Research Article

Impact of Sowing Time on Yield and Fibre of Bt. Cotton Varieties in Arid Environment of Dera Ismail Khan

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Abstract | Cotton is life line of the economy of Pakistan. Environment had significantly effected its production and fibre. Field research was conducted in 2016 and 2017 at Cotton Research Station, Dera Ismail Khan, Pakistan to assess the impacts of six sowing dates on yield and fibre characteristics of two cotton varieties. The experiments were laid out in RCBD with split-plot replicated thrice. Sowing dates i.e. March 15, April 01, April 15, May 01, May 15, and June 01 were kept in main and cotton varieties (CIM-602, CIM-616) in sub-plots. Results showed that April 15 sowing produced highest bolls per plant, boll weight-g, seed cotton yield, staple length, strength and micronaire amongst the other sowing dates. Results further showed that CIM-602 ranked first in number of bolls/plant, weight per boll, seed cotton yield, staple length, strength and micrronaire in April 15 sowing. Former and later on cotton sowing than April 15 resulted in decreased cotton yield and fibre due to shorter growth phase and unsuitable environment, respectively. Thus it is concluded that the genotype, CIM-602 sown on April 15 suits well to the study area and had the potential to optimize cotton yield and quality in irrigated condition of Dera Ismail Khan, Pakistan.

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Introduction

Cotton (*Gossypium hirsutum* L.) plays a significant role in the country's economy because of its high quality fiber. Pakistan is the fourth largest producer of cotton, the second largest exporter of raw cotton and the third largest consumer of cotton in the world (APTMA, 2016-17). It is grown on an area of 2.63 million hectares in Pakistan with an overall seed cotton production of 10.98 million bales. Cotton accounts for 6.9 percent of the value added in agriculture, 40% in employment, 60% in foreign exchange earning, 64% source of edible oil and about 1.4 percent to GDP (GoP, 2017) Additionally cotton provides raw materials to the local industries comprising of 396 textile mills, 960 ginning factories, 9.7 million spindles and over 2622 oil expelling units (PCCC, 2016).

Cotton crop is very sensitive to environmental conditions and grown in a wide range of ecological zones. A number of factors such as nature of cultivars, plant density, sowing time, nutrients and water management practices are involved in getting a profitable yield (Ali et al., 2005; Arshad et al., 2007; Zia-ul-Hassan et al., 2014). Optimum sowing date plays key role in yield potential; similarly, suitable genotype for a region is essential for optimum growth and development. Genotype selection and sowing date management are important factors that can have a large impact on yield and quality attributes of a cotton crop (Deho et al., 2012). These two factors mostly limit cotton growth, yield and quality as growth is a function of the product of genotype and environment (Sarwar et al., 2012; Zeng et al., 2014). Optimum sowing time for different genotypes varies with regions depending on environmental conditions of the area. Cotton genotype is mainly selected for higher yield plus fiber quality, greater tolerance to adverse conditions and earlier maturity.

Potential genotypes for higher yield and quality traits could be assessed by sowing them at different times i.e. early, late, and normal time. Both late and early sowing adversely affect cotton yield and quality. Research results revealed that early sown cotton contributes more towards vegetative growth rather than to yield (Iqbal et al., 2012). Moreover, early sown cotton reaches reproductive phase in the hottest month of the year that causes serious yield.

loss (Rahman et al., 2007). Contrary to this, late planting causes flowering and maturity when temperature is much cold. Consequently, cotton yield and quality is affected due to unfavorable environmental conditions and shorter growth period (Elayan et al., 2015). Karavina et al. (2012) reported that change in sowing date not only may effect cotton yield and quality but it also affects insect pest management. Therefore, sowing date management has become more important in recent farming. Optimum sowing date provides sufficient time to crop to complete its vegetative and reproductive cycles in a timely and efficient way. This also allows the grower to harvest crop in time and save from risk of late season insect pest attack particularly from those insects which attack on reproductive structures causing about 80% damage to cotton (Pedigo, 2004). The strategy of planting a crop at suitable time thwarts danger of early and late planting either due to adverse weather conditions or insect pests attack; both may result in increasing rates of fruit loss and abortion (Bange et al., 2008).

The strategy of planting a crop at suitable time thwarts danger of early and late planting either due to adverse weather conditions or insect pests attack; both may result in increasing rates of fruit loss and abortion (Bange et al., 2008). Some genotypes have the potential to resist insect pest and perform better in a specific environmental conditions such as temperature, rainfall, humidity, and day length. Therefore, it needs constant efforts to match genotype with suitable time of sowing in an environment in which all the components of climate are in the best favor of crop growth and development. Moreover, cotton genotypes are highly responsive to their surrounding environments and differ in their yield potential and many fiber properties. Thus, the present research was planned to determine the best sowing time for specific cultivars in arid environment of Dera Ismail Khan, Pakistan.

Materials and Methods

Study site

Field study was conducted during 2016 and 2017 at Cotton Research Station, Dera Ismail Khan (31°49´N, 70°55´E, 166 m a.s.l.), Pakistan, in silty clay loam soil. The region is an arid to semi arid having limited rain fall (≥ 200 mm), which is not enough for cotton crop. The soil of the experimental site is hyperthermic and Typic Torrifluvents (Soil Survey Staff, 2009). It is moderately saline; less fertile than the typical cotton belt in Punjab, Pakistan, having relatively high silt and clay content; and needs irrigation for crop production. The detail physico-chemical properties are given in Table 2. Weather data was monitored on Meteorological Station located near the study site. Detail about seasonal temperature and rainfall are presented in Table 1.

Experimental treatments and design

The experiment was designed with split-plot arrangement in a randomized complete block with three replications. The main plots comprised of six sowing dates namely March 15, April 01, April 15, May 01, May15, June 01 while subplots included two genotypes namely, CIM-602, CIM-616. Each subplot consisted of four rows of 10 m length and 0.75 m intra row width. Genotypes selected for this study were all transgenic improved cotton genotypes. All plots were managed uniformly regarding land preparation, sowing method, irrigation, pest control and fertilization. The land was prepared with disk plough (once) followed by tiller (twice) and rotavator (once) to break the clods and uprooting/destroying the roots and crop leftovers. The field was then leveled and divided into 24 sub plots.

Table 1: *Monthly seasonal precipitation, temperature and relative humidity (%) at Cotton Research Station, Dera Ismail Khan during 2016and 2017 growing seasons.*

Month	2016								2017							
	Temp (°C)			Relative humidity (%)					Temp (°C)			Relative humidity (%)				
				800hrs		1400 hrs		Rainfall (mm)				800hrs		1400 hrs		Rainfall (mm)
	Max	Min	Mean	Max	Min	Max	Min		Max	Min	Mean	Max	Min	Max	Min	
April	41	13	27	92	52	77	23	38	38	6	22	75	36	56	29	-
May	42	19	31	75	39	63	20	12	45	7	26	57	30	36	23	17
June	44	21	33	81	46	58	27	16.5	45	12	29	65	34	50	26	6.0
July	42	24	33	81	48	68	36	34	45	18	32	73	30	42	23	111
August	40	23	32					35	41	20	31	73	42	49	26	43
September	39	20	30	82	65	71	28	-	40	18	29	73	42	41	22	40.0
October	34	19	27					4	36	18	27	72	52	52	25	-
November	30	6	18	90	59	91	65	-	31	10	21	81	69	78	53	-
Total rainfall								139.5								217.0

Source: *Arid Zone Research Council (AZRC), D.I.Khan, Pakistan.*

Cotton seeds were treated with sulfuric acid (1kg H2SO4/10 kg cotton seed). Delinted cotton seeds were dibbled manually in rows as per scheduled sowing dates. Cotton seeds were sown in well prepared dry field followed by irrigation. The experimental plots were irrigated at 15 days interval till the crop maturity. Since there was sufficient rain in September 2016 and June 2017, scheduled irrigations were not given in the respective months. In this way experimental plots sown on March 15, April 01, April 15, May 01, May 15, and June 01 received total of 14, 13, 12, 11, 10, and 9 irrigations, respectively. Water was given at a depth of 10 cm during each irrigation. Moreover, last irrigation was given in the month of November. Pre-sowing herbicide, Pendimethaline [N-(1-ethylpropyl)-3,4-dimethyl- 2,6-dinitrobenzenamine], was sprayed at the rate of 1.2 kg ha-1 to control weeds. Post emergence herbicide, Haloxyfopp- ethyl (Percept 10.8% EC @ 350 ml/acre) was also sprayed to control grassy weeds in their early growth stages. The insecticide, Novastar 56 EC (bifenthrin+abamectin) was sprayed at the rate of 500 ml per acre two times on cotton crop with the help of a knapsack hand - sprayer at 15 days intervals starting from the time when the population of sucking insects such as whitefly, jassid and thrips, and mites reached the economic threshold level. Thinning was done within 25 days after sowing in the respective plots. The fertilizers phosphorus and nitrogen were applied in the form of triple super phosphate and urea at the rate of 90 and 150 kg ha^{-1}, respectively. Phosphorus was applied all at sowing while nitrogen was applied half at sowing and half in two equal splits with subsequent irrigations. Two pickings were performed one after 150 days and the other 190 days after each sowing.

Table 2: *Physico-chemical properties of the experimental soil.*

Characteristics	Values
Sand	151 g kg^{-1}
Silt	450 g kg^{-1}
Clay	400 g kg^{-1}
Electrical conductivity (EC)	2.66 dSm^{-1}
Soil pH (1:1)	7.80
Organic Matter	0.89 %
NO_3-N	5.52 mg kg^{-1}
Available K (mg kg^{-1})	180 mg kg^{-1} soil
AB-DTPA extractable P	7.8 mg kg^{-1} soil
Total N	0.99 g kg^{-1} soil

Procedure for data recording

Data were recorded on bolls $plant^{-1}$, boll weight (g), seed cotton yield (kg ha^{-1}), fiber length (mm), fiber strength (g tex^{-1}) and micronaire. Five representative plants were tagged in each treatment for the purpose of recording data. Bolls $plant^{-1}$ were recorded by counting bolls from randomly selected five plants in each treatment at maturity and converted to average number of bolls $plant^{-1}$. For recording boll weight, 50 bolls were randomly selected from already tagged plants in each plot. Total bolls weight was divided by 50 and mean boll weight was recorded in gram. Seed cotton yield was recorded by harvesting central 2 rows of each plot manually. Seed cotton samples were sundried and cleaned by removing inert matter from the samples. After drying and cleaning they were weighed and ginned separately by using electric ginning machine. For fiber length, representative samples of cotton lint were taken from each plot and mean length was obtained by using high volume instrument (HVI) system in laboratory. Similarly, micronaire (which indicates fiber fineness), fiber strength, and fiber uniformity all were determined in laboratory through HVI system in Central Cotton Research Institute, Multan, Pakistan.

Statistical analysis

Data were subjected to analysis of variance (ANOVA) using a split-plot within a randomized complete block design accordance to procedures outlined by Steel and Torrie (1980). Least significant difference tests were applied where data were found statistically significant according to MSTATC software.

Results and Discussion

Bolls count plant^{-1}

Bolls plant-1 results were significant for sowing dates, genotypes and their interactions (Table 3). Mean values for sowing dates revealed that April 15 sowing produced maximum bolls while June 01 sowing produced minimum bolls during 2016 and 2017 growing seasons (Table 4). The results further revealed that the response of genotypes was modified by sowing dates during both the growing seasons. The results indicate that CIM-602 sown on April 15 produced more bolls than CIM-616. In contrast to this too early (March 15) or too late sowing (June 01) resulted in lower number of bolls for all genotypes. In early sowing, flowering coincided with high temperature stress (June to early August) that probably resulted in abortion of flowers and young bolls and thus there were lower boll retention per plant as reported by some researchers (Reddy, 1992; Hodges et al., 1993). They examined temperature effects on cotton reproductive development by growing cotton under natural sunlight condition in temperature regulated growth chambers. Their work revealed that fruit retention declined quickly when the mean temperature in the chamber climbed above 28°C and fruit retention was almost zero when temperature exceeded 33°C. In our study, growth conditions including temperature in April sowing were much better than all other sowing dates that probably provided more favorable environment which resulted in maximum bolls (Ali et al., 2009).

Boll weight (g)

Boll weight had significant to sowing dates, varieties and their interactions (Table 3). Sowing on April 15 was optimum among all other sowing dates by producing highest boll weight (Table 5). May 01 and May 15 were the next suitable sowing date which produced higher boll weight than the rest of the sowing dates. Contrary to this earlier sown cotton had lower boll weight probably due to more attacks of insect pests. Generally, if a variety is sown before optimum time, its germination and growth both can be affected adversely. Moreover, earlier sown crop is more prone to insect pests and diseases attack. Among genotypes, CIM-602 produced highest boll weight. Interaction effects revealed that April 15 sowing produced heavier bolls compared to all other sowing dates irrespective of the genotypes. Our results revealed that boll weight declined when sowing was delayed beyond April 15. Cold night temperature may be the probable reason for poorly developed boll from late sowing date. Boll development in May to June sowing was coincided with cold night temperature that might have adversely affected boll growth and development. Yeates et al. (2013) reported that night temperature colder than 12oC might be detrimental for boll retention and growth. On the other hand, flowerings in too early sowing coincided with high temperature that also adversely affected boll growth and development (Yeates et al., 2010a). High summer temperature is a typical characteristic of the study area. That is why sterility and boll retention are common problems in cotton. Reddy et al. (1990) reported that three weeks' exposure of cotton plants to 40°C for 2 or 12 hour per day resulted in 0% bolls.

Seed cotton yield kg ha^{-1}

Seed Cotton Yields had significant response to sowing dates, genotypes, and sowing dates × genotypes interactions (Table 3). Highest seed cotton yield was obtained from April 15 sowing while late sowing (June 01) resulted in lowest seed cotton yield (Table 6). Means for genotypes revealed that CIM-602 produced highest seed cotton yield as against CIM-616 which produced lowest seed cotton yield. Interaction effects revealed that April 15 sowing optimized seed cotton yield. After April 15, May 01 was the next suitable sowing date gave greater seed cotton yield. The yield was low in early sown cotton, probably the reproductive stage of the crop came in the warmest month of the year that resulted in more vegetative growth and lower seed cotton yield (Sarwar et al.,2012).

Table 3: *Analysis of variance (mean squares) of bolls plant^{-1}, boll weight (g), seed cotton yield (kg ha^{-1}), fiber length (mm), fiber strength (g tex^{-1}) and micronaire as influenced by sowing date and varieties during 2016 and 2017 growing seasons.*

Source	Bolls plant^{-1}	Boll weight	Seed cotton yield	Fibre length	Fibre strength	Micronaire
	2016					
Replication	6.58	0.06	1332	0.05	0.50	0.02
Sowing dates	152.61**	1.13**	558624**	5.42**	1.88**	0.39**
Error a	3.89	0.01	1532	0.26	0.33	0.01
Varieties	1.00ns	1.72**	107584**	14.91**	8.98**	0.07ns
D × V	69.85**	0.51**	16087**	0.55*	0.22ns	0.04ns
Error b	1.89	0.07	354	0.12	0.24	0.02
	2017					
Replication	26.76	0.09	1445	0.14	0.34	0.09
Sowing dates	55.56ns	0.83**	450310**	6.52**	2.80*	0.22ns
Error a	18.72	0.04	1869	0.24	0.48	0.14
Varieties	20.10*	0.01ns	55539**	23.35**	0.48ns	6.55**
D × V	18.37**	0.03*	2032ns	0.72*	0.31ns	0.13ns
Error b	3.93	0.01	3138	0.18	0.38	0.11

**, **, Significant at 5% and 1% level of probability, respectively. ns, No-significant difference at 5%.*

Table 4: *Effect of sowing time on number of bolls per plant of Cotton varieties during 2016 and 2017.*

Year	Genotypes (G)	Sowing dates (SD)						Genotypes means
		March 15	April 01	April 15	May 01	May 15	June 01	
Y1 (2016)	CIM-602	44.6 a	28.5 ef	26.3 fg	24.7 g	32.1 cd	33.2 c	31.6
	CIM-616	34.7 c	39.1 b	28.2 ef	26.2 fg	28.9 ef	30.3 de	31.2
	Means	39.6 a	33.8 b	27.3 d	25.4 d	30.5 c	31.8 bc	
	$LSD_{0.05}$ for SD = 2.5381, SD × G = 2.4457							
Y2 (2017)	CIM-602	33.6 a	34.8 a	32.4abc	31.1abc	27.0bcd	30.5abc	31.6 a
	CIM-616	31.9abc	31.4abc	33.1 ab	34.0 a	26.7 cd	23.3 d	30.1 b
	Means	32.7	33.1	32.8	32.6	26.9	26.9	
	$LSD_{0.05}$ for G=1.4393, SD × G = 3.5256							

Note: *Means shared similar letters don't differ significantly at 5% level of probability. NS = Non-significant.*

Table 5: *Effect of sowing time on number of boll weight of Cotton varieties during 2016 and 2017.*

Year	Genotypes (G)	Sowing dates (SD)						Genotypes means
		March 15	April 01	April 15	May 01	May 15	June 01	
Y1 (2016)	CIM-602	2.45 bcd	2.63 bc	3.36 a	2.36 cd	2.56 bc	2.14 de	2.58 a
	CIM-616	2.85 b	2.56 bc	2.31 cd	2.18 de	1.84 e	1.12 f	2.15 b
	Means	2.65 b	2.59 b	2.84 a	2.27 c	2.20 c	1.63 d	
	$LSD_{0.05}$ for SD =0.1523, G =0.1863, SD × G = 0.4564							
Y2 (2017)	CIM-602	2.82	2.92	3.53	2.77	2.65	2.38	2.85
	CIM-616	2.82	2.77	3.43	2.70	2.87	2.28	2.81
	Means	2.82 b	2.84 b	3.48 a	2.74 b	2.76 b	2.33 c	
	$LSD_{0.05}$ for SD =0.2534							

The results indicate that there were significant variations among cultivars for seed cotton yield as also reported by Baloch (1997) and Ehsan et al. (2008). Regarding sowing dates, El-Akkad (1980) reported that April sowing produced more flowers more quickly than earlier and later sowing dates.

Table 6: *Effect of sowing time on number of seed cotton yield of Cotton varieties during 2016 and 2017.*

Year	Genotypes (G)	Sowing dates (SD)						Genotypes means
		March 15	April 01	April 15	May 01	May 15	June 01	
Y1 (2016)	CIM-602	1571 g	1830 d	2339 a	1944 c	1751 e	1335 h	1795.0 a
	CIM-616	1540 g	1801 de	2029 b	1852 d	1647 f	1246 i	1685.7 b
	Means	1556 e	1816 c	2184 a	1898 b	1699 d	1290 f	
	$LSD_{0.05}$ for SD =50.346, G =13.656, SD × G = 33.449							
Y2 (2017)	CIM-602	1708	1827	2243	2044	1752	1441	1835.8 a
	CIM-616	1663	1806	2140	1929	1660	1347	1757.3 b
	Means	1686 d	1817 c	2192 a	1986 b	1706 d	1394 e	
	$LSD_{0.05}$ for SD =55.617, G =40.683							

Table 7: *Effect of sowing time on number of fibre length of Cotton varieties during 2016 and 2017.*

Year	Genotypes (G)	Sowing dates (SD)						Genotypes means
Y1 (2016)	CIM-602	27.13 efg	28.48 bc	29.87 a	28.88 b	27.68 de	27.47 def	28.25 a
	CIM-616	25.34 h	26.83 fg	27.95 cd	27.82 cde	27.35 def	26.50 g	26.97 b
	Means	26.24 d	27.66 b	28.90 a	28.35 a	27.52 bc	26.98 c	
	$LSD_{0.05}$ for SD =0.6603, G = 0.2529, SD × G = 0.6195							
Y2 (2017)	CIM-602	28.58 de	29.93 bc	31.32 a	30.33 b	29.12 cde	28.92 de	29.70 a
	CIM-616	26.23 g	27.62 f	29.35 cd	29.21 cde	28.42 ef	27.71 f	28.09 b
	Means	27.41 c	28.78 b	30.34 a	29.77 a	28.77 b	28.31 b	
	$LSD_{0.05}$ for SD =0.6343, G = 0.3071, SD × G = 0.7523							

The more flowers thus resulted in higher seed cotton yield. Khan et al. (1980) and Khan et al. (1981) reported that April sowing gave higher seed cotton yield than sowing at later dates. Similarly, Arain et al. (2001) communicated analogous results who reported that planting on April 15 to May 1st produced maximum seed cotton yield. One possible reason for exhibiting higher seed cotton yield in April 15 sowing may be more favorable environment for production of growth hormones than all other sowing dates as reported by Rauf and Sadaqat (2007). April 15 sowing had also more number of bolls plant^{-1} and heavier boll weight compared to other sowing dates that probably resulted in more seed cotton yield (Azhar et al., 1999; Rauf et al., 2004). Our results indicate that planting earlier or later than April 15 produced lower seed cotton yield. Late sowing caused late flowering in cotton thus boll development occurred at lower temperatures. That is why sowing too early or too late resulted in lower number of bolls and boll weight that finally contributed to lower seed cotton yield. Analogous investigations were given by Elayan et al. (2015) who observed that late sowing resulted in lower seed cotton yield due to lower number of open bolls plant^{-1} and boll weight.

Fibre length (mm)

Fibre length showed significant responses to sowing dates, genotypes and sowing dates × genotypes interactions (Table 3). CIM-602 had higher fiber length during both the growing seasons (Table 7). Sowing dates results revealed that April 15 sowing produced optimum fiber length compared to all other sowing dates. Fiber length response to genotypes was modified by sowing dates. Optimum fiber length could be achieved from CIM-602 sown on April 15. All other combinations of sowing dates and genotypes had lower fiber length. El-Debeby et al., 1995 said that April sowing produced highest fiber length. Ewida et al. (1985) and Yaseen (1986) also reported analogous results. The results suggest that early and late sowing both affect fiber length adversely. In case of early and late sowing, picking will commence early and late in the season, respectively. Early or late picking of cotton should be avoided because early picking gives small fiber length with shrinking quality, which results in substandard fabrics and immature fiber obtained from bolls that darken immediately (Ahmad and Razi, 2011).

Fiber strength (g tex^{-1})

Fiber strength was significantly affected by sowing dates, genotypes, and sowing dates × genotypes

Table 8: *Effect of sowing time on number of fibre strength of Cotton varieties during 2016 and 2017.*

Year	Genotypes (G)	Sowing dates (SD)						Genotypes means
		March 15	April 01	April 15	May 01	May 15	June 01	
Y1 (2016)	CIM-602	27.20	27.30	28.52	27.93	27.70	27.01	27.61 a
	CIM-616	26.73	26.67	27.47	26.83	26.40	25.57	26.61 b
	Means	26.97 bc	26.98 bc	27.99 a	27.38 ab	27.05 b	26.29 c	
	$LSD_{0.05}$ for SD =0.7366, G= 0.3529							
Y2 (2017)	CIM-602	27.47	27.90	28.60	28.18	27.65	27.37	27.86 a
	CIM-616	26.58	26.07	26.93	26.77	26.68	25.57	26.43 b
	Means	27.03	26.99	27.77	27.48	27.17	26.48	
	$LSD_{0.05}$ for G = 0.5476							

Table 9: *Effect of sowing time on number of micronaire of cotton varieties during 2016 and 2017.*

Year	Genotypes (G)	Sowing dates (SD)						Genotypes means
		March 15	April 01	April 15	May 01	May 15	June 01	
Y1 (2016)	CIM-602	4.40	3.83	4.02	4.03	4.07	3.82	4.61
	CIM-616	4.98	4.43	4.77	4.60	4.77	4.08	4.03
	Means	4.69 a	4.13 c	4.39 b	4.32 b	4.42 b	3.95 d	
	$LSD_{0.05}$ for SD = 0.137, G= 0.3117							
Y2 (2017)	CIM-602	3.73	3.55	3.57	3.53	3.23	3.45	3.51 a
	CIM-616	4.53	4.40	4.73	4.27	4.42	3.83	4.36 b
	Means	4.13	3.98	4.15	3.90	3.83	3.64	
	$LSD_{0.05}$ for G = 0.2384							

interactions (Table 3). Mean values for sowing dates revealed that April 15 sowing gave higher fiber strength (Table 8). Among genotypes, CIM-602 produced higher fiber strength. Interaction effects of genotypes and sowing dates revealed that April 15 sowing in combination with CIM-602 produced highest fiber strength. Our findings are line with Arshad et al. (2001) and Baloch et al. (2001) who investigated that reduced fibre strength was obtained from late planting. Moreover, late planting contributed to late harvesting which exposed fibre to various environmental conditions, resulted in lower fiber strength, nep formation, and poor dye uptake (Bradow and Bauer, 1997; Duckett et al., 1999).

Micronaire

Micronaire indicates an indirect measure of cotton fiber gravimetric fineness (mass per unit length), and was significantly influenced by sowing dates and genotypes (Table 3). Sowing dates effects revealed that March 01 resulted in higher maicronaire value indicating lower fineness of the fiber while April 15 sowing produced lower micronaire value indicating more fineness of the fiber (Table 9). Among genotypes, CIM-602 had lower micronaire value compared to all other genotypes. Interaction effects revealed that CIM-602 sown on April 15 had the lower micronare value indicating more fineness of the fibers compared to all other combinations having higher micronaire values (low fineness of the fiber). Deho et al. (2012) reported that micronaire value was lower (more fine fiber) in April sowing compared to May sowing having higher micronaire value. McAlister and Rogers (2005) reported three types of micronaire values for marketing purposes, a premium (micronaire value of 3.7 to 4.2) with regard to price, normal (3.5, 3.6 and 4.3 through 4.9), and price discount range (3.4 and below and 5.0 and above are considered to have lesser value). Micronaire values in this study for April 15 × CIM-602 interactions were in the premium range.

Conclusions and Reommendations

This study comprised of six sowing dates (March 15, April 01, April 15, May 01, May 15 and June 01) and two Cotton varieties (CIM-602, CIM-616). It was observed that yield and quality traits were different for different genotypes. However, CIM-602 performed better regarding cotton yield and quality traits when sown on April 15. Late planting delayed crop maturity and caused flowering and boll formation at cold temperature stress that resulted in lower cotton yield. Similarly, early planting could not produce more seed cotton yield for the reproductive stage of the crop came in the warmest month of the year that resulted in more vegetative growth rather than seed cotton yield. April 15 sowing was the optimum sowing date at which all other genotypes also performed better regarding lint yield and quality. Therefore, it is generally recommended to grow cotton on April 15 irrespective of the genotypes, however, genotype, CIM-602 had a comparatively higher potential to optimize cotton yield and quality in D.I. Khan region of Khyber Pakhtunkhwa, Pakistan. Sowing genotype at an appropriate time can improve its yield potential. This work provides a foundation for more in-depth research on testing April 15 as optimum sowing date for cotton varieties. CIM-602 and April 15 sowing need to be tested on some other locations for broader recommendations.

Author's Contribution

Najeeb Ullah was the principal author who conducted this research. Niamatullah Khan measured observation and prepared draft. Abdul Aziz Khakwani supervised the study and provided technical input at every step. Muhammad Safdar Baloch analysed the lab work. Ejaz Ahmad Khan assisted in preparation of final draft. Farkhanda Khan helped in preparation of methodology, data collection and Zakir Ullah helped in financial support.

References

Ahmad, M. and M.F. Razi. 2011. Cotton sowing in doldrums. http://www.pakistan.com

Ali, H., D. Muhammad, M.N. Aftzal and S.A. Abid. 2005. Seed cotton yield of different cultivars as affected by sowing time under agro-climatic conditions of southern Punjab. Indus Cotton. 2(3): 186-189.

Ali, H., M.N. Afzal and D. Muhammad. 2009. Effect of sowing dates and plant spacing on growth and dry matter partitioning in cotton (Gossypium hirsutum L.). Pak. J. Bot. 41(5): 2145-2155.

APTMA. 2016. All Pakistan Textile Mills Association. Ministry of Textile Industry. Islamabad, Pakistan.

Arain, M.H., M.J. Baloach, C.K. Kalwar and A. A Memon. 2001. Performance of newly developed cotton strains under different sowing dates. Pak. J. Bio. Sci. 1(3-4): 1-2.

Arshad, M., A. Wajid, M. Maqsood, K. Hussain, M. Aslam and M. Ibrahim. 2007. Response of growth, yield and quality of different cotton cultivars to sowing dates. Pak. J. Agric. Sci. 44(2): 208-212.

Arshad, M., N. Illahi, M. Afzal, R. Ali and M. Hanif. 2001. Effect of planting dates on fiber characters of three upland cotton varieties. Pak. J. Biol. Sci. 4(4): 313-315.

Azhar, F.M., A.I. Khan and I. Mahmood. 1999. Path coefficient analysis of some advanced generation progenies of Gossypium hirsutum L. Int. J. Agric. Biol. 1(3): 85-87.

Baloch, E. 1997. Environmental adaptation analysis of several upland cotton varieties. Pak. J. Sci. Ind. Res. 41: 91-94.

Baloch, M., S.H. Ghaloo and A.A. Rajper. 2001. Are cotton fiber characters under influence of planting dates? Life Sci. Int. J. 1(1): 1-5.

Bange, M., E. Brown, J. Caton and R. Roche. 2004. Sowing time, variety and temperature effects on crop growth and development in the Hillston region. 11th Australian cotton conference proceedings. Gold Cost Conv. Exhibition centre, Broadbeach Queensland.

Bange, M.P., S.J. Caton and S.P. Milroy. 2008. Managing yields of high fruit retention in transgenic cotton (Gossypium hirsutum L.) using sowing date. Aust. J. Agric. Res. 59: 733-741. https://doi.org/10.1071/AR07423

Batool, S., N.U. Khan, K. Makhdoom, Z. Bibi, G. Hassan, K.B. Marwat, Farhatullah, F. Mohammad, Raziuddin and I.A.Khan. 2010. Heritability and genetic potential of upland cotton genotypes for morpho-yield traits. Pak. J. Bot. 42(2): 1057-1064.

Bauer, P.J., J.R. Frederich, J.M. Bradow, E.J. Sadler and D.E. Evans. 2000. Canopy photosynthesis and fiber properties of normal and late planted cotton. Agron. J. 92: 518-523. https://doi.org/10.2134/agronj2000.923518x

Bednarz, C.W., W.D. Shurley, W.S. Anthony and R.L. Nichols. 2005. Yield, quality, and profitability of cotton produced at varying plant densities. Agron. J. 97: 235-240.

Bolonhezi, A.C., M.M. Justi, R.C. Oliveira and C. Bolonhezi. 2000. Narrow spacing for varieties of herbaceous cotton (Gossypium hirsutum L.), plant development and retention of reproductive structures. Field Crop Res. 53(5): 611-613.

Bradow, J.M. and P.J. Bauer. 1997. How variety and weather determine yarn properties and dye uptake. p. 560-565. In: Proc. Beltwide Cotton Conf., New Orleans, LA. 6-10 Jan. 1997. Natl. Cotton Counc. Am. Memphis, TN.

Bremner, J.M. and C.S. Mulvaney. 1982. Nitrogen-total. In: methods of soil analysis. (Eds.): A.L. Page, R.H. Miller, D.R. Keeney. Part II. Chemical and microbiological properties. 2nd ed. Am. Soc. Agron. Madison, WI, USA. pp. 595-682.

Campbell, B.T. and M.A. Jones. 2005. Assessment of genotype × environment interactions for yield and fiber quality in cotton performance trials. Euphytica. 144: 69-78. https://doi.org/10.1007/s10681-005-4336-7

Deho, Z.A., S. Laghari, S. Abro, S.D. Khanzada and Fakhuruddin. 2012. Effect of sowing dates and picking intervals at boll opening percent, yield and fiber quality of cotton cultivars. Sci. Tech. Dev. 31(3): 288-293.

Duckett, K.E., L. Cheng, T. Sapaletalova, M. Watson and H. Ghorashi. 1999. Color grading of cotton measurement (Part I). p. 645-650. Proc. Beltwide Cotton Conf. Orlando.

FL. 3-7 Jan. 1999. Natl. Cotton Counc. Am., Memphis, TN. Ehsan, F., A. Ali, M.A. Nadeem, M. Tahir and A. Majeed. 2008. Comparative yield performance of new cultivars of cotton (Gossypium hirsutum L.). Pak. J. Life Soc. Sci. 6: 1-3.

Ehsan, K., Naseer, M. Iqbal, M.Z. Muhammad, T and Ahmad, S. 2008. Impact of sowing time on cotton (*Gossypium hirsutum* L.) genotypes. Asian J. Plant Sci. 3(7):561-563.

El-Akkad, M.H., M.A.A. El-Dayem, A.F.H. El-Okkia and M.H. Fouad. 1980. Influence of planting date on flowering, boll setting, yield and earliness in Giza 69 cotton variety. Agric. Res. Rev. 58(9): 149-168.

Elayan, E.D., Sohair, A.M.A. Abdalla, Abdel-Gawad, S.D. Nadia and A.E.F. Wageda. 2015. Effect of delaying planting date on yield, fiber and yarn quality properties in some cultivars and promising crosses of Egyptian cotton. Am. Eurasian J. Agric. Environ. Sci. 15(5): 754-763.

El-Debaby, A.S., G.Y. Hammam and M.A. Nagib. 1995. Effect of planting date N and P application levels on seed index, lint percentage, and technological characters of Giza 80 cotton cultivar. Ann. Agric. Sci. Moshtohor, 33(2): 455-464.

El-Zik, K.M., P.M. Taxton, T.F. Dusek and T.D. Brooks. 2000. Effect of planting date, moisture and heat units on cotton yield and fiber quality under dry conditions. Procd. Beltwide Cotton Conf. 1: 525-527.

Ewida, M.A.T., M.H. Fayed, A.M. Okaz and H.E.A. El-Gamal. 1985. Yield components and fiber quality of Egyptian and American cottons with different planting dates. Ann. Agric. Sci. Moshtohor. 23(2): 601-611.

GoP. 2017. Economic Survey of Pakistan. Ministry of food, agriculture and live ministry of national food security and research stock, Government of Pakistan, finance division, economic advisor wing, pp. 20.

Hodges, H.F., K.R. Reddy, J.M. McKinion and V.R. Reddy. 1993. Temperature effects on cotton. Miss. St. Univ. Exp. Stn. Bull. 990.

Hussain, M., A. Ahmad and S.I. Zamir. 2007. Evaluation of agro-qualitative characters of five cotton cultivars (Gossypium hirsutum L.) grown under Toba Tek Singh conditions. Pak. J. Agric. Sci. 44(4): 575-580.

Iqbal, J., S.A. Wajid, A. Ahmad and M. Arshad. 2012. Comparative studies on seed cotton yield in relation to nitrogen rates and sowing dates under diverse agro environment of Punjab. Pak. J. Agric. Sci. 64(1): 59-63.

Jowah, P. 1994. Studies on insecticide applications on small scale cotton farms. Thesis submitted for the degree of doctor of philosophy, Univ. Zimbabwe, Harare.

Karavina, C., R. Mandumbu, C. Parwada and T. Mungunyana. 2012. Variety and planting date effects on the incidence of bollworms and insect sucking pests of cotton (Gossypium hirsutum L.). Res. J. Agric. Sci. 3(3): 607-610.

Khan, F.U.Z., S.U. Rehman, M.A. Abid, W. Malik, C.M. Hanif, M. Bilal, G. Qanmber, A. Latif, J. Ashraf and U. Farhan. 2015. Exploitation of Germplasm for Plant Yield Improvement in Cotton (Gossypium hirsutum L). J. Green Physiol. Genet. Genomics. 1(1): 1-10.

Khan, W.S., M. Hanif and Z. Ahmad. 1980. Studies on the sowing date, quantum of irrigation and levels of fertilizers on the yield of American cotton in Sargodha. Pak. Cotton. 24: 75-85.

Khan, W.S., Z.A. Raja and A. Aziz. 1981. Studies on seed cotton yield for different sowing dates and spacings as affected by different years. Pak. Cotton. 25: 81-4.

McAlister, D.D. and C.D. Rogers. 2005. The effect of harvesting procedures on fiber and yarn quality of ultra-narrow-row cotton. J. Cotton Sci. 9: 15-23.

Nelson, D.W. and L.E. Sommers. 1982. Total carbon, organic carbon, and organic matter. In: Methods of Soil Analysis, (Eds.): A.L., R.H. Miller and D.R. Keeney. Part 2. Agron. No 9, Madison, Wisconsin, USA. 539-579.

PCCC. 2013. Pakistan Central Cotton Committee, Multan, ministry of national food security and research, Islamabad, Pakistan.

PCCC. 2016. Pakistan Central Cotton Committee-Multan, Ministry of National Food Security and Research, Islamabad, Pakistan.

Pedigo, L.P. 2004. Entomology and pest management. Prentice Hall, Englewood Cliffs.

Poonia, B.L., R.P. Singh and N.K. Jain. 2002. Response of upland cotton (*Gossypium hirsutum* L) cultivars to different dates of planting. India. J. Agri. Sci. 72(3): 171-173.

Rahman, H.R., S.A. Malik, M. Saleem and F. Hussain. 2007. Evaluation of seed physical traits in relation to heat tolerance in upland cotton. Pak. J. Bot. 39(2): 475-483.

Rauf, S. and H.A. Sadaqat. 2007. Effects of varied water regimes on root length, dry matter partitioning and endogenous plant growth regulators in sunflower (Helianthus annuus L.). J. Plant Interact. 2(1): 41-51. https://doi.org/10.1080/17429140701422512

Rauf, S., T.M. Khan, H.A. Sadaqat and A.I. Khan. 2004. Correlation and path coefficient analysis of yield components in cotton (Gosspium hirsutum L.). Int. J. Agric. Biol. 6(4): 686-688.

Reddy, K.R. 1992. Temperature effects on cotton fruit retention. Agron. J. 87: 820-826. https://doi.org/10.2134/agronj1995.00021962008700050007x

Reddy, K.R., H.F. Hodges and V.R. Reddy. 1990. Temperature effects on cotton fruit retention. Agron. J. 84(1): 26-30. https://doi.org/10.2134/agronj1992.00021962008400010006x

Richards, L.A. 1954. Diagnosis and improvement of saline and alkali soils. Agric. Handbook no. 60, U.S. Salinity Laboratory Staff. United states department of agriculture, U.S. Govt. Printing Press, Washington DC.

Sarwar, M., M.F. Saleem, M.A. Wahid, A. Shakeel and M.F. Bilal. 2012. Comparison of Bt and non-Bt cotton (Gossypium hirsutum L.) cultivars for earliness indicators at different sowing dates and nitrogen levels. J. Agric. Res. 50(3): 335-347.

Soil Survey Staff. 2009. Keys to Soil of NWFP, FATA and Northern Areas. Nat. Inst. Res. Soils Geomat. Lahore, Pakistan. p. 76.

Steel, R.G.D. and J.H. Torrie. 1980. Principles and procedures of statistics. McGraw-Hill, New York.

Tibugari, H., R. Mandumbu, P. Jowah and C. Karavina. 2012. Farmer knowledge, attitude and practice on cotton (Gossypium hirsutum L.) pest resistance management strategies in Zimbabwe. Arch. Phytopathol. Plant Prot. 1: 1-11.

Xian, G., M. Jun, G. Yuping, S. Mizhen1, Zhoujiajia, Y. Yanchao, Z. Tianzhen, S. Xuezhen and S. Xianliang. 2014. The relationship between fiber initiation and Lint percentage in cotton. Pak. J. Bot. 46(6): 2227-2238.

Yaseen, A.F.I.H. 1986. The relationship between yield and agronomic treatments for some Egyptian and American cotton varieties. Ph.D. Thesis. Fac. Agric. Ain Shams Univ. Egypt.

Yeates, S.J., G.A. Constable and T. McCumstie. 2010a. Irrigated cotton in the tropical dry season. II: Biomass accumulation, partitioning and RUE. Field Crop Res. 116(3): 290-299. https://doi.org/10.1016/j.fcr.2010.01.007

Yeates, S.J., M.F. Kahl, A.J. Dougall and W.J. Müller. 2013. The impact of variable, cold minimum temperatures on boll retention, boll growth and yield recovery of cotton. J. Cotton Sci. 17: 89-101.

Zeng, L., W.R.M. Jr., B.T. Campbell, J.K. Dever, J. Zhang, K.M. Glass, A.S. Jones, G.O. Myers and F.M. Bourland. 2014. Breeding and genetics. Genotype-by-environment interaction effects on lint yield of cotton cultivars across major regions in the U.S. cotton belt. J. Cotton. Sci. 18: 75-84.

Zia-ul-Hassan, K.A. Kubar, I. Rajpar, A.N. Shah, S.D. Tunio, J.A. Shah and A.A. Maitlo. 2014. Evaluating potassiumuse- efficiency of five cotton genotypes of Pakistan. Pak. J. Bot. 46(4): 1237-1242.