Research Article

Yield and Yield Contributing Traits of Cotton Genotypes as Affected by Sowing Dates

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Abstract | Cotton (*Gossypium hirsutum* L.), the White Gold, plays a vital role in Pakistan's economy. It is affected by variable environmental conditions throughout the country which confines its production. Two years field research was conducted at Cotton Research Station, Dera Ismail Khan to assess the impacts of six sowing dates on yield and yield attributing traits of seven cotton varieties during 2015 and 2016. The experiment was laid out in split plot design having three repeats. Sowing dates; March 15, April 01, April 15, May 01, May 15 and June 01 were kept in main plots while sub plot contained seven cotton varieties (CIM-600, CIM-616, CIM-622, CRIS-641, DNH-105, DNH-40 and DNH-57). Results indicated that earlier sowing produced extra vegetative growth rather than seed cotton yield while late planting induced flowering and boll formation when temperature was much cold that adversely affected cotton yield. The results further illustrated that, genotype DNH-105 ranked first for plant population, sympodia per plant, bolls per plant, weight per boll and seed cotton yield when sown on April 01. CIM-616 was the 2nd suitable variety under April 01 sowing. Earlier and later planting produced lower cotton yields due to unfavorable environment and shorter growth duration, respectively. Thus it is concluded that DNH-105 planted on April 01 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 is an important fibre crop sown in arid environment of Pakistan on an area of 3.20 million hectares with the total production of 2.15 million tons (APTMA, 2016). Apart from many biotic and a biotic stresses, inferior cotton varieties and sowing date are foremost factors accountable for low cotton productivity (Arshad et al., 2007). Optimum sowing time and suitable cotton genotypes for the area play an important role in cotton growth and development. Cultivar selection and sowing date management are vital factors, have a large influence on yield and yield attributes of cotton. These two factors mostly limit cotton growth, yield and quality as growth is a function of the product of genotype and environment (Zeng et al., 2014). Optimum time of sowing for different cotton varieties varies with regions depending upon the agro-climatic conditions of the area. Cotton varieties are mostly selected for greater yield, tolerance to unfavorable conditions and early maturity. Potential genotypes for better yield could be assessed by cultivating them in different sowing time. Both early and late sowing badly influence cotton yield.

Table 1: *Monthly seasonal precipitation, temperature and relative humidity (%) at Cotton Research Station, Dera Ismail Khan during 2015and 2016 growing seasons.*

Month	2015								2016							
	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.*

Arain et al. (2001) investigated that early sown cotton contributes more towards vegetative growth rather than cotton yield. Arshad et al. (2007) reported that warmest season caused severe loss of seed cotton yield due to dropping of flower and boll. Optimum sowing time provides sufficient time to cotton crop to complete its vegetative and reproductive periods efficiently and timely. Contrary to this, late planting causes flowering and maturity when temperature is much cold. 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). Insect pest can also be managed with late planting but this approach has lost its vitality due to the increasing use of transgenic cotton varieties which are resistant to pink bollworms. 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, much efforts is needed to adjust genotype with appropriate time of sowing in an environment in which all the components of climate are in the best favor of cotton growth and development. Furthermore, cotton varieties are more affective to the surrounding environments of the area and vary in their yields. Thus it is important to study interaction of sowing date and genotype to determine optimum sowing date for enhancing cotton yield and quality in irrigated condition of D.I. Khan, Pakistan.

Materials and Methods

Experimental site

Field trials were conducted during 2015and 2016 at Cotton Research Station, D.I.Khan (31°49´N, 70°55´E, 166 m a.s.l.). The experimental soil was fine, hyperthermic, and typic torrifluvents. It is an arid to semi arid region having limited rain fall (about 200 mm mean annual rainfall) which is not enough for growing crops. The soil of the research site was clay loam, having less than one percent organic matter and scarce in total N (0.07%). The site is calcareous and alkaline in nature, pH 7.78 (Soil Survey Staff 2009). Weather record was obtained from AZRC near the station are shown 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 treatments comprised of six sowing dates; March 15, April 01, April 15, May 01, May 15, and June 01 while subplots included seven genotypes namely, CIM-600, CIM-616, CIM-622, CRIS-641, DNH-105, DNH-40 and DNH-57. The land was prepared with cultivator and bed-furrows were made with special ridger 75 cm apart from each other. The beds were properly shaped with bed shaper and pre-emergenc herbicide (Pendimethaline) at the rate of 82.5 g ha^{-1} a.i. was applied to control weeds. The furrows were irrigated and delinted cotton seeds were dibbled manually on the same day in the moist soil on its proper place, at 75 cm inter-row and 22.5 cm intra-row spacing on May14 and May 17

Table 2: *Mean square values of plant population, sympodia, boll number, weight per boll, seed cotton yield as affected by sowing dates and genotypes.*

S.V	D. F	Plant Population	Sympodia	Bolls plant^{-1}	Weight per boll	Seed cotton yield
Replication	2	3.31	0.113	1.008	0.022	2885
Sowing dates (D)	5	4.34**	216.44**	346.65**	0.5315**	3823543**
Error a	10	1.78	0.347	1.770	0.0003	2261
Varieties (V)	6	1.22**	80.74**	253.02**	0.9423**	2279246**
D x V	30	2.92**	3.87**	5.43**	0.0027**	28197**
Error b	72	2.86	0.350	0.833	0.00067	1074

*, **: *Significant at 5% and 1% level of probability respectively.*

during both years. The furrows were irrigated 72 hours after dibbling to have successful seed emergence. However, subsequent irrigations were given at 15 days interval uptil crop maturity. Each subplot was 3 m wide and 10 m long and consisted of four rows. All phosphorous at the rate of 90 kg per ha was incorporated during land preparation, while N was given in 3 splits, namely one-third of the treatment each at sowing, at flowering, and at boll formation during both years. All agronomic and plant protection measures were adopted as per need of the cotton crop.

Procedure for data recording

Data on plant population were counted total number of plants in each plot at the end of the crop and calculated on hectare basis. Sympodia, fruit bearing braches per plant were counted from five randomly selected plants from each plot and then averaged. Number of bolls were counted from randomly selected five plants in each treatment at maturity and converted to average number of bolls plant^{-1}. Seed cotton of fully opened fifty bolls from each treatment was picked, sun dried, weighed and then averaged to per boll weight basis. After complete picking, seed cotton from each plot was weighed and then yield was calculated on hectare basis.

Statistical analysis

Data were recorded and analyzed statistically using analysis of variance techniques (Steel et al., 1997) and averaged over two years were compared by LSD ($p<0.05$) test. The analysis was performed by using "Statistix 8.1" computer software program.

Results and Discussion

Plant population

Plant population contributes fundamental share in the success or failure of cotton crop. ANOVA for plant population shared significantly differences for sowing dates, genotypes and sowing dates × genotypes interactions (Table 2). Mean vales for sowing dates averaged over years revealed that higher number of plants per hectare was recorded in April 01 sowing compared to all other combinations (Table 3). Mean vales for genotypes revealed that DNH-105 significantly produced more number of plants per hectare. Interaction revealed that DNH-105 sown on April 01 and April 15 produced more plant population per ha than all other genotypes. Palomo et al. (2000) reported that April sown cultivars gave the highest number of plans per unit area than June sown cultivars of cotton.

Sympodia per plant

Sympodial branch is a boll bearing branch which is an important quantitative character that contributes directly to seed cotton yield. The analysis of variance for sympodia revealed significant differences for sowing dates, genotypes and sowing dates × genotypes interactions (Table 2). Sowing dates effects averaged over years revealed that April 01 sowing had maximum sympodial branches among other sowing dates (Table 4). Generally, too early and too late sowing resulted in lower sympodia. Among genotypes, DNH-105 produced greater sympodia among all other varieties. Interaction revealed that DNH-105 sown on April 01 produced more number of sympodial branches per plant than all other genotypes. Poonia et al. (2002) reported that every fortnight delay in sowing aftar April 01 resulted decrease in sympodia. Ehsan et al. (2008) observed highly positive and significant relationship between sympodia and sowing time. Bolonhezi et al. (2000) reported analogous results who reported that different cultivars were different in number of sympodial branches due to differences in their genetic makeup.

Boll number per plant

Bolls plant^{-1} was significant for sowing dates,

Table 3: *Effect of sowing dates and genotypes on plant population per hectare.*

Genotypes	Sowing dates						Mean
	March 15	April 01	April 15	May 01	May 15	June 01	
CIM-600	26796 k-q	34347 def	27793 j-o	20864 st	23826 qrs	19338 t	25494 f
CIM-616	28106 i-n	38705 abc	35937 cd	30630 hij	28330 i-m	28187 i-m	31649 b
CIM-622	27007 k-p	36347 bcd	31011 g-j	26967 k-p	24819 o-r	25897 l-r	28675 d
CRIS-641	25007 n-r	36705 bcd	29011 i-l	24967 o-r	22819 rs	23897 p-s	27068 e
DNH-105	31040 ghi	41386 a	39851 a	35749 cde	31227 f-i	32723 e-h	35329 a
DNH-40	26106 l-q	39386 ab	33937 d-g	28630 i-m	26330 l-q	26187 l-q	30096 c
DNH-57	28796 i-m	32756 e-h	29793 h-k	22864 rs	25826 m-r	21338 st	26895 e
Mean	27551 c	37090 a	32476 b	27239 c	26168 d	25367 d	

$LSD_{0.05}$ Sowing dates: *917.87;* **Genotypes:** *1324.0;* **Sowing dates × genotypes:** *3243.0; Any two means in their respective group sharing no common letter(s) are significant ($p<0.05$).*

Table 4: *Effect of sowing dates and genotypes on sympodia plant^{-1}.*

Genotypes	Sowing dates						Means
	March 15	April 01	April 15	May 01	May 15	June 01	
CIM-600	9.17 no	12.33 h	10.00 mn	9.33 no	7.90 op	4.83 r	8.93 f
CIM-616	12.00 hij	17.00 bc	16.33 cd	15.33 e	11.23 jkl	7.17 q	13.18 b
CIM-622	11.50 ijk	12.33 hi	11.33 jk	10.7klm	7.90 pq	4.83 r	9.76 e
CRIS-641	15.17 jk	14.00 g	12.33 hi	11.33 jk	8.57 op	3.83 s	10.87 d
DNH-105	14.17 fg	18.67 a	17.33 b	15.67 de	12.90 h	9.17 no	14.65 a
DNH-40	11.33 jk	15.33 e	15.00 ef	12.00 hij	9.23 no	5.17 r	11.34 c
DNH-57	11.17 jkl	12.67 h	10.33 lm	9.33 no	7.57 q	4.50 rs	9.26 f
Mean	12.07 c	14.62 a	13.24 b	11.95 c	9.33 d	5.64 e	

LSD0.05 Sowing dates: *0.4049;* **Genotypes:** *0.3929;* **Sowing dates × genotypes:** *0.9623; Any two means in their respective group sharing no common letter(s) are significant ($p<0.05$)*

genotypes and their interactions (Table 2). Data over years mean revealed that April 01 sowing produced maximum boll per plant while June 01 sowing produced minimum bolls number per plant (Table 5). The results further indicated that the response of genotypes was modified by sowing dates. Mean values for genotype revealed that DNH-105 gave higher boll number as compared to all other genotypes. Interactive effect revealed that DNH-105 sown on April 1-15 produced more bolls per plant as compared to all other combinations. In too early and late sowing of cotton, flowering corresponded to high temperature stress (June - July) and thus lower bolls retention per plant was recorded as reported by cotton researchers (Elayan e al., 2015). In our study, growth conditions including temperature in April 1-15 sowing were much better than all other sowing dates that probably provided more favorable environment for translocation and mobilization of photosynthates which resulted in production of large number of bolls (Poonia et al., 2002).

Weight per boll

Boll weight was significantly affected by sowing dates, genotypes and their interactions (Table 2). Mean data for two years revealed that sowing on April 01 was optimum among all other sowing dates by producing highest boll weight (Table 6). April 15 was the next suitable sowing date after April 01 which produced higher boll weight than the rest of the sowing dates. In contrast, early sown cotton had lower weight per boll probably due to insect pests attack. Among genotypes, DNH-105 produced highest boll weight. Interactive effects indicated that DNH-105 exhibited maximum boll weight when sown on April 01. Our results revealed that boll weight declined when sowing was delayed beyond April 15. The lowest boll weight was thus obtained from June 01 sowing date. Cold night temperature may be the probable reason for poorly developed boll from late sowing date. Zeng et al. (2014) evaluated that cotton varieties had genetic potential to express boll weight under different sowing dates.

Table 5: *Effect of sowing dates and genotypes on bolls plant^{-1}.*

Genotypes	Sowing dates						Mean
	March 15	April 01	April 15	May 01	May 15	June 01	
CIM-600	14.50 n-q	18.00 ijk	15.67 l-o	13.50 q	13.33 q	9.17 r	14.03 f
CIM-616	20.50 d-g	25.00 b	24.33 b	22.50 c	19.33ghi	13.17 q	20.81 b
CIM-622	15.83 l-o	19.33 ghi	18.00 ijk	16.83 jkl	14.3 opq	9.50 r	15.64 e
CRIS-641	18.50 hi	19.67 fgh	19.33 ghi	18.17h-k	14.00 pq	8.50 r	16.36 d
DNH-105	28.83 a	30.0 a	29.0 a	24.17 b	21.00 c-f	15.2 m-p	24.69 a
DNH-40	17.83 ijk	21.67 cde	22.00 cd	20.17efg	16.0 lmn	9.83 r	17.92 c
DNH-57	17.83 ijk	18.33 hij	16.67 klm	16.17 lm	13.67 pq	8.50 r	15.19 e
Mean	19.12 c	21.71 a	20.71 b	18.77 c	15.95 d	10.55 e	

$LSD_{0.05}$ Sowing dates: *0.9148;* **Genotypes:** *0.6064;* **Sowing dates × genotypes:** *1.4853; Any two means in their respective group sharing no common letter(s) are significant (p<0.05)*

Table 6: *Effect of sowing dates and genotypes on boll weight (g.).*

Genotypes	Sowing dates						Mean
	March 15	April 01	April 15	May 01	May 15	June 01	
CIM-600	2.27 r	2.65 n	2.50 p	2.40 q	2.30 r	2.20 s	2.39 f
CIM-616	2.81 ij	3.19 b	3.04 d	2.94 f	2.84 hi	2 2.74 k	2.93 b
CIM-622	2.61 o	2.86 gh	2.71 kl	2.61 o	2.51 p	2.41 q	2.62 d
CRIS-641	2.60 o	2.85 ghi	2.70 klm	2.60 o	2.50 p	2.40 q	2.61 d
DNH-105	5 2.93 f	3.34 a	3.19 b	3.09 c	2.99 e	2.88 g	3.07 a
DNH-40	2.66 mn	2.94 f	2.79 j	2.69 lmn	2.59 o	2.49 p	2.69 c
DNH-57	2.58 o	2.83 hij	2.68 lmn	2.58 o	2.48 p	2.38 q	2.59 e
Mean	2.64 d	2.95 a	2.80 b	2.70 c	2.60 e	2.50 f	

$LSD_{0.05}$ Sowing dates: *0.0108;* **Genotypes:** *0.0172;* **Sowing dates × genotypes:** *0.0422; Any two means in their respective group sharing no common letter(s) are significant (p<0.05).*

Table 7: *Effect of sowing dates and genotypes on seed cotton yield kg ha^{-1}.*

Genotypes	Sowing dates						Mean
	March 15	April 01	April 15	May 01	May 15	June 01	
CIM-600	1506.6 u	1829.8 l-o	1680.1 rs	1399.2 v	1236.8 x	711.2 z	1394.0 g
CIM-616	2098.9 fg	2504.6 c	2363.2 d	2237.2 e	1933.5 ij	1326.2w	2077.3 b
CIM-622	1800.2 op	2008.1 h	1901.2 jk	1803.8no	1429.8 v	944.6 z	1647.9 d
CRIS-641	1887.9 jkl	1984.1 hi	1873.5 klm	1744.5pq	1314.5 w	806.8 a	1601.9 e
DNH-105	2816.4 b	2915.8 a	2791.5 b	2393.5 d	2040.8gh	1537.2 u	2415.9 a
DNH-40	1893.7 jk	2196.2 e	2133.2 f	2036.8 h	1625.8 st	1033.8 y	1819.9 c
DNH-57	1855.8 k-n	1828 mno	1703.2 qr	1606.8 t	1295.8 w	833.2 z	1520.5 f
Mean	1979.9 c	2181.0 a	2063.7 b	1888.8 d	1553.9 e	1027.6 f	

$LSD_{0.05}$ Sowing dates: *32.697;* **Genotypes:** *21.778;* **Sowing dates × genotypes:** *53.345; Any two means in their respective group sharing no common letter(s) are significant (p<0.05).*

Seed cotton yield kg per hectare

Seed cotton yield had significant response to sowing dates, genotypes and sowing dates × genotypes interactions (Table 2). Data over two years mean revealed that highest seed cotton yield was obtained from April 01 sowing while late sowing (June 01) resulted in lowest seed cotton yield (Table 7). Means for genotype revealed that DNH-105 produced highest seed cotton yield as against CIM-600 which produced lowest seed cotton yield. Interaction effects revealed that April 01 sowing optimized seed cotton yield with cotton genotype DNH-105. April 15 and

May 01 were second suitable sowing dates after April 01 for better 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).

Conclusion

This study comprised of six sowing dates (March 15, April 01, April 15, May 01, May 15, and June 01) and seven genotypes (CIM-600, CIM-616, CIM-622, CRIS-641, DNH-105, DNH-40, DNH-57). It was observed that yield and DNH-105 performed better regarding cotton yield and yield attributing traits when sown on April 01. 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 01 sowing was the optimum sowing date at which all other genotypes. Therefore, it is generally recommended to grow cotton on April 01 irrespective of the genotypes, however, genotype, DNH-105, namely Israr Shaheed had a comparatively higher potential to optimize seed cotton yield in D.I. Khan region of Khyber Pakhtunkhwa, Pakistan.

Authors' Contribution

Dr. Niamat ullah Khan is the principal and corresponding author who conducted this research. Mr. Najeeb Ullah is the co-author who measured observation and prepared draft. Mr. Inam Ullah assisted in preparation of the draft of this paper. Mr. Asif Imran Shah helped in preparation of methodology, data collection.

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