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Effect of different sowing time on plant height, nodes, square and flowering initiation of *Gossypium hirsutum* under current climatic condition

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Abstract

Changing scenario of climate has moved the attention of scientists to modify the sowing time of various crops. Global warming has shifted the cultivation season of many crops as compared to previously adopted production technologies. It is a documented fact that early or late sowing of crops usually resulted in a significant reduction of yield. However, improvement in production technologies regarding sowing time of crops is the necessity of time to achieve the goal of sustainable yield. Therefore, a field experiment was conducted with the hypothesis that improvement in sowing time would improve the phenological attributes of various cotton genotypes. There were four cotton genotypes (CIM-595, CIM-598, CIM-599 and IR-3701) sown at five different sowing dates (March 15, April 01, April 15, May 01 and May 15). The seeds rate was 20 kg ha^{-1}. Recommended NPK fertilizers were also applied to meet the nutritional demand of plants. Results confirmed that March 15 is the best sowing time for significant improvement in plant height (61.7 and 61.5%) and number of nodes per cotton plant (56.7 and 47.5%) of CIM-599 comparative to late sowing (May 15) of CIM-598 in year-I and year-II respectively. A significant improvement in square initiation (11.0 and 9.54%) and flower initiation (5.61 and 6.27%) in cotton validated the effectiveness of March-15 sowing as compared to May 15 during year-I and year-II respectively. Maximum increase of 3.91 and 2.77% in flower initiation and 4.48 and 8.22% in square initiation confirmed the efficacious role of IR-3701. It is concluded that both CIM-599 and IR-3701 have potential to give maximum growth if sowing would be done at March-15.

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Introduction

Changing climatic conditions is one of the major hurdle for achieving the goal of maximum yield of crops. It is well-documented fact that season of crop sowing directly affects cultural practices, bioavailability of nutrients, pest and insect attack on crops (El-Zik, 1980). Besides other agronomic factors, time of sowing of various cotton genotypes are important to get maximum yield of the cotton crop (Bozbek *et al.*, 2006). Optimum sowing time selection is one of the vital manageable factors which control the yield and growth of cotton plants (Bozbek *et al.*, 2006). Too early crop plantation results into lower yield potential and vigour because of poor crop establishment while plants are sown too late become very vegetative and difficult to manage giving lower seed cotton yield (Wrather *et al.*, 2008; Ali *et al.*, 2009).

The growing season duration dependent on temperature is of utmost importance to attain an economical and profitable yield. Selecting optimal sowing time is of tremendous significance that can improve cotton growth and development and is pivotal to maintain a sustainable agricultural economy (Huang, 2016). Early sowing is conducive to curtail higher boll number, boll weight and seed index which ultimately lead to higher seed cotton yield while late plantation tends to show a decline in crop production that may be due to the availability of shorter time for boll maturity and initiation (Arshad *et al.*, 2007; Bange *et al.*, 2008; Ali *et al.*, 2009; Ahmad and Razi, 2011).

Cotton (*Gossypium hirsutum* L.) is a major cash crop commonly known as 'White Gold' considered as the backbone of country's economy is cultivated on the vast areas of Pakistan as compared to other crops to earn the largest export revenues (Khan *et al.*, 2009; Desai *et al.*, 2014). Among 80 major cotton producing countries of the world including Pakistan, India and many Latin American countries, cotton is considered one of the important crop because of its production (123 million bales) for earning of foreign exchange (Fortucci, 2002; United States Department of Agriculture, 2012). Since the last 30 years in Pakistan, the area under cotton cultivation has increased significantly. In Pakistan cotton crop is responsible for less than 10% of value addition in agriculture, contributes around 2% of GDP and two-thirds of national export earnings are from cotton and cotton products which along with textiles account more than $2.5 billion to Pakistan's economy. In addition to providing raw material to the local textile industry, the lint cotton is an export item and the cotton seed values about 70% of the national oilseed production. Globally Pakistan is considered the fourth largest cotton producer while stands at the third position for export of raw cotton (Government of Pakistan, 2017). Keeping in mind the economic importance of cotton plants, a field study was designed with the hypothesis that proper sowing time would improve the growth of various cotton genotype.

Material and methods

Collection of seeds

For experimental purpose seeds of advanced BT (*Bacillus thuringiensis*) cotton genotypes CIM-595, CIM-598, CIM-599 and IR-3701 were collected from certified seed dealer of the government of Punjab.

Site of experiment

Two years (2015-16) was carried out at the Central Cotton Research Institute Multan Pakistan.

Soil, weather and altitude

The experimental site was situated at latitude 30°, 12' N, Longitude 71°, 28' E and altitude 123 m. The cotton belt of Pakistan lies between latitude 29°N and 37°N spreading diagonally throughout the country and covers a length of 960 km and the breadth of 320 km. The area falls in an arid subtropical continental climate.

Pre-experimental soil characterization

The texture of soil was silt loam in 0-15 and 15-30 cm depth which was analyzed by the hydrometer method (Bouyouces, 1962). For determination of pH*s* method of Schofield and Taylor (1995) was adopted. Soil EC*e* was analyzed according to US Salinity Laboratory

Staff (1954). Walkley (1935) method was followed for the determination of soil organic matter. Soil total nitrogen was analyzed by the methodology of Bremner (1996). Extractable soil phosphorus was examined according to Olsen and Sommers (1982). Nadeem *et al.* (2013) method was used to assess for extractable soil potassium.

Sowing dates

There were five different sowing dates i.e. March 15, April 01, April 15, May 01 and May 15 to explore the influence of sowing time on the growth of different cotton genotypes.

Preparation of Beds and Furrows

For cultivation of cotton cultivars, beds and furrows were prepared with bed shaper and special ridger. Row to row distance was maintained 75 cm while plant to plant distance of 22.5 cm was shaped.

Seed rate

The seeds at the rate of 20 kg ha^{-1} were planted manually by dibbling method on five various sowing dates. Sowing dates were maintained for main plots while cotton genotypes were kept in subplots.

Fertilizer application rate

Nitrogen in the form of urea (46% N) was applied at the rate of 150 Kg ha^{-1} in the three split doses. Phosphorous was applied at the rate of 50 kg ha^{-1} in the form of TSP (46% P_2O_5) in a single split at the time of sowing. Pendimethalin was applied at the rate of 82.5 g ha^{-1} to control weeds at pre-emergence stage. Besides fertilizer addition and weeds control, all cultural practices and measures were implemented as per demand of the cotton crop at various stages of cotton growth.

Experiment design

The experiment was laid out in a randomized complete block design (RCBD) with split plot arrangements and with four replications.

Data collection

Plants were harvested at the time of maturity. Data regarding plant height, number of nodes, square initiation and flowering initiation was recorded soon after harvesting.

Statistical analysis

Statistical analysis was done on Statistix 8.1 according to the standard statistical procedure of Steel *et al.* (1997). The least significant difference (LSD) at 5% probability was applied to compare the differences among the treatments (Steel *et al.*, 1997).

Results

Plant height

Both main and interactive effects of different sowing dates (SD) and cotton genotype (CG) differed significantly for cotton plant height in a two-year study.

Table 1. Effect of sowing dates and transgenic genotypes on cotton plant height (cm).

Sowing Dates	Year-I					Year-II				
	Cotton Genotypes					Cotton Genotypes				
	CIM-595	CIM-598	CIM-599	IR-3701	Means	CIM-595	CIM-598	CIM-599	IR-3701	Means
March-15	154.0 bc	141.5 de	177.9 a	160.4 b	158.5 A	156.8 bc	142.8 e	172.5 a	149.0 d	155.3 A
April-01	148.1 cd	136.3 ef	160.0 b	154.2 bc	149.7 B	149.7 d	136.6 fg	161.8 b	156.6 bc	151.2 B
April-15	134.9 ef	122.0 hi	146.5 d	141.7 de	136.3 C	142.2 ef	129.0 h	153.5 cd	149.5 d	143.6 C
May-01	127.3 gh	114.8 ij	138.3 ef	133.0 fg	128.4 D	130.0 h	116.0 i	141.7 ef	138.0 fg	131.4 D
May-15	120.8 hi	110.0 j	132.7 g	125.0 h	122.1 E	119.5 i	106.8 j	133.0 gh	129.0 h	122.1 E
Means	137.0 C	124.9 D	151.1 A	142.9 B		139.6 C	126.2 D	152.5 A	144.4 B	

It was noted that sowing of CIM-599 at March 15 performed significantly best as compared to CIM-595, CIM-598 and IR-3701 for plant height in year-I and year-II (Table 1). Sowing of CIM-599 and IR-3701 at April 01 remained statistically alike to each other but only CIM-599 differed significantly as compared to CIM-595 and CIM-598 in year-I for plant height. In year-II sowing of CIM-599 and IR-3701 at April 01 and May 01 remained significantly better as compared to CIM-595 and CIM-598 in year-I and year-II for plant height. For plant height sowing of CIM-599 and IR-3701 at April-15 remained significant as compared to CIM-595 and CIM-598. However, CIM-599 sowing at May 15 performed significantly best as compared to all cotton genotype for plant height.

Table 2. Effect of sowing dates and transgenic genotypes on number of nodes per cotton plants.

Sowing Dates	Year-I					Year-II				
	Cotton Genotypes					Cotton Genotypes				
	CIM-595	CIM-598	CIM-599	IR-3701	Means	CIM-595	CIM-598	CIM-599	IR-3701	Means
March-15	39.0 cd	36.5 d-f	47.5 a	43.5 b	41.6 A	39.2 bc	36.7 c-g	45.0 a	40.4 b	40.3 A
April-01	38.0 c-e	35.4 e-h	40.0 c	39.0 cd	38.1 B	38.2 b-f	35.5 d-h	39.8 bc	39.6 bc	38.3 B
April-15	35.5 eh	30.3 i	38.0 c-e	37.0 de	35.2 C	37.0 c-g	34.0 g-i	38.5 b-d	38.3 b-e	37.0 B
May-01	34.0 f-h	31.1 i	36.5 de	35.4 e-h	34.3 CD	35.1 fi	32.3 ij	37.0 c-g	36.8 c-g	35.3 C
May-15	33.0 g-i	30.5 i	35.6 e-g	32.8 hi	33.0 D	33.0 h-j	30.5 j	35.8 d-h	35.2 e-i	33.6 D
Means	35.9 C	32.6 D	39.4 A	38.0 B		36.5 B	33.8 C	39.2 A	38.1 A	

It is also visible from the results that with each delay in sowing time there was a considerable significant shortening of plant height. Maximum increase of 61.7% and 61.5% in plant height was noted in CIM-599 sown at March 15 as compared to CIM-598 sown at May 15 in year-I and year-II respectively.

Number of nodes per cotton plant

Both main and interactive effects of SD and CG remained significant for number of nodes per cotton plant in a two-year study. It was noted that sowing of CIM-599 at March 15 performed significantly best as compared to CIM-595, CIM-598 and IR-3701 for number of nodes per cotton plant in year-I and year-II. Sowing of CIM-595, CIM-599 and IR-3701 at April 01 remained statistically alike to each other but only CIM-599 and IR-3701 differed significantly as compared to CIM-598 in year-I and year-II for number of nodes per cotton plant (Table 2).

Table 3. Effect of sowing dates and transgenic genotypes on square initiation (days) of cotton plants.

Sowing Dates	Year-I					Year-II				
	Cotton Genotypes					Cotton Genotypes				
	CIM-595	CIM-598	CIM-599	IR-3701	Means	CIM-595	CIM-598	CIM-599	IR-3701	Means
March-15	30.5	27.5	31.0	32.0	30.3 A	31.0	28.0	32.0	33.0	31.0 A
April-01	29.8	27.8	31.5	31.0	30.0 A	30.0	28.0	32.0	32.0	30.5 A
April-15	29.0	27.3	30.0	30.3	29.1 B	29.0	27.0	31.0	32.0	29.8 AB
May-01	28.8	26.0	29.0	29.3	28.3 C	28.0	26.0	30.0	31.0	28.8 BC
May-15	27.0	25.0	28.0	29.0	27.3 D	28.0	26.0	29.0	30.0	28.3 C
Means	29.0 B	26.7 C	29.9 A	30.3 A		29.2 B	27.0 C	30.8 A	31.6 A	

For number of nodes per cotton plant,sowing of CIM-595, CIM-599 and IR-3701 at April 15 remained statistically alike to each other but differed significantly as compared to CIM-595 in year-I. However, CIM-599 and IR-3701 sowing at April 15 performed significantly better as compared to CIM-595 and CIM-598 for number of nodes per cotton plant. Results also validated that with each delay in sowing time there was a considerable significant reduction in number of nodes per cotton plants. Maximum increase of 56.7% and 47.5% in number of nodes per cotton plant was noted in CIM-599 sown at March-15 as compared to CIM-598 sown on April 15 and May 15 in year-I and year-II respectively.

Square initiation of cotton plant

Main effect of SD and CG remained significant but their interaction (SD × CG) did not differ significantly for square initiation of cotton plant. In year-I and year-II, CIM-599 and IR-3701 remained statistically alike to each other but differed significantly as compared to CIM-595 and CIM-598 for square initiation of cotton plant (Table 3). Sowing of CG at March 15 and April 01 remained significantly similar to each other but differed significantly as compared to April 15, May 01 and May 15 for square initiation of cotton plants in year-I. In year-II, sowing of CG at March 15, April 01 and April 15 remained statistically alike to each other but March 15 and April 01 differed significantly as compared to May 01 and May 15 for square initiation of cotton plant. Sowing of CG on April 15 and May 01 did not differ significantly for square initiation of cotton plants. Results also confirmed that with each delay in sowing time there was a considerable significant reduction in square initiation of cotton plant. Maximum increase of 11.0% and 9.54% in square initiation of cotton plants was noted when CG was sown at March 15 as compared to May 15 in year-I and year-II respectively. Similarly, maximum increase of 4.48% and 8.22% in square initiation of cotton plant was noted in IR-3701 as compared to CIM-595 in year-I and year-II respectively.

Table 4. Effect of sowing dates and transgenic genotypes on flower initiation (days) of cotton plant.

Sowing Dates	Year-I					Year-II				
	Cotton Genotypes					Cotton Genotypes				
	CIM-595	CIM-598	CIM-599	IR-3701	Means	CIM-595	CIM-598	CIM-599	IR-3701	Means
March-15	58.3	55.8	59.0	60.7	58.4 A	59.0	57.0	60.0	61.0	59.3 A
April-01	57.0	55.0	59.3	59.5	57.7 A	58.0	56.0	60.0	60.0	58.5 A
April-15	56.0	55.3	58.0	58.3	56.9 B	58.0	55.0	59.0	60.0	58.0 A
May-01	55.0	54.0	57.0	57.0	55.8 C	57.0	53.0	58.0	58.0	56.5 B
May-15	55.3	53.0	56.0	57.0	55.3 C	56.0	53.0	57.0	57.0	55.8 B
Means	56.3 B	54.6 C	57.9 A	58.5 A		57.6 B	54.8 C	58.8 AB	59.2 A	

Flower initiation of cotton plant

Main effect of SD and CG remained significant but their interaction (SD × CG) did not differ significantly for flower initiation of cotton plant. In year-I and year-II, CIM-599 and IR-3701 remained statistically alike to each other but differed significantly as compared to CIM-595 and CIM-598 for flower initiation of cotton plant (Table 4). Sowing of CG at March 15 and April 01 remained significantly similar to each other but differed significantly as compared to April 15, May 01 and May 15 for flower initiation of cotton plant in year-I. In year-II, sowing of CG at March 15, April 01 and April 15 remained statistically alike to each other but differed significantly as compared to May 01 and May 15 for flower initiation of cotton plant. Results also showed that with each delay in sowing time there was a considerable significant reduction in flower initiation of cotton plant. Maximum increase of 5.61% and 6.27% in flower initiation of cotton plant was noted when CG were sown at March 15 as compared to May 15 in year-I and year-II respectively. Similarly, maximum increase of 3.91% and 2.77% in flower initiation of cotton plant was noted in IR-3701 as compared to CIM-595 in year-I and year-II respectively.

Discussion

Results of current experiment confirmed that late sowing of cotton significantly decreased growth attributes in the various genotype of cotton. This reduction in growth attributes of cotton was might be due to change in temperature and humidity of the environment due to late sowing of seeds (Siddiqui *et al.*, 2004). Soomro *et al.* (2007) also noted a significant effect of sowing time on the yield of cotton. They argued that early or late sowing of seeds resulted in low production (Qayyum *et al.,* 1990) of cotton due to changing climatic condition (temperature) for optimum germination of seeds(Jamro *et al.,* 2017). Sowing of crops under low temperature resulted in less or late germination of seeds (Hussain *et al.,* 2012). It was observed that delay in sowing of cotton genotype significantly reduced plant height. The reduction in height was might be due shorter period of vegetative phase that cotton genotype experienced as a result of delay sowing. The findings of Williams (2008) also justified our argument regarding low plant height due to delay sowing of crops. They suggested that reduction in vegetative phase and prolonged reproductive phase is one of the major cause of decrease in height of plant. According to results of this study, sowing of cotton in March 15 can give maximum number of nodes per cotton plants. El-Moneim *et al.* (2017) also reported similar kind of results that early sowing (April 1st) of cotton gave maximum number nodes as compared to late sowing in May 2nd. Improvement in square and flower initiation in various cotton genotypes of the study was might be due to optimum prevalence of climatic temperature. Huang (2016) argued that sowing of cotton at proper season improved the square and flower initiation due to the growth of cotton in optimum required temperature (Khan *et al.*, 2017). Similar kind of results were also reported by Shah *et al.* (2017). Bozbek *et al.* (2006) suggested that better environmental conditions facilitate early initiation of squaring, flowering and boll formation that played an imperative role in the improvement of yield (Wrather *et al.*, 2008). Higher temperature usually resulted in the shedding of square that significantly decreased the yield of crops (Reddy *et al.*, 1999). According to Shah *et al.* (2017) sowing of cotton in March provides sufficient time for completion of all phenophases that resulted in improvement of initiation of squares and flowers.

Conclusion

It is concluded that cotton sowing on March 15 is the best time for sowing to achieve the maximum yield of cotton. Both CIM-599 and IR-3701 are good varieties that can be sown at March 15 to get optimum yield. However, CIM-599 is comparatively better than IR-3701. More, investigation is yet suggested to introduce good cotton genotype and best method of sowing in combination with optimum use of fertilizer to achieve maximum yield.

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