Pakistan Journal of Life and Social Sciences
www.pjlss.edu.pk

RESEARCH ARTICLE

Effect of Different Sowing Times and Cultivars on Cotton Fiber Quality under Stable Cotton-Wheat Cropping System in Southern Punjab, Pakistan

Qaiser Abbas and Shakeel Ahmad*
Bahauddin Zakariya University, Multan-60800, Pakistan

ARTICLE INFO

Received: Jun 01, 2018
Accepted: Dec 12, 2018

Keywords
Gossypium hirsutum L.
Micronaire
Staple length
Staple strength
Uniformity index ratio

***Corresponding Author:**
shakeelahmad@bzu.edu.pk

ABSTRACT

The quality of cotton fibers can affect the textile quality and therefore it can also impact the farmer's income accordingly. So, counting those factors that play important role to optimize fiber length, strength, uniformity index ratio and micronaire are necessary. Early sown cotton (*Gossypium hirsutum* L.) crop has ability to enhance planting potential by escaping high temperature and water deficit conditions at reproductive stage. Late sown crop resulted late flower initiation and move to boll growth in low temperature which increased the quality attributes staple, staple strength and uniformity index ratio but decrease the fiber micronaire. The interaction between the planting time and genetic information indicated significant affect. The main objective of this study was to choose the more suitable planting dates that maximize the cotton production and quality of cotton fiber under cotton-wheat cropping system at different locations. Four cotton cultivars MNH-886, IR-3701, CIM-573 and BH-167 were sown at May 1st, 15th, June 1st, and June 15th, in cotton growing districts, i.e., Bahawalpur, Khanewal and Multan under cotton-wheat cropping system during both years. All agronomic practices remained constant. The late sown cotton crop on June 15th displayed maximum staple-length (29.87 mm), staple-strength (27.64 g/tex) and uniformity-index-ratio (83.76%), while micronaire values were observed maximum (5.39 µg inch^{-1}) at early sown crop on May 1st. Cotton cultivars MNH-886 represented maximum staple-length (29.96 mm), staple-strength (27.45 g/tex), uniformity-index-ratio (84.15%) and micronaire (5.50 µg inch^{-1}). Maximum staple-length (29.12 mm), staple-strength (27.23 g/tex), uniformity-index-ratio (82.25%) and micronaire (5.21 µg inch^{-1}) was observed during 2nd year as compared to 1st year. The temperature 15 to 21 °C is considered best for fiber length. When temperature decreased below the 25 °C, micronaire values declines. Fiber strength is reduced under temperature stress conditions. Cotton Cultivar MNH-886 showed best results regarding quality attributes in case of late sown condition.

INTRODUCTION

Subtropical and semiarid origin is best for cotton (*Gossypium hirsutum* L.) as it is familiar to high temperature and arid situation (Pettigrew, 2008). Textile industry gave more importance to cotton fiber. Planting time is a major factor which play important role in maximum production and better quality cotton. Cotton fiber value count depends on fiber yield and quality (Deho et al., 2012). Inheritance improvements in production and fiber superiority traits by cotton breeders have changed cotton lint more attractive to textile industry but poor cultural practices and climatic condition keeps bad impacts on fiber quality (Iqbal et al., 2011). Former study displayed that delayed planting decrease yield and displayed lint superiority. Callose and cellulose has same structure and when enlarge ratio of callose in cell wall of fiber cell, the quality of fiber deteriorated. Photosynthetic carbon fixation along with cellulose synthesis is affected by environmental factors which make fiber wall thickening and ultimately fiber quality. Cellulose and sucrose play important role in fiber quality which is determined by sowing dates (Zhao et al., 2012).

Quality of cotton fiber reduces when temperature above 30°C and decreases flower retention when temperature across 40°C. Boll maturity phase and size of boll is reduced with increase of temperature and length of fiber is decreased. Increasing night temperature resulted more micronaire. More night temperature ranging 5-25 °C is separated from high sunlight light energy and keeps positive effect on production. Low night temperature resulted slow growth of boll and decreased the cellulose formation. Highest fiber length was observed at night temperature of 21.1 °C. Cotton plant has capability to create cooling effect through evapotranspiration when humidity increases (Pettigrew, 2008). Micronaire of cotton is fiber quality related to fineness and fiber maturity. Maximum values of micronaire considered coarse fiber and unwanted for textile industry. If micronaire value is less than 3.8 fibers is considered immature and caused in breakages in fiber with in yarn and poor dye uptake during textile processing. Time of sowing can create such lint quality which is more appealing for textile industry. Many environmental factors are involved to make quality of fiber (Bange et al., 2010). The best night temperature ranges 15 to 21 °C for good quality fiber of maximum length and beyond this range length of fiber reduced. The micronaire decreased when night temperature is less than 25°C. Genetic enhancement in lint quality characters by scientists for long time has prepared cotton competitive benefit globally. Unluckily, unfavorable ecological circumstances can have a humid effect and cover any hereditary development in lint quality (Pettigrew, 2001).

Sowing date affects significantly cotton quality parameters (Ahmad and Raza, 2014; Ahmad et al., 2018). Early sowing get benefits of favorable climatic condition before low rainfall and warm temperature at flowering and fruiting stage (Ahmad et al., 2017). Late sown crop decreased micronaire and enhanced fiber length (Soomro et al., 2014). After 7 days of anthesis fiber and outer covering of seed get maximum part of photosynthates. Sharing of photosynthates among reset of seed and fiber is about same quantity. Length of fiber starts two days after anthesis and keeps on 28 days. Cellulosic secondary wall deposition begins after 15 days which control the fiber maturity. The extent of secondary wall deposition decides fiber fineness and micronaire. Increasing temperature 50 days after planting keeps bad impacts on micronaire and 150 days after planting showed better results regarding micronaire. Rising temperatures reduced fiber length and increased fiber micronaire. Fiber length and micronaire reduced as temperature low after 42 days from anthesis to boll opening. Morphological and physiological effects of less temperature during germination and early plant development can affect fiber quality. The number of unproductive branches emerged earlier than productive branches and formation of productive branches is controlled by environment and genetic factors. Early sowing cotton crop displayed more production and best quality fiber due to escaping water deficit conditions and warm temperature at reproductive stage (Davidonis et al., 2004). Variations in its surrounding i.e. changes in temperature, humidity and soil moisture resulted source of energy photosynthates to sinks other than lint yield. So, earlier planting showed poor establishment of plant due to cool temperature impacts and too late sowing indicated less production and enhanced pest population due to susceptibility. Late start of flowering and boll maturity phase resulted boll set, fiber lengthening and fiber width happening when mean temperature is less. Sowing of cotton crop can be started when soil temperature become warm sufficient to grow healthy plant establishment. To get healthy plants and high-quality fiber cotton seed needs the high soil temperature for its germination and healthy seedlings. Late sowing decreased micronair and fiber length, while fiber strength is increased, while some scientists finding showed controversy results and proved that late sown crop enhanced the fiber length and strength and decreased microanire (Gormus and Yucel, 2002).

The purpose of this study was to determine the impacts of appropriate sowing dates and different cultivars and their parallel interactions on cotton fiber production and quality parameters under stable cotton-wheat cropping system at different locations in Southern Punjab, Pakistan.

MATERIALS AND METHODS

Field experiment of four cotton cultivars i.e. MNH-886, IR-3701 (BT cultivar), CIM-573 and BH-167 (Non-BT cultivars) was conducted at three different locations i.e. Bahawalpur, Khanewal, and Multan during both years.

Cotton fiber quality

Lint was isolated from seed by saw gin machine operating with electric power. Fibers examination of cotton was placed on maximum capability apparatus HVI-900 A, Uster, America was utilized of yarn checking for lint samples. Checking procedure was that of ASTM Standards (1997) at 8% moistures level in cotton. Lint sample was kept in condition at 20 + 2°C along with 65 + 2°C comparative moisture for one day and one night. Consequently, cotton superiority character was obtained from HVI. The following quality parameters were recorded, i.e., fiber length, fiber strength, micronaire and Uniformity index ratio.

Fibre length

Fiber length is standard dimension along the length by quantity of more extent on 50% of thread by load in sample. Extent of fiber in which 25% of the fibers by weight are lengthy and 75% less than the length gained.

Array method is applied to determine fiber length. A suter-webb sorter is applied for insertion fibers and set into clustering degree cell in mode similar to cotton fiber examination.

Fiber strength

Fiber strength is relationship of the busted strength to assembly of fiber broken down. It was calculated by HVI and mentioned as gram tex^{-1}. Flat bundle technique is used by Pushing Tester of newly developed Scott, Clemson and Stelo meter device. Lint sample are set by hand join to parallelize fibers to a little strip of 3/16 to ¼ inch width. Strip of fiber is fixed firmly in little jaws and lint distended border outside tops of jaws paired off as to provide a special space of thread end-to-end.

Uniformity index ratio

It is significant relationship between regular space end to end and elevated half average measurement lengthwise. Uniformity index ratio was calculated as

$$\text{Uniformity Index Ratio} = 100 \text{ x } \frac{\text{Mean length}}{\text{Upper half mean length}}$$

Fiber uniformity index is assessment of fibers dimension lengthwise as prescribed on base of percentile. Where mean measurement length is an estimation of fibers mean distance end to end, approximately one fourth parts of inches and more length and the higher semi piece average length is the dimension of yarn long in upper semi part as determined through fibro graph.

Micronaire

Micronaire is weight for each part of length of yarn or linear compactness of fiber and is frequently described in terms of microgram per inch of yarn length. It is a necessary superiority parameter of lint fiber, which facilitates in calculating cotton spinning data, that is determined by various techniques i.e. air flow technique as well as with instrument similar to micronaire-920 module.

RESULTS

Staple length (mm)

Effect of the years on staple-length showed highly significant response on all locations (Table 1). All-out staple-length was obtained (29.12 mm) during 2nd year compared to 1st year (28.50 mm). Cultivars displayed significant behavior concerning staple-length on all locations. The MNH-886 characterized all-out values for staple-length (29.96 mm), IR-3701 and CIM-573 produced staple length (29.10 mm) and (28.45 mm), respectively while, lowest value was showed for BH-167 (27.75 mm). Influence of sowing times concerning staple-length was observed significant on all sites. Late sowing on June 15th displayed maximum staple-length (29.87 mm) which indicated 7.16% more than in early sowing on May 1st (27.73 mm). May 15th along with June 1st indicated staple-length 28.52, and 29.14 mm. Staple lengths showed non-significant interactions among years, cultivars and sowing dates on all sites. Interactive effect of cultivars and sowing dates indicated significant behavior on Bahawalpur and Multan, while between cultivars and years showed significant response on all sites. Interaction between sowing dates and years remained significant at Multan. The cultivar MNH-886 recorded highest values for staple-length 31.03 mm, 30.75 mm and 29.11 mm during 2nd year, BH-167 indicated minimum staple-length 28.64 mm, 27.29 mm and 26.49 during 1st year at Bahawalpur, Khanewal, and Multan, respectively (Table 2(a)). The maximum staple-length 29.24 mm was obtained by late sowing during 2nd year and early sown crop displayed lowermost staple-length 26.21 mm during 1st year in Multan (Table 3). Cultivar MNH-886 characterized highest staple-length (32.03) and 30.19 mm in late sowing and lowest values for staple-length was obtained by BH-167 (28.07) mm and (25.66) mm in early sown condition at Bahawalpur along with Multan, respectively (Table 4(b)). Average values for staple length was recorded 29.87, 28.77, and 27.80 mm at Bahawalpur, Khanewal, and Multan, respectively.

Staple strength (g/tex)

Table 1 showed that years significantly influenced fiber strength at all sites. Year-II indicated more staple strength (27.23 g /tex) as matched to 1st year (26.86 g/tex). Cultivars revealed significant affects regarding staple strength on all sites. Cultivar MNH-886 represented maximum staple strength (27.45 g/tex) that was statistically at par for IR-3701 (27.17 g/tex). The cultivar CIM-573 showed 2% staple strength (26.91 g/tex) and BH-167 showed 5.35% less staple strength (25.98 g/tex) than MNH-886. Staple strength is affected significantly by time of sowing at all locations. Late sown crop June 15th displayed highest staple strength (27.64 g/tex). June 1st and May 15th represented the 27.17 and 26.85 g/tex. Lowest staple length was observed 26.52 g/tex by early sowing on May 1st. Interactive effect between years along with sowing dates showed significant response on all locations. Significant interaction between years along with cultivars, cultivars along with sowing dates was obtained at Multan. Maximum staple-strength was displayed 28.99 g/tex, 27.57 g/tex and 27.09 g/tex during 2nd year by late sown crop June 15th and lowest staple strength was observed 27.09 g/tex, 26.10 g/tex, 25.96 g/tex by early sown crop May during 1st year at Bahawalpur, Khanewal, along with Multan, respectively (Table 2(b)). Cultivar MNH-886 documented highest staple-strength 27.04 g/tex during 2nd year and BH-167 characterized minimum staple-strength 26.11 g/tex during both years at Multan (Table 2(b)). Highest staple strength was introduced by the cultivar MNH-886 27.35 g/tex in June 15th sowing while minimum staple length was observed 25.63 g/tex by BH-167 in May 1st sowing at Multan (Table 4(c)). Mean values for staple strength was noted 27.79 g/tex, 26.87 g/tex and (26.47 g/tex) at Bahawalpur, Khanewal, and Multan, respectively (Table 1).

Table 1: Cotton quality parameters (staple length, staple strength, uniformity index ratio and micronaire) as effected by cultivars and sowing dates

Treatments	Staple Length (mm)				Staple Strength (g tex^{-1})				Uniformity Index Ratio				Micronaire (ug inch^{-1})			
	BWP	KWL	MLN	Mean	BWP	KWL	MLN	Mean	BWP	KWL	MLN	Mean	BWP	KWL	MLN	Mean
A. Years																
Year-I	29.63^{b}	28.28^{b}	27.60^{b}	28.50	27.39^{b}	26.81^{b}	26.39^{b}	26.86	83.07^{b}	82.47^{b}	81.20^{b}	82.25	5.25^{b}	5.12^{b}	4.93^{b}	5.10
Year-II	30.11^{a}	29.26^{a}	28.00^{a}	29.12	28.20^{a}	26.93^{a}	26.56^{a}	27.23	83.35^{a}	82.81^{a}	81.96^{a}	82.71	5.36^{a}	5.19^{a}	5.07^{a}	5.21
LSD %	0.14	0.15	0.13		0.10	0.04	0.05		0.24	0.23	0.15		0.05	0.03	0.04	
Significance	**	**	**		**	**	**		*	**	**		**	**	**	
B. Cultivars																
MNH-886	30.99^{a}	30.02^{a}	28.88^{a}	29.96	28.22^{a}	27.26^{a}	26.86^{a}	27.45	85.04^{a}	84.49^{a}	82.92^{a}	84.15	5.70^{a}	5.50^{a}	5.29^{a}	5.50
IR-3701	30.07^{b}	29.06^{b}	28.16^{b}	29.10	27.92^{b}	27.01^{b}	26.59^{b}	27.17	83.77^{b}	83.17^{b}	82.03^{b}	82.99	5.39^{b}	5.20^{b}	5.10^{b}	5.23
CIM-573	29.53^{c}	28.38^{c}	27.45^{c}	28.45	27.68^{c}	26.72^{c}	26.34^{c}	26.91	82.54^{c}	81.97^{c}	81.14^{c}	81.88	5.18^{c}	5.05^{c}	4.91^{c}	5.05
BH-167	28.88^{d}	27.65^{d}	26.72^{d}	27.75	27.35^{d}	24.49^{d}	26.11^{d}	25.98	81.50^{d}	80.93^{d}	80.23^{d}	80.89	4.97^{d}	4.86^{d}	4.70^{d}	4.84
LSD %	0.20	0.21	0.18		0.14	0.06	0.07		0.34	0.32	0.22		0.06	0.04	0.06	
Significance	**	**	**		**	**	**		**	**	**		**	**	**	
C. Sowing Dates																
May 1st	28.82^{d}	27.86^{d}	26.52^{d}	27.73	27.31^{d}	26.23^{d}	26.01^{d}	26.52	81.97^{d}	81.31^{d}	80.41^{d}	81.23	5.53^{a}	5.34^{a}	5.29^{a}	5.39
May 15th	29.68^{c}	28.37^{c}	27.51^{c}	28.52	27.61^{c}	26.62^{c}	26.32^{c}	26.85	82.74^{c}	82.04^{c}	81.14^{c}	81.97	5.39^{b}	5.25^{b}	5.03^{b}	5.22
June 1st	30.07^{b}	29.06^{b}	28.28^{b}	29.14	27.82^{b}	27.08^{b}	26.62^{b}	27.17	83.62^{b}	83.22^{b}	81.99^{b}	82.94	5.28^{c}	5.16^{c}	4.95^{c}	5.13
June 15th	30.90^{a}	29.81^{a}	28.89^{a}	29.87	28.44^{a}	27.54^{a}	26.95^{a}	27.64	84.51^{a}	83.99^{a}	82.77^{a}	83.76	5.03^{d}	4.87^{d}	4.75^{d}	4.88
LSD %	0.20	0.20	0.18		0.14	0.06	0.07		0.34	0.32	0.22		0.06	0.04	0.06	
Significance	**	**	**		**	**	**		**	**	**		**	**	**	
Interactions																
A x B	**	**	**		NS	NS	**		NS	NS	NS		*	*	NS	
A x C	NS	NS	*		**	**	*		NS	NS	NS		NS	NS	NS	
B x C	*	NS	*		NS	NS	*		NS	NS	NS		**	**	*	
A x B x C	NS	NS	NS		NS	NS	NS		NS	NS	NS		NS	NS	NS	
Mean	29.87	28.77	27.80		27.79	26.87	26.47		83.21	82.64	81.58		5.31	5.15	5.00	

Means sharing different letters in a column differ significantly at P = 0.05; *, ** = Significant at 5% and 1%, respectively; NS = Non-significant; BWP = Bahawalpur; KWL = Khanewal; MLN = Multan.

Uniformity index ratio (%)

Data (Table 1) indicated that uniformity index ratio was significantly affected by years at all locations. Average values for uniformity index ratio was maximum during 2nd year (82.71%) as compared to first year of trials (82.25%). Cultivars significantly affected uniformity index ratio at all experimental sites. Averagely, cultivar MNH-886 obtained highest uniformity-index-ratio (84.15%). Cultivar IR-3701 and CIM-573 displayed (82.99%) and (81.88%), respectively. Lowest uniformity index ratio (80.89%) was achieved by the cultivar BH-167. Data showed that time of sowing kept significant effects on uniformity index ratio at all experimental sites. Late sown crop June 15th obtained highest uniformity index ratio (83.76%) which exceeds 3.02% than May 1st (81.23%) sowing. However, May 15th sowing recorded 81.97 uniformity index ratio and June 1st represented 82.94% values for uniformity index ratio. Interaction among seasons, cultivars and sowing times concerning uniformity-index-ratio displayed non-significant results on all locations. Highest average values for uniformity index ratio was received 83.21% at Bahawalpur followed by 82.64% at Khanewal and 81.58% at Multan sites.

Micronaire value (ug inch^{-1})

Data presented in Table 1 showed that cotton micronaire was significantly affected by seasons at all experimental sites. Mean values for micronaire were obtained maximum (5.21 µg inch^{-1}) in second year trial as compared to first year (5.10 µg inch^{-1}). Cotton micronair was affected significantly by cultivars at all sites. Cultivar MNH-886 represented highest micronair values (5.50 µg inch^{-1}) which was 4.91% more than IR-3701 (5.23 µg inch^{-1}), 8.18% more than CIM-573 (5.05 µg inch^{-1}) and BH-167 represented lowest values for micronaire value (4.84 µg inch^{-1}) which was 18.55% less than MNH-886. Effect of sowing times remained significant regarding micronaire at all experimental sites. Maximum micronair values were achieved at May 1st sowing date (5.39 µg inch^{-1}). Late sown crop showed lowest values for cotton micronair (4.88 µg inch^{-1}). Crop sown on May 15th and June 1st indicated (5.22 µg inch^{-1}), (5.13 µginch^{-1}), respectively. Effect of seasons, varieties and sowing times along with years and sowing dates remained non-significant results on all sites. Significant results of cotton micronaire were also seen between years and varieties at Bahawalpur along with Khanewal. Interaction between varieties along with sowing times represented significant results regarding cotton micronair at Bahawalpur, Khanewal and Multan. Table (2(c)) showed that highest values for micronair were obtained by cultivar MNH-886 (5.71 and 5.54) µg inch^{-1} during 2nd year trial and lowest were represented by cultivar BH-167 which was 4.87 and 4.86 µg inch^{-1} during 1st year trial at Bahawalpur and Khanewal, respectively. In early sowing, cultivar MNH-886 indicated highest micronaire values 5.98 µginch^{-1} at Bahawalpur followed by 5.78 µg inch^{-1} at Khanewal, and lowest micronaire values were obtained 5.62 µg inch^{-1} at Multan, respectively (Table 4(a)) and smallest

Table 2: Interactive effect of years and cultivars, year and sowing dates on cotton staple length (mm) and strength (g/tex) and micronaire values (ug inch^{-1})

	Bahawalpur			Khanewal			Multan		
	Year-I	Year-II	Mean	Year-I	Year-II	Mean	Year-I	Year-II	Mean
(a)-Year x Cultivar									
	Staple length			Staple length			Staple length		
V_1	30.95^{a}	31.03^{a}	30.99	29.28^{b}	30.75^{a}	30.02	28.65^{b}	29.11^{a}	28.88
V_2	29.73^{c}	30.41^{b}	30.07	28.54^{c}	29.57^{b}	29.06	28.00^{d}	28.31^{c}	28.16
V_3	29.18^{d}	29.88^{c}	29.53	28.03^{d}	28.72^{c}	28.38	27.28^{f}	27.62^{e}	27.45
V_4	28.64^{e}	29.11^{d}	28.88	27.29^{e}	28.01^{d}	28.15	26.49^{h}	26.95^{g}	26.72
Mean	29.63	30.11		28.54	29.26		27.61	28.00	
LSD 5%		0.28			0.30			0.26	
(b)-Year x Sowing dates									
D_1	27.09^{f}	27.54^{d}	27.32	26.10^{e}	26.37d	26.24	25.96	26.05^{f}	26.01
D_2	27.23^{ef}	27.98^{c}	27.61	26.58^{c}	26.66^{c}	26.62	26.27^{e}	26.37^{d}	26.32
D_3	27.36^{de}	28.27^{b}	27.82	27.05^{b}	27.11^{b}	27.08	26.51^{c}	26.72^{b}	26.62
D_4	27.88^{c}	28.99^{a}	28.44	27.51^{a}	27.57^{a}	27.54	26.81^{b}	27.09^{a}	26.95
Mean	27.39	28.20		26.81	26.93		26.39	26.56	
LSD 5%		0.20			0.09			0.09	
(c)-Year x Cultivar									
	Micronaire			Micronaire			Staple strength		
V_1	5.69^{a}	5.71^{a}	5.25	5.45^{b}	5.54^{a}	5.50	26.68^{b}	27.04^{a}	26.86
V_2	5.36^{b}	5.42^{b}	5.39	5.15^{d}	5.25^{c}	5.20	26.51^{c}	26.66^{b}	26.59
V_3	5.09^{d}	5.26^{c}	5.18	5.00^{f}	5.09^{e}	5.05	26.25^{d}	26.42^{c}	26.34
V_4	4.87^{e}	5.07^{d}	4.97	4.86^{g}	4.86^{g}	4.86	26.11^{e}	26.11^{e}	26.11
Mean	5.25	5.37		5.12	5.19		26.39	26.56	
LSD 5%		0.09			0.05			0.09	

Means sharing different letters in a column differ significantly at P = 0.05; *, ** = Significant at 5% and 1%, respectively; NS = Non-significant.

Table 3: Interactive effect of years and sowing dates on cotton staple length (mm)

Year x Sowing dates	Multan		
	Year-I	Year-II	Mean
D_1	26.21^{f}	26.82^{e}	26.52
D_2	27.42^{d}	27.61^{d}	27.52
D_3	28.23^{c}	28.32^{bc}	28.28
D_4	28.55^{b}	29.24^{a}	28.90
Mean	27.60	28.00	
LSD 5%		0.26	

Means sharing different letters in a column differ significantly at P = 0.05; *, ** = Significant at 5% and 1%, respectively; NS = Non-significant.

Table 4: Interactive effect of cultivars and sowing dates on cotton staple length, strength, and micronaire

Cultivar x Sowing dates		V_1	V_2	V_3	V_4	Mean
(a)-Micronaire (ug inch^{-1})						
Bahawalpur	D_1	5.98^{a}	5.62^{b}	5.36^{c}	5.15^{ef}	5.53
	D_2	5.88^{a}	5.45^{c}	5.22^{de}	5.03^{fg}	5.52
	D_3	5.74^{b}	5.34^{cd}	5.10^{ef}	4.92^{g}	5.28
	D_4	5.21^{e}	5.13^{ef}	5.03^{fg}	4.77^{h}	5.04
Mean		5.70	5.39	5.18	4.95	
LSD 5%				0.13		
Khanewal	D_1	5.78^{a}	5.39^{d}	5.17^{f}	5.01^{h}	5.34
	D_2	5.69^{b}	5.30^{e}	5.09^{g}	4.92^{i}	5.25
	D_3	5.58^{c}	5.21^{f}	5.01^{h}	4.82^{j}	5.16
	D_4	4.95^{hi}	4.90^{i}	4.92^{i}	4.69^{k}	4.87
Mean		5.50	5.20	5.05	4.86	
LSD 5%				0.07		
Multan	D_1	5.62^{a}	5.38^{b}	5.17^{c}	4.97^{d}	5.29
	D_2	5.36^{b}	5.14^{c}	4.94^{de}	4.67^{g}	5.03
	D_3	5.19^{c}	5.11^{c}	4.82^{ef}	4.66^{g}	4.95
	D_4	4.98^{d}	4.77^{fg}	4.72^{fh}	4.52^{h}	4.75
Mean		5.29	5.10	4.91	4.71	
LSD 5%				0.12		
(b)-Staple length (mm)						
Bahawalpur	D_1	29.88^{def}	29.00^{g}	28.33^{h}	28.07^{h}	28.82
	D_2	30.75^{c}	30.02^{de}	29.14^{g}	28.79^{g}	29.68
	D_3	31.30^{b}	30.22^{d}	29.71^{ef}	29.07^{g}	30.08
	D_4	32.03^{a}	31.03^{bc}	30.95^{bc}	29.58^{f}	30.88
Mean		30.99	30.07	29.53	28.86	
LSD 5%				0.40		
Multan	D_1	27.28^{e}	26.80^{f}	26.32^{g}	25.66^{h}	26.52
	D_2	28.56^{c}	27.91^{d}	27.20^{e}	26.38^{g}	27.51
	D_3	29.48^{b}	28.75^{c}	27.74^{d}	27.15^{ef}	28.28
	D_4	30.19^{a}	29.17^{b}	28.54^{c}	27.69^{d}	28.90
Mean		28.88	28.16	27.45	26.72	
LSD 5%				0.37		
(c)-Staple strength (g/tex)						
Multan	D_1	26.32^{e}	26.14^{f}	25.94^{g}	25.63^{h}	26.01
	D_2	26.71^{c}	26.45^{d}	26.21^{ef}	25.90^{g}	26.32
	D_3	27.07^{b}	26.73^{c}	26.47^{d}	26.20^{ef}	26.62
	D_4	27.35^{a}	27.03^{b}	26.72^{c}	26.71^{c}	26.95
Mean		26.86	26.59	26.34	26.11	
LSD 5%				0.13		

Means sharing different letters in a column differ significantly at P = 0.05; *, ** = Significant at 5% and 1%, respectively; NS = Non-significant.

values for micronaire 4.77 µg inch^{-1}, 4.69 µg inch^{-1} in and 4.52 µg inch^{-1} was received in late sowing at Bahawalpur, Khanewal along with Multan, respectively. Average micronaire were recorded 5.31, 5.15 and 5.00 µg inch^{-1} on Bahawalpur, Khanewal along with Multan, respectively (Table 4).

DISCUSSION

Temperature affected the cotton fiber quality. Variation in temperature determines the fiber strength. Fiber strength enhanced as increased in temperature. Environmental stress caused lower plant vigor altered fiber properties through declining cellulose within secondary walls. The cellulose accumulation along with fiber strength was decreased due to less temperature. Temperature also influenced enzymes action like sucrose synthase along with sucrose phosphate synthase. Increase in cellulose production is due to genetic and temperature stress may change rate of enhancing cellulose along with reducing fiber strength (Zeng and Pettigrew, 2015). Less temperature influenced the carbohydrate flux and increase in cellulose of cotton fiber four times. Carbohydrate concentration in leaf and ovule tissue reduced due to low solar radiation in late sowing. Less sucrose concentration is noted by minimum solar rays in late sowing leading to decrease cotton micronaire (Gormus and Yucel, 2002). Sucrose produced in photosynthetic flesh is transferred to fruiting part by phloem tissue and the funiculs. Less glucose and fructose content was observed because less solar rays in late sowing. Photosynthates transferred to seed covering by funiculars that ultimately moved to fiber. Fiber formed at high temperature regime was 3% strong than thread ambient administration (Pettigrew, 2001). Significant response was demonstrated by cultivars concerning cotton quality attributes because of genetic makeup. Cotton fiber quality depends on maturity ratio. Mature fiber formed high quality fiber than non mature fiber (Baloach et al., 2010). Maximum plant height was observed in the cultivar MNH-886 and move additional photosynthates to new opening bolls which displayed early maturity. Yard spinning values depends on the fiber strength (Arshad et al., 2007; Saleem et al., 2010; Baloach et al., 2010; Aziz et al., 2011; Khan et al., 2007; Ali et al., 2010; Saeed et al., 2014). The best temperature is considered 15 to 21 °C for better fiber length and length of fiber reduced beyond this range. The micronaire values reduced when night temperature below the 25 °C. Micronaire is directly proportional to photosynthesis rate. Poor quality fiber is produced in less sunlight conditions (Pettigrew, 2001). Micronaire rose at the daily average temperature of 30.3 °C and decreased after this temperature (Bange et al., 2010). The percentage lint and micronaire increased in early sowing but fiber strength, leaf trashes and lint yellowness was observed greater in late sown as compared to early sown. Early sowing resulted high micronaire values which is undesired (Wrather et al., 2008). Timely sown cotton gave more production and best quality fiber by escaping the effects of water deficit conditions and warm temperature. Fiber and outer integuments got largest part of photosynthate after first week of anthesis. Fiber length starts after two days of anthesis and remains till 3-4 weeks. Accumulation of cellulosic secondary wall starts after 15 days of anthesis which conclude fiber maturity (Usman et al., 2016). Micronaire is a complex which determines maturity and fiber fine quality since fiber cells with the equal wall thickness can have various micronaire values. Micronaire is device that applied to calculate maturity and fineness of cotton fiber (Zeng and Pettigrew, 2015). Rainfall, temperature, and irradiance can change seed and fiber growth. Variation in temperature prior and behind the anthesis and during fiber growth has been concerned in changes in fiber quality. Raising temperature in first 50 days after sowing keeps bad effect and 100 to 150 days after sowing showed better results on fiber quality (Saleem et al., 2010). Fiber length reduced if more temperature along with sufficient moisture and micronaire rose. After 7 weeks from anthesis to boll opening, less temperature reduced fiber length and micronaire. Micronaire values are directly proportional to amount of canopy photosynthesis that comes 15 to 45 days after flowering. Late sowing cotton resulted decrease in micronaire and fiber length may be increased, unchanged or decreased (Davidonis et al., 2004). Gormus and Yucel (2002) concluded that late sown cotton crop decreased micronaire and fiber length, while fiber strength was observed more. Boll maturation period and boll size reduced with more temperature, while fiber length was decreased. High temperature characterized high sunlight and less precipitation. Rate and amount of cellulose accumulation decreased as night temperature reduced. When night temperature reaches 21.1 °C then length of fiber is increased. Fiber formed under warm temperature regime was 3% more powerful as compare to fiber under ambient regime. Temperature did not affect the micronaire but it's one part is affected by temperature i.e. fiber maturity was 2% more under high temperature but other part's fiber perimeter was not influenced (Yeates et al., 2010). The temperature above the 32 °C is harmful to cotton crop. When the temperature exceeds the 30 °C decreased the reproductive weights and show low lint production. High temperature reduced 10% lint reduction. Higher temperature decreased fiber length produced higher micronaire and increased the fiber maturity (Pettigrew, 2008). Planting time influenced the cotton production and yarn superiority but results were always contradictory. Boll weight along with fiber strength declined in delayed planting because of less boll period temperature in late planting. In delayed planting, sucrose content along with cellulose content improved however sucrose transformation rate plus cellulose content reduced. This is because of deteriorated environment condition in delayed planting which forced callose formation (Davidones et al., 2004). Sucrose content enlarged, and sucrose conversion rate was less, so in delayed planting cotton, there was adequate sucrose in cotton fiber, but that may not be easily applied in cellulose formation as in usual planting time. Earlier findings have investigated that lesser quantity of cellulose collected in fiber cell, lesser staple strength was consequently conversion of cellulose, callose and sucrose, together with their gathering parameters may result conversion of final fiber weight along with fiber quality. It was also concluded that response of fiber quality to ecological factors linked to genetic characters fiber growth (cellulose, callose and sucrose) and planting time and the collection of parameters of cellulose, callose and sucrose which plays major role to fiber quality (Zhao et al., 2012).

In conclusion, late sown cotton crop enhanced all quality characteristics of cotton fiber i.e. staple-length, staple-strength, uniformity-index-ratio and high values for micronaire during 2nd year at Bahawalpur, Khanewal and Multan locations. It was also concluded that cotton cultivar MNH-866 produced best quality fiber during 2nd year at Bahawalpur and Khanewal locations. Climatic conditions i.e. temperature and effective rainfall during 2nd year was more appealing for production of good quality fiber. Late sowing is best for cotton crop to enhance quality characteristics cotton fiber which is highly desired by textile industry.

Acknowledgements

Authors acknowledged funding of Higher Education Commission (HEC) (Grant; NRPU-4511), and Bahauddin Zakariya University, Multan, Pakistan for this research.

Authors' contribution

QA did experiments, collected and analyzed data and SA supervised this research work.

REFERENCES

Ahmad S, M Iqbal, T Muhammad, A Mehmood, S Ahmad and M Hasanuzzaman, 2018. Cotton productivity enhanced through transplanting and early sowing. Acta Scientiarum-Biological Sciences, 40: e34610.

Ahmad S, Q Abbas, G Abbas, Z Fatima, Atique-ur-Rehman, S Naz, H Younis, RJ Khan, W Nasim, M Habib ur Rehman, A Ahmad, G Rasul, MA Khan and M Hasanuzzaman, 2017.

Quantification of climate warming and crop management impacts on cotton phenology. Plants, 6: 1-16.

Ahmad S and I Raza, 2014. Optimization of management practices to improve cotton fiber quality under irrigated arid environment. Journal of Food, Agriculture and Environment, 12: 609-613.

Ali H, MN Afzal, S Ahmad, D Muhammad, Z Husnain, R Perveen and MH Kazmi, 2010. Quantitative and qualitative traits of *Gossypium hirsutum* L. as affected by agronomic practices. Journal of Food, Agriculture and Environment, 8: 945-948.

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. Pakistan Journal of Agricultural Sciences, 44: 208-212.

ASTM, 1997. Standard Test Method for Laboratory Determination of the Fiber Content of Peat Samples by Dry Mass. (https://www.astm.org/Standards/D1997.htm retrieved on January 30, 2018).

Aziz A, N Akhtar, M Afzal, M Ashraf, A Tanveer, R Ahmad and S Ahmad, 2011. Comparative performance of Bt cotton with some elite conventional cotton cultivars under arid to semi-arid conditions. African Journal of Agricultural Research, 5: 1600-1606.

Baloch MS, ITH Shah, MA Nadim, MI Khan and AA Khakwani, 2010. Effect of seeding density and planting time on growth and yield attributes of wheat. The Journal of Animal and Plant Sciences, 20: 239-240.

Bange MP, GA Constable, DB Johnston and D Kelly, 2010. A method to estimate the effects of temperature on cotton micronaire. Journal of Cotton Science, 14: 164-172.

Davidonis GH, AS Johnson, JA Landivar and Fernandez, 2004. Cotton fiber quality is related to boll location and planting date. Agronomy Journal, 96: 42-47.

Deho ZA, S Laghari, S Abro, SD Khanzada and K Fakhuruddin, 2012. Effect of sowing dates and picking intervals at boll opening percent, yield and fiber quality of cotton cultivars. Science, Technology and Development, 31: 288-293.

Gormus O and C Yucel, 2002. Different planting date and potassium fertility effects on cotton yield and fiber properties in the Cukurova region, Turkey. Field Crops Research, 78: 141-149.

Iqbal M, S Ahmad, T Muhammad, M Hussain, A Mehmood, A Jabbar, W Nazir, H Hussnain and N Hussain, 2011. Lowering virus attack with improved yield and fiber quality in different cotton genotypes by early sown cotton (*Gossypium hirsutum* L.). African Journal of Biotechnology, 10: 7367-7371.

Khan NU, HU Khan, K Usman, HU Khan and S Alam, 2007. Performance of selected cotton cultivar for yield and fiber related parameters. Sarhad Journal of Agriculture, 23: 257-259.

Pettigrew WT, 2001. Environmental effects on cotton fiber carbohydrate concentration and quality. Crop Science, 41: 1108-1113.

Pettigrew WT, 2008. The effect of higher temperatures on cotton lint yield production and fiber quality. Crop Science, 48: 278-285.

Saeed F, SA Kang and M Amin, 2014. Performance of genotypes at different sowing dates on yield and quality traits in *Gossypium hirsutum*. International Journal of Agriculture and Crop Sciences, 7: 274-278.

Saleem MF, MF Bilal, M Awais, MQ Shahid and SA Anjum, 2010. Effect of nitrogen on seed cotton yield and fiber qualities of cotton (*Gossypium hirsutum* L.) cultivars. The Journal of Animal and Plant Sciences, 20: 23-27.

Soomro AW, FH Panhwar, AR Channa, MZ Ahsans, MS Majidano, FI Khaskheli and KB Sial, 2014. Effects of sowing time on yield, GOT and fiber traits of upland cotton (*Gossypium hirsutum* L.). International Journal of Scientific and Engineering Research, 5: 194-198.

Usman K, Ayatullah, N Khan and S Khan, 2016. Genotype-by-sowing date interaction effects on cotton yield and quality in irrigated condition of Dera Ismail Khan, Pakistan. Pakistan Journal of Botany, 48: 1933-1944.

Wrather JA, BJ Phipps, WE Stevens, AS Phillips and ED Vories, 2008. Cotton planting date and plant population effects on yield and fiber quality in the Mississippi Delta. Journal of Cotton Science, 12: 1-7.

Yeates SJ, GA Constable and T McCumstie, 2010. Irrigated cotton in the tropical dry season. III: Impact of temperature, cultivar and sowing date on fiber quality. Field Crops Research, 116: 300-307.

Zeng L and WT Pettigrew, 2015. Combining ability, heritability, and genotypic correlations for lint yield and fiber quality of Upland cotton in delayed planting. Field Crops Research, 171: 176-183.

Zhao W, Y Wang, H Shu, J Li and Z Zhou, 2012. Sowing date and boll position affected boll weight, fiber quality and fiber physiological parameters in two cotton (*Gossypium hirsutum* L.) cultivars. African Journal of Agricultural Research, 7: 6073-6081.