Research Article

Performance of Early and Late Planting Cotton Genotypes under Agro-Ecological Conditions of Multan, Punjab, Pakistan

Muhammad Iqbal[1], Muhammad Mahmood Iqbal[1]*, Saghir Ahmad[1], Athar Mahmood[2], Muhammad Akram[1], Hammad Husnain[1], Muhammad Shahid[1], Saeed Ahmad[1], Ali Raza[1], Ansar Hussain[3], Allah Ditta Abid[4], Qaisar Abbas[5], Mussarrat Hussain[5], Muhammad Akram[6] and Muhammad Umair Hassan[2]

[1]Cotton Research Institute, Multan, Pakistan; [2]Department of Agronomy, University of Agriculture, Faisalabad, Pakistan; [3]Ghazi University Dera Ghazi Khan, Pakistan; [4]Department of Plant Protection, Malair Halt Karachi, Pakistan; [5]Entomological Research Station, Multan, Pakistan; [6]Agronomic Research Institute, Faisalabad, Pakistan.

Abstract | Cotton is an imperious cash crop of Pakistan and change in climatic conditions are continuously limiting its production across the globe. Sowing time is an important agronomic consideration which should be optimized to ensure better cotton yield and quality. Therefore, this study was performed to determine the potential of cotton genotypes under varied planting times at cotton research institute, Multan during 2018 and 2019. The experiment was comprised of four cotton genotypes IUB-13, MNH-1016, MNH-1020 and MNH-1026 and eight different sowing times *viz* 1st March, 16th March, 1st April, 16th April, 1st May, 16th May, 1st June and 16th June. The experiment was performed in RCBD with split plot arrangement and was repeated thrice. Sowing times were placed in main plot and cultivars were placed in sub plots. Results revealed that seed cotton yield and fiber strength was more when cotton was planted early between 1st March to 16th April compared to late planted cotton (1st May to 16th June). Highest seed cotton yield was obtained when cotton was sown on 1st April during first year (3946 kg ha^{-1}) and 16th March during second year (3307 kg ha^{-1}). Minimum seed cotton yield (852, 299 kg ha^{-1}) during both years was obtained when cotton was sown on 16th June. Among cotton genotypes highest seed cotton yield was recorded in MNH-1020 during first year (3021 kg ha^{-1}) and MNH-1016 during second year (2150 kg ha^{-1}). However, minimum seed cotton yield, ginning out turn (38.9, 36.6%) and fiber length (27.6, 26.8 cm) were recorded in IUB-13 during both years. MNH-1020 had highest ginning out turn (41.1, 39.3%), fiber strength (35.88, 40.44 g/tex) and fiber length (28.7, 29.2 cm) during both years. MNH-1020 was also least effected with cotton leaf curl virus when planted on 1st March during first year (25.0%) and 16th march sowing during second year (3.0%). In conclusion, cotton cultivar MNH-1020 can sown from 1st March to 16th April in order to get better cotton yield and quality.

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Introduction

Cotton (*Gossypium hirsutum* L.) being the king of fibers occupies central position in the modern commerce. It plays an imperative role in Pakistan's economy nonetheless, per hectare yield of Pakistan is lower than the other cotton producing countries. Cotton crop has a share of 0.8% in national GDP

while it has a contribution of 4.1% in total value added in agriculture (GoP, 2020). In the countries like Pakistan which is vulnerable to climate change, selection of climate resilient crop management practices plays an appreciable role to achieve the desired yield (Deho *et al*., 2012). The wrong selection of management consideration can cause a significant reduction in final yield. Abiotic factors such as rainfall, temperature, and irradiance are the main ecological factors influencing cotton growth and development (Bradow and Davidonis, 2000; Chen *et al*., 2012). Sowing time is an imperative management option to reduce the impact of abiotic factors like drought and heat stress (Hassan *et al*., 2020a). Deciding the growing season length through sowing date is of remarkable importance (Huang, 2016; Muhsin *et al*., 2021) owing to fact it has significant impact on crop vegetative and reproductive growth (Hallikeri *et al*., 2009). The cotton sown in early season faces the hottest period during their reproduction phase which cause a significant reduction in yield (Rahman *et al*., 2007). Moreover, in late planted cotton flowering and maturity are exposed to high rainfall, low temperature and shorter growth period which in turn reduce the cotton yield and quality (Elayan *et al*., 2015).

An ever-increasing global population calls for agricultural production systems and cultivars that are productive in unreliable weather patterns and are more efficient in utilization of resources in scenarios of climate change, heat and drought stress (Hassan *et al*., 2020b). The cultivation of suitable cultivar plant a crucial role in growth and final productivity (Chattha *et al*., 2017, 2020; Hassan *et al*., 2018, 2019a, b, 2020c; Ilyas *et al*., 2021). Varieties with varied yield potentials are available but their production potential could not be attained under field conditions (Reynolds and Tuberosa, 2008). Yield reduction is mainly due to the cultivation of varieties without considering their behavior under particular sowing environments (Nasim *et al*., 2010). Cotton cultivars are highly responsive to specific environmental conditions including the day length, specific humidity, temperature and rainfall (Shah *et al*., 2010). They behave differently to their surrounding environments regarding yield, fiber properties and disease incidence (Moser *et al*., 2000). Therefore, selection of suitable, aggressive and resistant crop species are the agronomic approaches employed to take yield advantages under varied environmental conditions (Devita *et al*., 2017). In the changing climatic conditions; selection of superior cotton genotypes according to the varied sowing environment is the dire need of the time. Therefore, two years study was conducted to match suitable time of sowing for Bt cotton genotypes in order to get the higher yield and quality.

Materials and Methods

Experimental site and soil

Two years field study was carried out at cotton research institute, Multan. The soil samples from different parts of soil were collected and analyzed to determine different soil properties by following the methods of Homer and Pratt (1961). The soil was silt loam (sand 29%; silt 53%; clay 18%) with EC 1.8 dSm^{-1}, pH 8.1, soil organic matter (0.64%), available nitrogen total phosphorus and exchangeable potassium were 0.04%, 7.8 mg kg^{-1} 169 mg kg^{-1} respectively. The prevailed weather conditions during the study period are presented in Table 1.

Planting material and experimental details

Four cotton genotypes IUB-13, MNH-1016, MNH-1020 and MNH-1026 were sown at eight different sowing times *viz* 1st March, 16th March, 1st April, 16th April, 1st May, 16th May, 1st June and 16th June. MNH-1016, MNH-1020 and MNH-1026 were Bt cultivars of cotton research institute, Multan whereas seeds of Bt cultivar IUB-13 were collected from Islamia University, Bahawalpur. The experiment was performed in randomized complete block design with split plot arrangement and was repeated thrice. For both years net plot dimensions were 3 ×10 m.

Crop husbandry

Two cultivations followed by one rotavation were made for soil preparation. After that one laser land leveling followed by two cultivations were done for seed bed preparation. Beds and furrows each of 2.5 feet width were made by tractor mounted bed planter. Delinted cotton seeds were manually sown with row and plant space of 75 and 30 cm respectively. For successful stand establishment re-irrigation after 3 days was done in the furrows and then subsequent irrigations were applied at 7-21 days interval depending upon weather conditions and crop requirement un-till crop maturity. Phosphorus and potassium were applied as basal dose while nitrogen was applied in three splits i.e. at sowing, flowering and boll formation. Thinning at four leaf stage was done to get the desired and healthy plant population. Insect population was

maintained under economic threshold level through recommended insecticides.

Observations

Growth and yield parameters

In each plot, ten plants were marked branches and nodes were counted and averaged. At maturity plant height was determined from tagged plants with meter rod and balls/plant were counted and averaged. Randomly selected 25 opened bolls were picked, weighed and obtained weight was divided with 25 to get the boll weight in grams. Each plot was manually picked three times, weighed and added together along with the weight of 25 opened bolls to determine the seed cotton yield and later on converted into t ha^{-1}.

Crop development

Crop phenological parameter such as time to squaring, flowering and boll opening were determined by daily visual observation of tagged plants in each plot. Each phenological stage was considered when 50% of the tagged plants attained that stage.

Cotton leaf curl virus infestation

Fortnight data of cotton leaf curl virus was taken from infested plants showing disease symptoms. Leaves with small and main vein thickness, curling and small 'enation' were considered as an infected and percentage of infected plants was calculated by following methods of Akhtar *et al.* (2010).

Quality parameters

Seed cotton samples were sun dried, weighed and ginning was done with the ginning machine. The lint of each collected sample was weighed and ginning out turn (a ratio of lint to seed cotton yield) was determined in percentage. A sub sample of lint (50 g) was taken for determining the micronaire, staple length and fiber strength. High volume instrument spectrum-1 (HVI) was used for determining these physical fiber properties.

Statistical analysis

The data on different collected traits were analyzed by ANNOVA and differences amid the treatments were compared with least significant difference test at 5% probability level (Steel *et al.*, 1997).

Results and Discussion

Growth

Plant growth parameters were significantly affected by different sowing dates. During first year, maximum plant height (153.6 cm) and nodes per plant (47.19) were recorded when cotton was sown on 1st April that was statistically same with 16th March sown cotton (Table 2). Minimum plant height (105.4 cm) and nodes per plant were recorded in crop sown on 16th June sowing (Table 2). Among cotton genotypes, MNH-1026 had highest height and nodes per plant whereas plants of IUB-13 had lowest height and nodes per plant during first year (Table 2). During second year, maximum plant height was noted in genotype MNH-1026 when sown on 1st May and highest nodes per plant were recorded in same genotype in 1st and 16th March sowing date that was statistically same with 1st April, 16th April, 1st May and 16th May sowing date with MNH-1026. Moreover, minimum plant height and nodes per plant were recorded in cotton genotype MNH-1016 when sown at 16th June during second year (Table 2).

Table 1: *Weather data of the experimental site during cotton growing seasons 2018 and 2019.*

Months	Rainfall (mm)		Relative humidity (%)		Temperature (°C)					
					Mean maximum		Mean minimum		Mean	
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
March	0	24	75.9	78.1	31.29	26.55	16.87	14.35	24.08	20.45
April	8	17	59.7	69.9	36.80	35.90	22.37	21.80	29.58	28.85
May	4	13	45.1	52.1	40.81	40.55	26.65	25.06	33.73	32.81
June	4	55	48.2	39.5	41.20	43.13	29.03	29.30	35.12	36.22
July	6	21	68.6	59	38.58	39.52	29.48	29.97	34.03	34.74
August	3	46	71.8	71.8	37.16	38.00	28.94	28.45	33.05	33.23
September	0	28	64.8	67.9	36.33	38.33	26.83	28.80	31.58	33.57
October	0	38	68	74.6	33.97	33.45	21.16	20.52	27.56	26.98

Source: *Cotton Research Institute, Multan, Pakistan.*

Table 2: *Effect of genotypes and sowing dates on cotton phenology, growth, yield and fiber quality traits during 2018 and 2019.*

Treatments	Plant height (cm)		Nodes per plant		Bolls per plant		Boll weight (g)		Seed cotton yield (kg ha-1)		Ginning out turn (%)		Staple length (mm)		Micronaire		Fiber strength (g/tex)	
Genotypes	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
IUB-13	134.2B	111.1C	39.78C	38.02C	31.68C	24.40C	3.49C	3.33B	2235D	1842B	38.9C	36.63C	27.6C	26.80B	4.596A	4.72A	32.32B	35.63C
MNH-1016	139.9A	113.1C	41.45C	38.49C	34.55B	26.48B	3.77B	3.79A	2779B	2150A	40.0AB	37.75B	28.3B	28.99A	4.440B	4.23C	34.46AB	37.51BC
MNH-1020	140.9A	140.4B	42.01B	43.77B	36.63A	28.43A	3.90A	3.85A	3021A	2093A	41.1A	39.26A	28.7A	29.23A	4.467B	4.36C	35.88A	40.44A
MNH-1026	143.2A	169.3A	43.65A	51.01A	33.86B	28.14AB	3.45C	2.99C	2450C	1794B	38.9BC	38.40B	27.9C	28.90A	4.623A	4.5B4	33.16B	38.29AB
LSD	3.64	5.32	1.26	1.73	1.2	1.68	0.1	0.13	185.9	121.4	1.14	0.75	0.32	0.75	0.083	0.163	2.33	2.36
Sowing time																		
1st March	151.0A	152.1A	44.02B	53.43A	38.73BC	32.86A	3.83A	3.55	3295B	3154A	39.7	36.97	27.7	27.97C	4.456	4.19E	35.98AB	38.06
16th March	151.1A	151.1A	47.06A	49.70B	39.04B	34.30A	3.76AB	3.55	3552AB	3307A	39.2	37.89	27.9	28.23C	4.5	4.31DE	36.23A	37.78
1st April	153.6A	152.0A	47.19A	47.59BC	41.78A	33.97A	3.87A	3.52	3946A	3190A	40.1	38.08	28.1	27.80C	4.542	4.48CD	35.74ABC	36.38
16th April	152.0A	150.8A	45.47B	46.75BC	41.62A	32.00AB	3.87A	3.49	3423B	2340B	39.7	38.16	28.1	28.11C	4.433	4.25E	34.37ABCD	36.31
1st May	146.2B	143.1AB	41.36C	44.42CD	36.59C	30.23B	3.75AB	3.57	2709C	1403C	40.1	38.7	28.3	28.37BC	4.529	4.57BC	33.06BCDE	37.16
16th May	135.1C	133.2B	40.81C	41.05D	32.26D	23.40C	3.54BC	3.43	1836D	1232C	40.3	38.7	28.5	28.62ABC	4.525	4.68AB	31.19E	40.03
1st June	122.1D	109.3C	36.17D	35.04E	22.11E	18.30D	3.42CD	3.35	1357E	833D	39.3	38.31	28.2	29.53A	4.633	4.78A	32.87CDE	40.24
16th June	105.4E	76.1D	31.72E	24.62F	21.28E	9.85E	3.17D	3.46	852F	299E	39.2	37.28	28.2	29.23AB	4.632	4.46CD	32.20DE	37.77
LSD≤0.05P	3.34	13.11	1.55	3.51	2.19	2.39	0.24	NS	423.9	268.7	NS	NS	NS	1.002	NS	0.194	3.02	NS

Figures sharing the same letter for a parameter in a year do not differed significantly at p≤0.05, NS= Non significant.

Crop development

Plant mapping data during first year reveal that early sown cotton (March and April) had highest number of squares during the month of July and August whereas late sown cotton (May and June) had highest squares during the month of August and September (Figure 1). However, during second year, early sown cotton had highest squares during August and late sown had during September. Among cotton genotypes during first year highest squares were recorded in the month of August for all genotypes but highest were recorded in IUB-13 followed by MNH-1020. MNH-1020 also had highest squares during July when compared with other genotypes for highest squares during July (Figure 1). Phenological data of crop development verified that during first year lowest time for squaring was noted in MNH-1016 sown on 1st April that was statistically same with the same sowing date with varieties IUB-13 and MNH-1020. During second year, lowest squaring time and boll opening time was recorded in MNH-1020 and highest was noticed in MNH-1026 sown 1st May (Table 3).

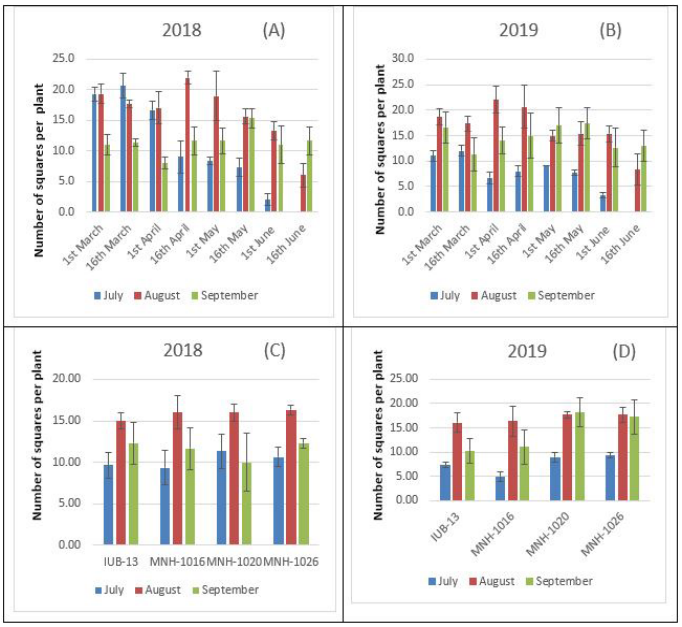

Figure 1: *Effect of sowing time on number of squares per plant in new cotton genotypes during 2018 and 2019.*

Yield and yield attributes

Cotton genotypes and sowing dates had significant differences for bolls/plant and boll weight in both studied years (Table 2). For sowing dates, highest bolls per plant and boll weight were recorded in 1st April sown cotton that was statistically similar to 16th April sowing during first year. Among cotton genotypes highest bolls/plant (36.63) and boll weight (3.90 g) were recorded in cotton genotype MNH-1020 during both years and lowest bolls were noticed in IUB-13 and boll weight was recorded in MNH-1026 during both years (Table 2). In first year of study, highest seed cotton yield was obtained when cotton was planted on 1st April that was statistically similar to seed cotton yield obtained from 16th March sowing. During second year, 16th March sown cotton had highest seed cotton yield that was similar to seed cotton yield obtained from 1st March and 1st April sowing date. Among cotton cultivars, MNH-1020 produced highest seed cotton yield during first year and MNH-1016 during second year, however, it was statistically similar to seed cotton yield obtained from MNH-1020 during second year. Lowest seed cotton yield was recorded in IUB-13 during first year and but statistically similar to IUB-13 during second year (Table 2).

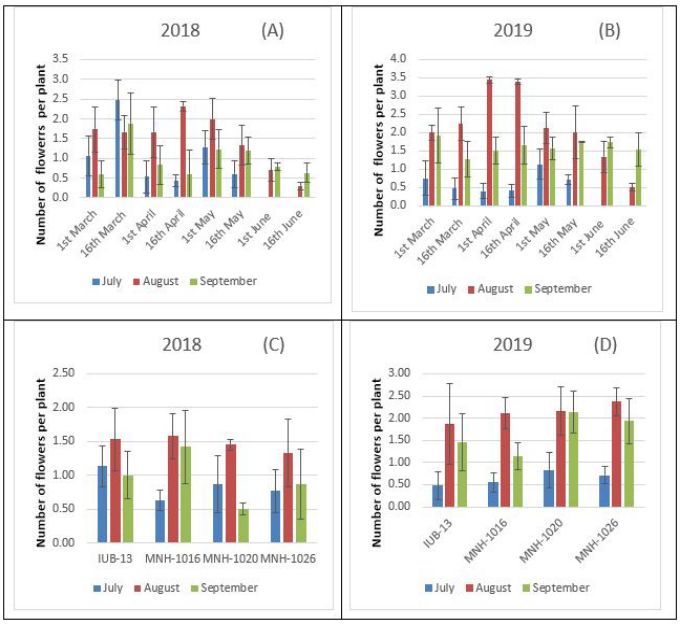

Figure 2: *Effect of sowing time on number of flowers per plant in new cotton genotypes during 2018 and 2019.*

Cotton leaf curl virus infestation (%)

Genotype and sowing environment interaction had significant impact on the infestation of cotton leaf curl virus during both years. Graphical representation of cotton leaf curl virus showed that during first year early sown cotton (March-April) had lowest virus infection during the month of July whereas late sown cotton faced early virus attack during the month of July limiting plant growth and development. During second year early sown cotton was least infected by virus during July, August and September compared to late sowing (Figure 4). During first year, lowest virus infestation was recorded in cotton cultivar MNH-1020 planted on 1st March that was statistically

similar to the 1st April with same variety. Highest virus infestation was recorded in cotton cultivar IUB-13 sown on 16th June 2019. During second year, cotton cultivar MNH-1020 planted on 16th April was least effected with virus whereas same variety sown on 1st May exhibited greatest virus infestation (Figure 4).

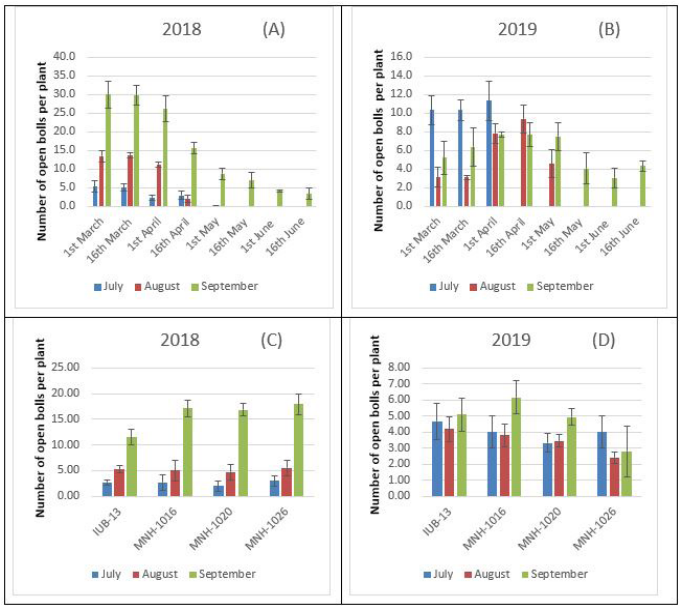

Figure 3: *Effect of sowing time on number of open bolls per plant in new cotton genotypes during 2018 and 2019.*

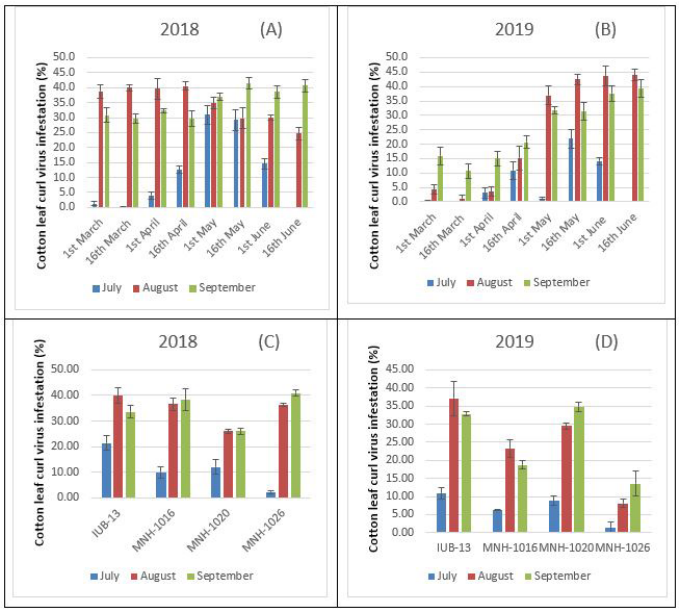

Figure 4: *Effect of sowing time on cotton leaf curl virus infestation (%) in new cotton genotypes during 2018 and 2019.*

Cotton fiber quality

MNH-1020 had highest ginning out turn (41.1, 39.3) and staple length (28.7, 29.23 cm) whereas IUB-13 had lowest GOT (38.90, 36.63%) and staple length (27.6, 26.80 cm) during both years. During second year, cotton cultivar MNH-1026 had highest staple length (30.90 cm) when planted on 16th June. Lowest staple length was attained in cotton cultivar IUB-13 with 16th April sowing statistically similar with 1st April sowing (Table 4). Lowest Mike maximum value was recorded in cotton genotype MNH-1016 that was statistically same with MNH-1020 during both years. For sowing dates 1st March sowing had least mike similar with 16th March and 16th April. Cotton sown on 1st June had greatest Mike (Table 2). Fiber of MNH-1020 had greatest strength during both years. 16th March sown cotton had greatest fiber strength whereas 16th May sown cotton has lowest fiber strength (Table 2).

Results of two years field trials confirmed that along with genetic makeup varied sowing environments also had significant impact on the growth and quality traits and cotton yield. Genotypes with diverse background vary in terms of growth and development (Bange and Milroy, 2004). Plant height and nodes per plant were highest in MNH-1026 because of genetic difference (Boquet and Clawson, 2009) but sowing window from 1st March to 30th April (Early sown cotton) also had highest expression of these growth parameters (Table 2) owing to environmental conditions prevailed during growth of crop. Advance sowing had early climatic support of higher sunshine hours, effective rainfall and total water used by crop (Table 1) that caused better crop growth (Patil *et al.*, 2009).

Data regarding cotton leaf curl virus infestation revealed that during August and September 2018 cotton leaf curl virus infestation was highest compared to 2019 (Figure 4). High rainfall during second year may be the reason of low attack CLCV during second year. However, growing of resistant genotype with advanced sowing date is vital to reduce the attack of cotton leaf curl (Karavina *et al.*, 2012). Low infestation of CLCV on cotton genotype MNH-1020 when planted early increased seed cotton yield (Table 2) whereas high infestation of cotton leaf curl virus on late planted IUB-13 decreased its yield (Table 2). Due to enhanced growth, early sown cotton (March-April) withstands the attack of leaf curl virus (Pedigo 2004). Moreover, early plantation escaped from virus stress (Figure 4) during peak flowering time (Figure 2) while late planted crop hitted very earlier by CLCV and infestation becomes severe during peak flowering period resulting in reduction in yield (Gormus and Yucel, 2002).

Table 3: *Interactive effect of sowing date and cultivar on time to squaring, flowering and boll opening in cotton.*

Treatments		Time to squaring (Days)		Time to flowering (Days)		Time to boll opening (Days)	
		2018	2019	2018	2019	2018	2019
1st March	IUB-13	39.00ghi	44.00defg	54.00jk	64.67bcd	88.33hijk	99.00efgh
	MNH-1016	41.00ef	48.00a	57.00f	68.33a	88.00hijk	101.67cdef
	MNH-1020	39.33gh	46.67ab	57.00f	67.67a	87.33ijk	102.00cde
	MNH-1026	38.00hijk	46.22abc	54.33jk	67.11ab	86.33k	101.83cde
16th March	IUB-13	39.33gh	42.67fghi	55.00hijk	62.67def	88.33de	94.67ijk
	MNH-1016	37.00kl	41.67hi	55.33ghij	61.00fg	88.00hijk	97.33ghij
	MNH-1020	41.67de	42.00ghi	56.33fgh	64.67bcd	88.33hijk	94.67ijk
	MNH-1026	38.67ghij	42.11fghi	54.67ijk	62.67def	88.67ghijk	95.44hijk
1st April	IUB-13	34.67mn	40.67ij	47.67o	57.00hi	87.67ijk	93.67jk
	MNH-1016	33.33n	42.00ghi	53.67kl	59.00gh	87.00ijk	98.00fghi
	MNH-1020	34.67mn	41.00ij	50.33n	58.67gh	87.00ijk	95.00ijk
	MNH-1026	35.00m	41.22hi	50.33n	58.22h	87.00ijk	95.56hijk
16th April	IUB-13	34.67mn	38.33k	52.00m	57.00hi	86.67jk	95.00ijk
	MNH-1016	37.67ijk	37.33kl	55.33ghij	57.00hi	86.33k	95.00ijk
	MNH-1020	40.00fg	37.67k	52.33lm	54.33j	86.33k	91.67kl
	MNH-1026	35.33m	35.67lm	52.00m	55.33ij	86.33k	103.33cd
1st May	IUB-13	46.00bc	37.00kl	62.67c	51.00k	87.67ijk	83.00m
	MNH-1016	45.67c	40.67ij	64.33b	55.00ij	91.00defg	89.67l
	MNH-1020	47.00abc	35.00m	67.00a	51.67k	89.00fghij	81.00m
	MNH-1026	46.33bc	38.33k	66.33a	55.67ij	90.33efgh	114.33a
16th May	IUB-13	47.00abc	46.67ab	57.33ef	66.67ab	86.33k	98.00fghi
	MNH-1016	47.33ab	43.33efgh	62.00c	62.67def	88.33hijk	100.67defg
	MNH-1020	47.00abc	42.33fghi	60.33d	61.67ef	89.33fghi	101.33def
	MNH-1026	48.33a	39.00jk	62.67c	66.33ab	93.00cd	107.33b
1st June	IUB-13	41.67de	43.33efgh	58.67e	56.67hij	92.00de	96.00hij
	MNH-1016	43.00d	42.67fghi	60.33d	62.00ef	91.33def	97.33ghij
	MNH-1020	43.00d	44.33cdef	61.33cd	56.67hij	89.33fghi	95.67hij
	MNH-1026	43.00d	45.67bcd	60.33d	63.67cde	88.67ghijk	102.67cde
16th June	IUB-13	35.67lm	46.67ab	55.33ghij	65.00bcd	93.33cd	102.67cde
	MNH-1016	35.33m	47.00ab	56.67fg	68.00a	95.00bc	103.00cd
	MNH-1020	37.33jk	45.33bcde	56.00fghi	66.00abc	97.67a	102.67cdee
	MNH-1026	40.00fg	46.33abcd	56.33fgh	58.33h	96.67ab	105.33bc
LSD≤0.05P		1.56	1.97	1.42	2.55	2.45	3.78

Figures sharing the same letter for a parameter in a year do not differed significantly at p≤0.05, NS= Non significant.

Yield determining parameters such as bolls/plant and boll weight were greater during first year because of decrease in monthly mean temperature during July, August and September (peak flowering period) and low rainfall compared to second years (Table 1). An increase in temperature had profound effect on flower shedding and boll retention (Fisher, 1975). However, cotton plants sown early have the ability to compensate better by producing new floral parts and convert them into yield traits compared to late planted plants (Table 2). Because of extended growth period due to early planting, plants received additional soil moisture and nutrients which favored the more balls to mature (Huang and Ji, 2016). Early planted cotton had improved boll size (Table 2) owing to accretion of more assimilates and prolonged period for ball development as well as maturity (Pettigrew, 2002; Nuti *et al*., 2006). Whereas late-planted cotton had more flowers and bolls later in the growing season (Figure 2) with low temperature (Table 1) lengthened the period from sowing to boll opening (Table 3) which delayed maturity and reduced yield (Elayan *et al*., 2015; Wanga *et al*., 2016).

Table 4: *Interactive effect of sowing date and cultivars on plant height, number of nodes, bolls per plant, cotton leaf curl virus infestation and staple length in cotton.*

Treatments		Plant height (cm)		Nodes per plant		Bolls per plant		Cotton leaf curl virus infestation (%)		Staple length (mm)	
		2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
1st March	IUB-13	147.3	141.1 h-j	42.37	52.23b-d	37.27	31.50b-d	44.67e-h	28.33f-h	27.2	26.52j
	MNH-1016	150.7	128.9 jk	42.63	49.97c-f	38.27	32.90a-d	41.33 f-j	11.33k-m	27.8	28.25d-i
	MNH-1020	151.9	158.6 d-g	44.47	52.87b-d	40.57	35.47ab	25.00l	14.67kl	28.3	29.48a-d
	MNH-1026	154	179.9 bc	46.6	58.63a	38.83	31.57b-d	40.67f-j	26.67g-i	27.6	27.63e-j
16th March	IUB-13	147.5	132.4 i-k	45.83	46.33e-g	37.53	32.47a-d	43.33 f-i	24.33g-i	27.4	27.38g-j
	MNH-1016	150.5	142.4 g-j	46.8	48.87d-f	38.7	35.27a-d	40.00 f-j	9.67k-m	28	28.42d-h
	MNH-1020	151.8	155.2 e-h	47.03	44.97f-h	41.07	36.53a	35.67i-k	7.33mn	28.4	29.82abc
	MNH-1026	154.7	174.3 cd	48.57	58.63a	38.87	32.93a-d	40.00f-j	22.00h-j	27.8	27.30g-j
1st April	IUB-13	148.1	141.7 g-j	44.07	44.48f-h	40.17	33.00a-d	43.00 f-j	21.33ij	27.3	26.37j
	MNH-1016	154.1	125.0 j-l	47.27	39.85h-j	41.83	34.00a-c	35.67 jk	8.33l-n	28.6	28.67c-g
	MNH-1020	155.5	167.2 c-e	47.6	52.13b-d	43.47	35.77ab	25.67l	34.00d-f	28.8	28.62c-g
	MNH-1026	156.5	173.9cd	49.83	53.90a-d	41.67	33.10a-d	51.33cde	38.33cd	27.6	27.57f-j
16th April	IUB-13	144.4	126.9j-l	42.87	41.55gh	40.07	29.80c-e	37.73 h-k	37.33cd	27.6	26.13j
	MNH-1016	151.1	134.9i-k	45.27	42.14gh	42.07	32.20a-d	37.67 h-k	6.67mn	28.2	28.23d-i
	MNH-1020	154.5	165.9c-f	45.93	51.23b-e	43.13	36.13ab	35.43jk	3.00n	29	28.58c-g
	MNH-1026	158	175.6cd	47.8	52.06b-d	41.2	29.87cde	40.00f-j	40.33b-d	27.8	29.50a-d
1st May	IUB-13	143.6	104.7m-o	39.1	35.15j-l	34.2	28.90de	45.67 d-g	40.33b-d	27.8	26.90h-j
	MNH-1016	146	118.8k-m	41.7	40.67hi	37.2	29.27cde	39.67f-j	29.33fg	28.6	28.70 c-g
	MNH-1020	147.3	148.6f-i	41.63	45.30f-h	38.97	30.17cde	31.33kl	48.33a	28.7	28.60c-g
	MNH-1026	147.8	200.1a	43	56.56ab	36	32.60a-d	38.67g-k	11.67k-m	28.2	29.27b-d
16th May	IUB-13	123.1	90.2op	38.5	31.75k-m	28.53	16.23g	57.67bc	45.33ab	28.2	27.00h-j
	MNH-1016	137	110.0l-n	39.77	35.96i-k	31.33	21.80f	44.67e-h	23.33g-i	28.7	29.27b-d
	MNH-1020	139.3	135.5i-k	42.23	41.55gh	35.1	26.00ef	41.67f-j	34.67c-f	29.1	29.13c-e
	MNH-1026	141.1	197.0ab	42.73	54.93a-c	34.07	29.57c-e	46.67d-f	15.67jk	28	29.07b-f
1st June	IUB-13	119.5	87.3op	35.1	30.42lm	17.97	14.57gh	59.93b	34.67c-f	27.6	27.40g-j
	MNH-1016	122.5	82.9pq	36.57	29.56m	24.2	16.03g	47.07d-f	34.67c-f	28.1	30.40ab
	MNH-1020	120.5	109.5l-n	34.83	35.05j-l	26.37	16.50g	43.83e-h	46.00ab	29	30.30ab
	MNH-1026	125.8	157.4d-h	38.17	45.15f-h	19.9	26.10ef	55.73bc	29.67e-g	27.9	30.00a-c
16th June	IUB-13	99.9	64.5qr	30.43	22.23no	17.67	8.77i	76.00a	40.67bc	27.9	26.73ij
	MNH-1016	107.6	61.8r	31.57	20.91o	22.8	10.33hi	53.00bcd	41.00bc	28.3	29.97a-c
	MNH-1020	106.4	82.4pq	32.37	27.11mn	24.33	10.90hi	46.67def	37.33cd	28.5	29.33b-d
	MNH-1026	108	95.7n-p	32.5	28.22m	20.33	9.40i	59.00b	36.00c-e	28.1	30.90a
LSD≤0.05P		NS	18.473	NS	5.49	NS	4.7432	NS	6.58	NS	1.52

Figures sharing the same letter for a parameter in a year do not differed significantly at p≤0.05, NS= Non-significant.

Highest ginning out turn, fiber strength as well as staple length in cotton genotype MNH-1020 (Table 2) authenticated that genetic makeup of cultivars plays a major role in the fiber strength and length (Jordan, 2001) and lint index (O'Berry *et al*., 2009). The quantity of deposited cellulose determines the fiber strength, fineness and maturity (Ramey, 1999). The cultivars having the long molecules of cellulose has the higher fiber strength owing to presence of few breaking points in lint and superior cross linking amid the fibers (Jordan, 2001). Fiber quality mainly influenced by cultivars, whilst management considerations are the secondary one (Bednarz *et al*., 2005). Ginning out turn was not effected with late or early planting during both years (Table 2). Similar results were noticed by Braunack *et al*. (2012). However, micronaire value declined in early sowing compared to later sowing (Table 2). Early planting

avoid decline in macronaire value (Deho *et al*., 2012). Late planted cotton had more yellow and grey fiber owing to late harvesting which exposes the fiber to different environment conditions not favorable for development of fiber (Duckett *et al*., 1999). Early sown cotton had highest fiber strength compared to late sown (Table 2). Late planted cotton reached at maturity later in the season and farmers harvest the immature cotton have low fiber strength and poor dye uptake capacity (Bradow and Bauer, 1997).

Conclusions and Recommendations

For varied sowing dates, increased expression of yield and yield related parameters due to decreased incidence of cotton leaf curl virus disease argued that cotton sowing window should be from 1st March to 16th April for maximum and quality harvest. Among cotton genotypes MNH-1020 has the potential to perform better under arid conditions where low rainfall and high temperatures are the main characteristics.

Novelty Statement

The rapid climate changes direly need the optimization of agronomic practices to ensure the better crop yield and quality. The sowing time is an important management consideration which plays a significant role in the final cotton yield and quality. However, limited studies are conducted to determine the optimum sowing time for cotton cultivars grown in Agro-Ecological Conditions of Multan. Therefore this study determine the suitable planting time for sowing of different cotton cultivars under Agro-Ecological Conditions of Multan.

Author's Contribution

Muhammad Iqbal and Muhammad Mahmood Iqbal: Conducted the experiment and wrote the original draft.
Saghir Ahmad, Athar Mahmood, Muhammad Akram, Saeed Ahmad, Ali Raza, Ansar Hussain, Allah Ditta Abid, Qaisar Abbas, Mussarrat Hussain, Muhammad Akram and Muhammad Umair Hassan: Reviewed and edited the article.
Hammad Husnain and Muhammad Shahid: Helped in Data collection.

Conflict of interest
The authors have declared no conflict of interest.

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