported that possible reasons of reduced plant growth and yield with late plantation were the unfavorable weather conditions that increased insect-pest incidence.

Conclusion

Early plantation of cotton in Pakistan was benefited by the favorable environmental conditions before the commencement of monsoon and high temperature during flowering and fruit development. Moreover, cotton variety MNH-886 performed better and might be recommended for early plantation in Vehari region. However, the various production factors contributed to higher seed cotton yield still need to be explored to sustain cotton crop productivity.

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