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INFLUENCE OF SOWING TIME ON COTTON GROWTH, YIELD AND FIBER QUALITY

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ABSTRACT

Cotton crop is considered to be the backbone of Pakistan economy and efforts are required to rise it's per hectare yield. This field study investigated the effects of sowing date and cotton genotypes on growth, yield and fiber quality of cotton under the agro-ecological conditions at Sakrand, Sindh, during Kharif season, 2014. A randomized complete block design in split plot arrangement was used with four sowing dates [SD_1 = 15th April, SD_2 = 1st May, SD_3 = 15th May, SD_4 = 1st June] were randomized in the main plots and two genotypes [V_1 = Bt. CRIS-508, V_2 = CRIS-342] in subplots during 2014. Results showed that sowing dates and genotypes had significant difference ($P \leq 0.05$) on growth, yield and fiber quality traits. Significantly maximum (2939 kg. ha^{-1} and 2801 kg. ha^{-1}) seed cotton yield was observed for genotypes Bt. CRIS-508 and CRIS-342 when sown on 15th April while minimum (1853 kg. ha^{-1} and 1648 kg. ha^{-1}) seed cotton yield for genotypes Bt. CRIS-508 and CRIS-342 when sown on 1st June. It was concluded that April 15 sowing was the most appropriate sowing date for these genotypes under agro-climatic condition of Sakrand, Sindh, Pakistan.

Key Words: Cotton, sowing dates, genotypes, GOT %, seed cotton yield.

INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is an important fiber crop of the world (Killi and Aloglu, 2000) and a cash crop of Pakistan, which earns a sustainable amount of foreign exchange through export of raw cotton and its products (Ahmad *et al*., 2009 and Anon, 2011). It has an important role in agriculture and agro-based industries of the country. It contributes 6.7 % to the value added products in agriculture and 1.4 % to gross domestic production (Govt. of Pakistan, 2013-14). Currently, the area under cotton is 2.81 million hectares and total production is 12769 thousand bales with an average yield of 773 kg. ha^{-1} (Govt. of Pakistan, 2013-14). Being one of the most important fiber crops of Pakistan, its domestic average yield per unit area is well below as compared to other cotton growing countries of the world due to determined efforts of breeders and agronomist (Ali *et al*., 2005). The reasons of low cotton production in Pakistan can be manifold and attributed to several crop husbandry problems, which reflect the growth and yield of cotton. Sowing date is one of the main agronomic reasons, which linearly affect the growth and yield contributing parameters including fiber quality traits that are closely associated with environments favorable for higher yields.

In Pakistan, cotton-growing areas face the extreme temperature, which is perhaps unique features among other cotton growing areas. Temperature increases significantly in May, peak in June and continue at a high level during July and August in Central Cotton Research Institute Sakrand. High temperatures linearly coincide with growth and early reproductive phases of seed cotton production (Arain and Khan, 1998). However, sowing date/environmental temperature is the key factor, which significantly affects the growth, cultivars yield and yield parameters including fiber quality. Moreover, it was observed that delay of a week in sowing resulted in a clear reduction in yield (Abdel-Malak *et al*., 1996). It is considered to investigate the suitable sowing date of cotton cultivars under the particular agro climatic conditions (Kakar *et al*., 2012). Early sown cotton produced significantly higher seed cotton yield and yield attributes (Soomro *et al*., 2000). Maximum seed cotton yield was observed in middle districts of Sindh when crop was sown on 15th April and 1st May (Arain *et al*., 2001). Seed cotton yield is mostly related with sowing dates as bolls per plant and boll weight, which are associated with the yield (Mahmood-ul-Hassan *et al*., 2003). Cotton quality and yield traits viz., GOT (%), staple length, plant height, bolls per plant, boll weight, seed index and seed

cotton yield were significantly affected due to different sowing dates (Niazi. 2005). Sowing date is a main cause influencing growth and development of cotton as it influences the time of vegetative and reproductive stage of the crop. Moreover, too early and too late sown crop caused in drastic reduction in seed cotton yield (Bange and Milroy, 2004). Cotton plant is very sensitive to temperature fluctuation and seeded in a wide range of agro-ecological zones. It is influenced by a number of factors while sowing date is important to explore the potential of cultivars in a region (Ali *et al*., 2009). Moreover, optimum-sowing date for a cultivar in a region is crucial to be the most significant controllable factor in cotton crop (Bozbek *et al*., 2006). Cotton cultivars vary with respect to fiber traits (Mohammad, 2001) and may be affected by environmental condition (Killi *et al*., 2005). Fiber quality traits like GOT%, staple length, and oil content were different significantly among planting dates and cotton cultivars which is due to early sowing (Iqbal and Khan, 2011). Cotton cultivars exhibited maximum seed cotton yield in early sowing of 15th April as compared to late 15th June sowing (Siddiqui *et al*., 2004).

There is a need to increase the yield of the cultivars under the local environmental conditions of Sindh. Keeping in view the above discussion a research was conducted with the aim to evaluate the effect of sowing dates and cultivars on seed cotton yield and fiber quality traits, under the agro-ecological conditions at Sakrand, Sindh.

MATERIALS AND METHODS

Study site

The present study was performed at the experimental field of Central Cotton Research Institute under Agronomic Section, Sakrand, Sindh, to evaluate the productivity of Bt. CRIS-508 variety as affected by different sowing dates during Kharif seasons, 2014.

Weather

Figure 1 shows the summary of weather data for the crop growth period during 2014. During study the mean maximum temperature at 15th April, 1st and 15th May and 1st June were 40.5 ^{o}C, 39.8 ^{o}C and 44 ^{o}C respectively. The mean maximum temperature of 1st and 15th May was 1.73 % and 9.75 % lower than 15th April and 1st June sowing. The mean minimum temperature on 15th April, 1st and 15th May and 1st June was 17.9 ^{o}C, 21.4 ^{o}C, 24.8 ^{o}C and 24.8 ^{o}C respectively. The mean minimum temperature at 15th April was 16.4 % and 27.8 % lower than 1st and 15th May and 1st June. Most of the rainfall was received during the month of August. Maximum rainfall was received in the month of August (112 mm). Maximum average relative humidity was observed in the months of August and September.

Experimental design and cultural practices

A randomized complete block design in split plot arrangement with three replication and has plot size of 6.0 m x 3.0 m. Four sowing dates (SD_1 = 15th April, SD_2 = 1st May, SD_3 = 15th May, SD_4 = 1st June) were randomized in the main plots while two varieties (V_1 = Bt. CRIS-508, V_2 = CRIS-342) were applied in subplots. The metrological data was recorded during the cropping season 2014 (Figure 1). After the harvesting of wheat crop the land was prepared for cotton by giving two dry ploughings with disc plough followed by clod crushing to achieve fine seed bed. The soil of the experimental field was clay loam in texture under mono-cropping system. Cotton varieties were sown on different sowing dates with single row hand drill in 75 cm apart rows using seed rate of 20 kg ha^{-1}. Whole of the phosphorous at the rate of 75 kg ha^{-1} was applied at the time of sowing in the form of SSP while the nitrogen at the rate of 115 kg ha^{-1} was applied in the form of Urea in three splits 1/3 at the time of sowing and remaining 1/3 nitrogen with first irrigation and 1/3 with second irrigation. All other agronomic practices were kept uniform for all the treatments.

Development, agronomic and fiber quality parameters of cotton

Development and agronomic parameters of cotton, including germination (%), plant height (cm), number of bolls per plant, boll weight (g), plant population (ha^{-1}), seed cotton yield (kg. ha^{-1}), seed index (%), ginning out turn (%), staple length (mm), Micronaire and oil content (%) were recorded. The data of crop emergence were recorded after sowing. For this purpose, we selected an area of 1 m^{-2} from two places randomly and emergence in each experimental unit counts were made on daily basis up to the emergence constant level. Plant population was recorded from 18 plots, then converted into hectare basis. Ten plants were selected to record plant height, number of bolls per plant and boll weight. Three samples of 100 seeds were taken at random from each plot to record seed index. The seed cotton yield was recorded on per plot basis and was converted to kg. ha^{-1}. The seed cotton was picked carefully on full maturity of the crop and air-dried. After sundry samples were taken from each repeat of sowing dates and varieties: these samples were ginned by eight saw ginning machine. The ginning machines were

standardized in such a way that the ginning loss may not exceed from two percent. The ginning out turn percentage was calculated by following formula:

$$\text{Ginning out turn (GOT) \%} = \frac{\text{Lint weight}}{\text{Weight of seed cotton}} \times 100$$

Fourty grams of lint from each sample was taken in a paper envelope signifying the name of sowing dates and varieties and ginning number on envelope and sent to fiber testing laboratory of CCRI, Multan for the fiber quality analysis i.e. GOT (%), staple length (mm), micronaire value (µg. inch^{-1}) and oil content.

Statistical Analysis

Data collected was analyzed statistically by applying Fisher's analysis of variance technique. Least significant difference (LSD) test was employed at 5% probability level to test the significance of the treatments' means (Steel *et al*., 1997).

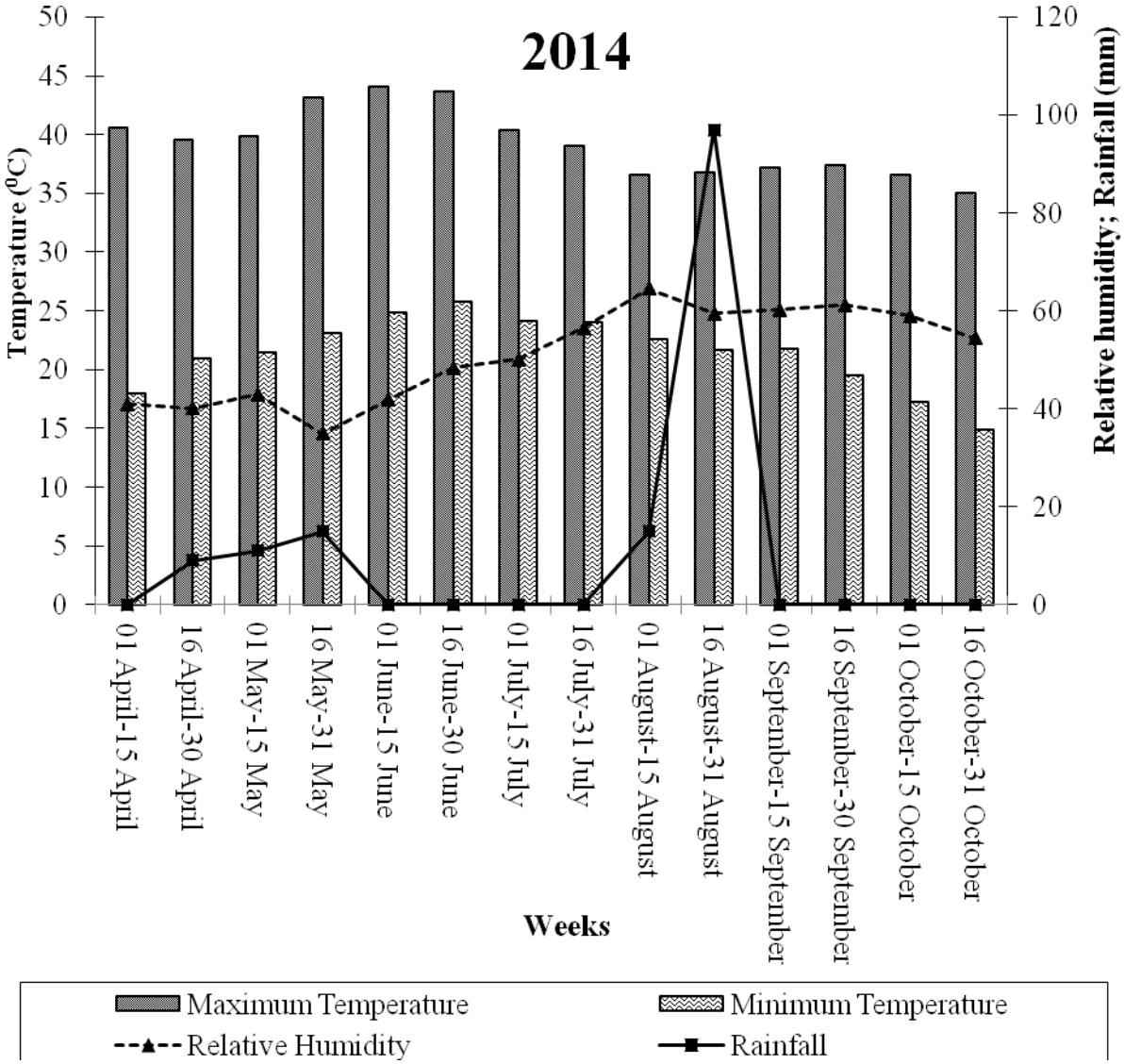

Fig. 1. Meteorological data recorded at Central Cotton Research Institute, Sakrand during 2014.

Table 1. Soil analysis of experimental site during 2014.

Soil analysis	**Value**
Mechanical Analysis	
Sand (%)	39
Silt (%)	23
Clay (%)	38
Textural classes	Clay loam to silt clay loam
Chemical Analysis	
Soil pH	8.4
EC (dS. m^{-1})	7.71
Organic matter (%)	0.35
Available N (g. kg^{-1})	0.15
Available P (mg. kg^{-1})	6.2
Available K (mg. kg^{-1})	160
Physical Analysis	
Bulk density (g. cm^{-3})	1.58
Porosity (cm. cm^{-3})	0.40
Volumetric water content (mm. cm^{-1})	0.7
Penetration resistance (0-30 cm) (kpa)	1763

RESULTS

This study was conducted to investigate the effects of different sowing dates in two varieties. Results showed significant differences among sowing dates and varieties for all traits except emergence- (Table 2 and 3). While the interaction amongst sowing dates x varieties depicted in Table 4 were non-significant.

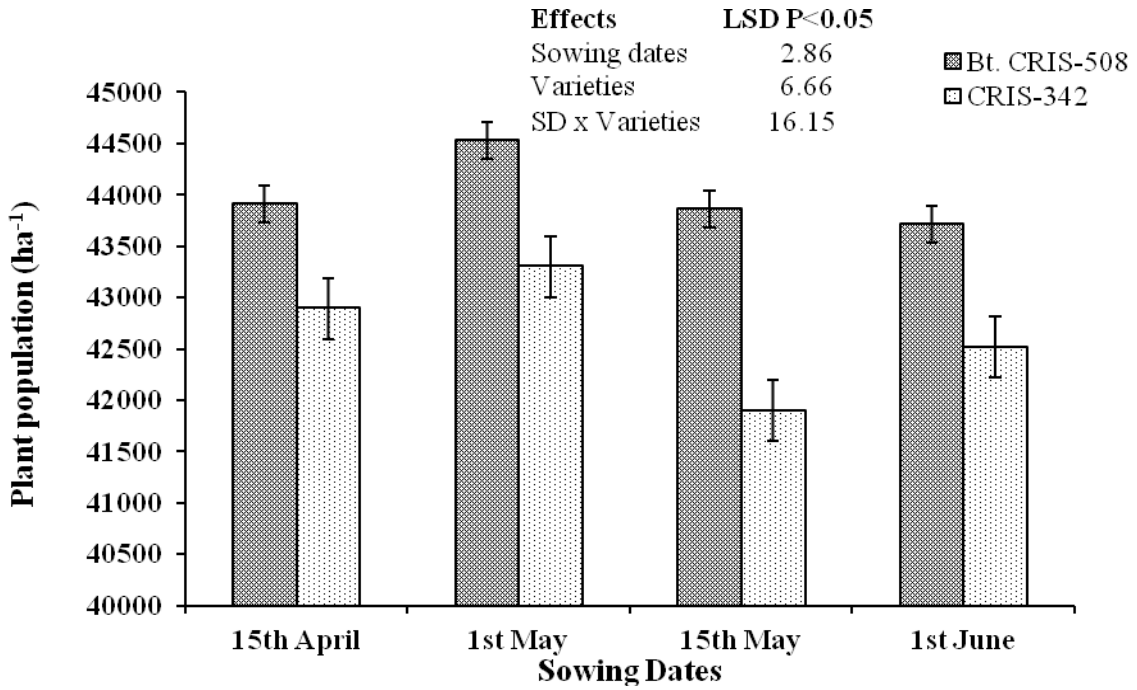

Fig. 2. Sowing dates and varieties effect on plant population size of cotton (ha^{-1}) in 2014.

Effect of sowing dates and cultivars on agronomic and quality traits

Sowing dates had significant effects on growth, yield and quality parameters except emergence (Table 2). In the 2014 growing season, 15th April had significantly higher plant height compared than other sowing dates while plant height of 15th May was at par with 1st May. The 15th April had 7 %, 8 % and 21 % higher plant height than 1st May,

15th May and 1st June respectively. During growing season, 15th April had significantly higher number of bolls per plant that was 18 %, 32 % and 36 % higher number of bolls per plant than in 1st May, 15th May and 1st June.

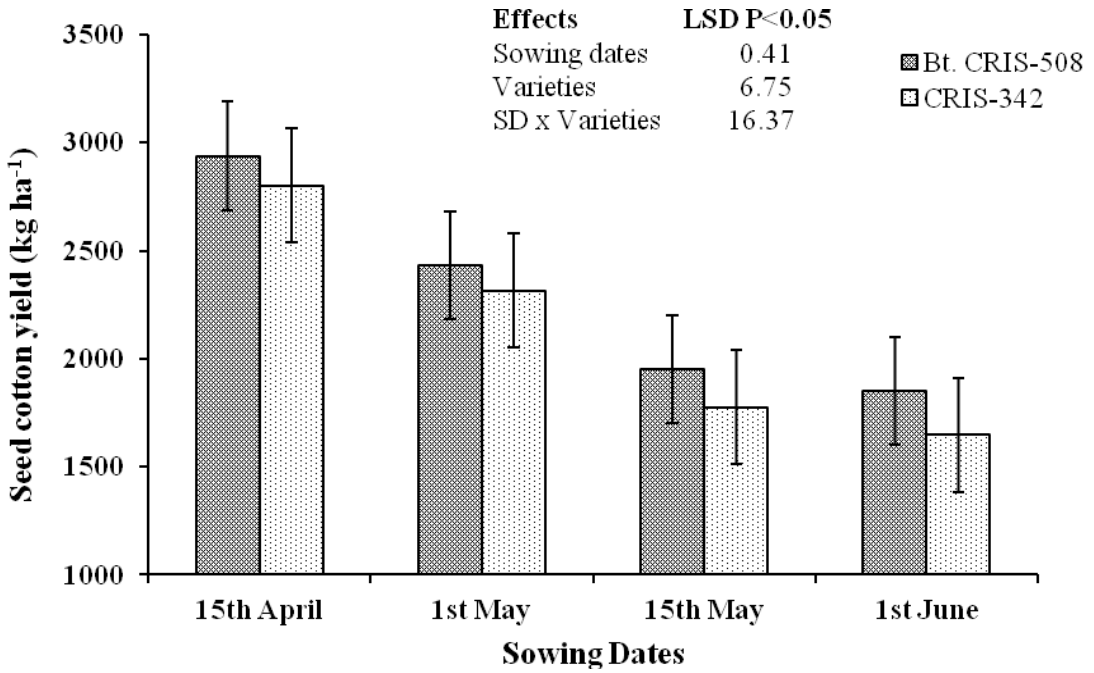

Fig. 3. Sowing dates and varieties effect on seed cotton yield (kg. ha^{-1}) in 2014.

Table 2. Effects of sowing dates on agronomic and quality characters of two cultivars of cotton.

Plant Traits	Sowing Dates				
	LSD (5 %)	15th April	1st May	15th May	1st June
Emergence (%)	0.09	83.3	83.4	83.3	83.3
Plant height (cm)	2.83	156.4 a	144.9 b	143.3 b	124.1 c
Number of bolls plant^{-1}	4.62	30.3 a	24.9 b	20.6 bc	19.5 c
Boll weight (g)	0.18	3.5 a	3.4 a	3.2 b	3.1 bc
Seed Index (g)	0.16	8.30 a	8.15 a	7.89 b	7.54 c
GOT (%)	0.16	38.95 a	38.65 b	38.36 c	38.13 d
Staple length (mm)	0.14	28.51 a	28.27 b	27.99 c	27.78 d
Micronaire (mic. value)	0.27	4.2 b	4.5 b	4.8 a	3.9 c
Oil content (%)	0.14	21.26 a	21.06 b	20.65 c	20.09 d

Mean values with similar letters in the respective category do not differ significantly by DMR test (P< 0.05).

Table 3. Varietal response on agronomic and quality characters of two cultivars of cotton.

Plant Traits	Cultivars		
	LSD (5 %)	Bt. CRIS-508	CRIS-342
Emergence (%)	0.18	83.4	83.2
Plant height (cm)	2.31	145.2 a	139.1 b
Number of bolls plant^{-1}	1.28	24.6 a	23.0 b
Boll weight (g)	0.13	3.4 a	3.2 b
Seed Index (g)	0.09	8.15 a	7.79 b
GOT (%)	0.09	38.64 a	38.41 b
Staple length (mm)	0.07	28.19 a	28.08 b
Micronaire (mic. value)	0.22	4.2 b	4.5 a
Oil content (%)	0.12	20.92 a	20.61 b

Mean values with similar letters in the respective category do not differ significantly by DMR test (P< 0.05).

Table 4. Interaction amongst sowing dates x cultivars for agronomic and quality characters of two cultivars of cotton.

Plant Traits	Sowing Dates								
	LSD (5 %)	15th April		1st May		15th May		1st June	
		Bt. CRIS-508	CRIS-342	Bt. CRIS-508	CRIS-342	Bt. CRIS-508	CRIS-342	Bt. CRIS-508	CRIS-342
Emergence (%)	0.19	83.2	83.4	83.5	83.2	83.4	83.1	83.4	83.2
Plant height (cm)	2.31	158.3	154.4	148.5	141.2	147.1	139.4	126.7	121.5
Number of bolls plant^{-1}	0.15	31.0	29.5	25.5	24.3	21.5	19.7	20.5	18.5
Boll weight (g)	0.09	3.6	3.3	3.5	3.2	3.3	3.1	3.2	3.0
Seed Index (g)	0.25	8.50	8.10	8.35	7.95	8.12	7.65	7.62	7.45
GOT (%)	0.21	39.10	38.80	38.75	38.55	38.45	38.27	38.26	38.00
Staple length (mm)	0.07	28.55	28.47	28.31	28.22	28.06	27.92	27.85	27.71
Micronaire (mic. value)	0.09	4.1	4.4	4.3	4.7	4.7	4.9	3.8	4.0
Oil content (%)	0.18	21.42	21.10	21.22	20.90	20.85	20.45	20.18	20.00

Mean values with similar letters in the respective category do not differ significantly by DMR test ($P < 0.05$)

Number of bolls per plant of 15th May was at par with 1st May. During the study, 15th April and 1st May had 9 % higher bolls weight than 15th May and 1st June. However, 1st May produced maximum plant population (Fig. 2) that was 1 % and 2 % higher than 15th April, 15th May and 1st June. Whereas seed cotton yield (Fig. 3) was significantly higher (2870 kg ha^{-1}) in 15th April that was 17 %, 35 % and 39 % higher seed cotton yield compared with 1st May, 15th May and 1st June 2014 growing season. Significantly maximum seed index was recorded in 15th April and 1st May which was 9 % higher than 1st June. Moreover, 15th April produced (38.95 %) GOT and staple length (28.51) that was 2 % and 3 % higher than 1st June. However, sowing dates of 15th April, 1st May and 1st June had 12 %, 6 % and 19 % lower Micronaire than 15th May while oil content of 15th April was 1 %, 3% and 6 % higher than 1st May, 15th May and 1st June respectively. The varieties had significant effect on growth, yield and quality parameters while non-significant for germination % (Table 3). During this study, cotton varieties showed significant response to sowing dates. Between the tested varieties, Bt. CRIS-508 had better performance than CRIS-342. The response of varieties may be due to genetic potentiality of the variety. Significantly maximum plant height of cotton was noted in Bt. CRIS-508 that was 4 % greater than the plant height of CRIS-342. Similarly, number of bolls per plant (24.6) and boll weight (3.4) was higher in Bt. CRIS-508 that was 7 % and 6 % higher than CRIS-342. During the study period, maximum plant population (Fig. 2) was recorded in Bt. CRIS-508 that was 3 % higher than CRIS-342. Moreover, Bt.CRIS-508 produced 7 % higher seed cotton yield (Fig. 3) than CRIS-342. Significantly, seed index of Bt. CRIS-508 was 4 % more than CRIS-342. Maximum GOT (38.64), staple length (28.19) were noted in Bt. CRIS-508 that was 1 %, 0.4 % and 2 % higher than CRIS-342 while in case of Micronaire Bt. CRIS-508 had significantly 7 % lower than CRIS-342. Interactions results of sowing dates and cultivars were also significant for plant population (ha^{-1}) and seed cotton yield (kg ha^{-1}) (Fig. 2 and 3). The sowing dates of 1st May with Bt. CRIS-508 (Fig. 2) manifested significantly higher plant population (44533 ha^{-1}) compared than other sowing dates with cultivars (Bt. CRIS-508 and CRIS-342). Moreover, significantly lower plant population was recorded at 15th May with cultivar CRIS-342. The interaction results revealed that the seed cotton yield was significantly higher (2939 kg ha^{-1}) at 15th April in cotton cultivar Bt.CRIS-508 followed by CRIS-342 with same sowing date with average seed cotton yield of 2801 compared than other sowing dates. Whereas, the interactions of sowing dates x cultivars were not significant for germination (%), plant height (cm), number of bolls plant^{-1}, boll weight (g), seed index (g), GOT (%), staple length (mm), Micronaire and oil content (%). However, the interactions of 15th April sowing x Bt. CRIS-508 resulted numerically better GOT (39.10), staple length (28.55) and oil content (21.42); followed by cotton cultivars CRIS-342 with same date of sowing.

DISSCUSSION

Different sowing dates and varieties had non-significant effect on germination during the study period. There was a substantial difference in maximum and minimum temperatures (Fig. 1) at the time of planting among different sowing dates, which effects on plant growth and development except germination. Our results were quite in line with the finding of Siddique *et al*. (2004) who reported that outer temperature variability had not a prominent role on plant germination. Significantly higher plant height at 15th April and in Bt. CRIS-508 was recorded (Table 2 and 3). Longer plant height was due to early planting in the month of 15th April which provides greater degree days. The primary factor affecting crop development is temperature. These results supported by Hodges *et al*. (1993); he found the higher plant height in early sowing. Maximum number of bolls per plant was noted in Bt. CRIS-508 at 15th April sowing (Table 2 and 3). Cotton has an indertminate growth habit, which provides more number of bolls per plant if it is remained longer time in the field/ planted earlier. These results substantiate findings of Mohammad *et al*., 2003 who reported the maximum number of bolls per plant in early sowing. Boll weight is an important yield attributes which directly affects the seed cotton yield. Results showed that delayed in sowing varieties gave lower boll weight. Our results are contradictory with the findings of Bednarz *et al*. (2006) who noted delayed in sowing produced higher boll weight. Plant population (Fig. 2) per unit area at the time of harvest is the crucial yield-determining factor in cotton. A review of the data described that higher plant population was recorded at 1st May in Bt. CRIS-508. The lower plant population in 15th April may be rainfall (Fig. 1) after the sowing of the crop and in the month of May which affects the plant population. Crop vegetative growth trend is indicated by seed cotton yield that is an index of photosynthetic efficiency. A perusal of fig. 3 revealed that significant effect of sowing dates, varieties and their interaction had significant effect on seed cotton yield. It is showed from the results that during the study year, each delay in sowing tended to reduce the seed cotton yield and Bt. CRIS-508 gave higher yield under other sowing dates. Our results supported the findings of Tenor *et al*. (2006) and Roche *et al*. (2003); they reported that decreased seed cotton yield with delayed sowing. The seed index is also a major yield-contributing component that it is affected by soil nutrients status, irrigation availability and the abrupt environmental changes. Results depicted in Table 2 and 3 showed that delayed in sowing gave lower seed index due to mean maximum and minimum temperature which resulted poor crop stand and effects on crop development. Our results are in line with the findings of Gurmeet *et al*. (2002) and Norton and Clark (2004); they had noted that the proper sowing time affects the growth and yield parameters in cotton. They also reported that late sowings were attributed with decreased yield attributes and seed cotton yield. A review of the data (Table-2 and 3) depicted that 15th April sowing with Bt. CRIS-508 gave significantly maximum GOT (%), staple length and oil content (%). However, a lower value of Micronaire was observed in Bt. CRIS-508 at 15th April sowing. The maximum GOT percentage showed positive contribution in case of fiber length and oil content whereas offered negative response on Micronaire value. Significantly, maximum GOT percentage was due to higher seed cotton yield and other yield attributes. These factors supported GOT percentage, which showed better response in fiber length and oil content. Our results supported the finding of Rasheed *et al*. (2009); Ahuja *et al*. (2006) and Hussain *et al*. (2000) they all reported that seed cotton yield had positive direct effects on ginning out turn percentage, which gave indirect positive effects on staple length and oil content and negative effects on micronaire value. Micronaire value showed negative effects on GOT percentage and seed cotton yield. Our results supported the finding of Rasheed *et al*. (2009); they reported that that fiber fineness directly affected by seed cotton yield.

CONCLUSION

Cotton crop is an important profitable and basic textile fiber crop, which plays a vital role in the economy of Pakistan. In Pakistan, it is the cash crop and makes a good fortune to the country in the form of foreign exchange. It can be concluded from this study that for getting determined seed cotton yield among different sowing dates and varieties, the crop should be sown on 15th April with Bt. CRIS-508 under agro-ecological conditions of Central Zone of Sindh. This result shows that early sowing and day/night mean minimum and maximum temperature during growth and development are supportive to the cotton crop at all growth phases by above combination, that is why, crop gives significant seed cotton yield as compared to other combination of sowing dates and varieties.

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