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Varietal comparison of Bt and non-Bt cotton (*Gossypium hirsutum* L.) under different sowing dates and nitrogen rates

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Abstract

To compare the effect of planting time and N levels on phenology and seed cotton yield of Bt and non-Bt cotton, an experiment was laid out at Students' Farm, University of Agriculture, Faisalabad, Pakistan. Two cotton cultivars; FH-113 (Bt) and CIM-496 (non-Bt) were planted during mid March and mid May using 115, 145 and 175 kg ha^{-1} N levels. Planting times were placed in main plots, varieties in sub plots and N levels in sub sub plots in randomized complete block design with three replications. All the interactions (sowing date × varieties, sowing dates × nitrogen levels, varieties × nitrogen levels, sowing dates × varieties × nitrogen levels) were non significant for parameters (Days taken to squaring, flowering, first boll splition, vertical and horizontal flower interval, boll maturation period, node above white flower, node number for first fruiting branch, first fruiting branch height, earliness index, number of monopodial and sympodial branches per plant, average boll weight per plant, seed cotton yield kg ha^{-1}) under discussion except variety × sowing date for seed cotton yield. Mean values for various phenological events like days taken to squaring, first flower and first boll splition, BMP (boll maturation period), first fruiting branch height (cm), first fruiting branch node number and node above white flower varied invariably between Bt and non Bt sown at different times. Vertical as well as horizontal flower intervals remained unaffected. Maximum seed cotton yield was recorded in FH-113 at mid March planting and minimum in CIM-496 at mid May planting. A N level of 145 kg ha^{-1} gave maximum seed cotton yield against the minimum with 115 kg ha^{-1}. It was concluded that performance of Bt cotton was better in both mid March and mid May planting with respect to seed cotton yield per hectare.

Keywords: Vertical flower interval, horizontal flower interval, NAWF, Seed cotton yield

Introduction

Adopting new technology always involves advantages and risks. Bt cotton (*Gossypium hirsutum* L.) is a well known technology in developed countries for its many advantages, such as higher lint yield, reduced pesticide application and better insect pest control; however, its success in developing countries is still a question mark (Bilal *et al*., 2012). Bt cotton use by farmers in Pakistan was increased in 2009, reaching to almost 80% in Punjab and Sindh (Govt of Pakistan, 2010). Global adoption of Bt cotton has risen dramatically from 0.76 million ha in 1996 to 7.85 million ha in the 2005 (Arshad *et al*., 2007).

Cotton "white gold" or "the king of fiber" is the leading fibre crop world wide and is grown commercially in more than 50 countries (Smith, 1999). It is cash crop of Pakistan and a good fortune in the form of foreign exchange for the country (Ahmad *et al*., 2009). In 2011-2012, cotton was planted on an area of 2.8 million hectares, having production of 13.6 million bales with average yield of 815 kg ha^{-1} (Govt of Pakistan, 2012).

In United States Bt (transgenic insect resistant) cotton was first time grown commercially in 1996 (Hardee and Herzog, 1997). Bollgard cotton commonly known as Bt cotton was developed by Monsanto for the control of insect pest in cotton crop (Jenkins *et al*., 1997). The Bt cotton varieties produced profitable yields comparable to that of conventional varieties (Presley *et al*., 1999).

Deviation in temperature during cotton growing season affects various phenological stages; days to first floral bud, first flowering, first boll spilition and boll opening period (Hussain *et al*., 2000). Delayed sowing decreased yield and fiber traits due to a reduced fruiting period and delayed maturity relative to normal sowing of cotton crop (Bauer *et al*., 2000). Delayed planting of cotton crop results in reduction of seed cotton yield (Sharma and Sharma, 1992). Peak flowering occurs during August so, temperature during this month significantly affects cotton yield low maximum temperatures are associated with higher yield and high temperatures with lower yield due to more square, flower and boll drop due to higher temperature (Oosterhuis,

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1999). Bt transgenic (cv, SCRC 21) in early planting gave better yield than late planted (Hezhong *et al*., 2006). During peak squaring and boll period N contents in Bt cotton cultivars were more than their parents, this increase in uptake of N in the leaf of Bt cotton might be due to introduction of Bt gene (Chen *et al*., 2005).

In dynamic crop like cotton, immoderate nitrogen impediments maturity, promotes vegetative growth and reduced cotton yields (Meconnell *et al*., 1996). Opened bolls per plant and boll weight were significantly higher at 143 kg N ha^{-1} than with 95 kg N ha^{-1} (Sawan *et al*., 2006). Leaf photosynthetic rate increased by 11 to 29%, when plants were given up to 157 kg N ha^{-1} (Cadena and Cothren, 1995). In building the protein structure (Frink *et al*., 1999), seed development and carbon skeletons N played important role (Patil *et al*., 1996). Due to N deficiency ethylene was probably produced, which resulted increased fruit loss in cotton (Lege *et al*., 1997). The present experiment was conducted to study the phenological traits and yield response of Bt and non Bt cotton, planted at different times, to low, medium and high dose of nitrogen. Our assumption was "A good non-Bt cotton cultivar can compete Bt cotton in productivity if planted earlier (Feb- March) with higher N dose".

Table 1: Physio-chemical analysis of soil

Characteristic	Unit	Value			
		2009		2010	
A) Depth of sample	**cm**	**0-15**	**15-30**	**0-15**	**15-30**
B) Mechanical analysis					
Sand	%	49	49	49	49
Silt	%	22	22	22	22
Clay	%	29	29	29	29
Textural class		Loam			
C) Chemical analysis					
Saturation	%	32	32	31	31
EC	mS cm^{-1}	0.60	0.48	0.60	0.48
pH	--	7.4	7.4	7.4	7.4
Organic matter	%	0.75	0.55	0.74	0.56
Total nitrogen	%	0.041	0.037	0.042	0.036
Available phosphorus	mg kg^{-1}	8.5	7.2	8.6	7.1
Available potassium	mg kg^{-1}	230	210	235	205

Materials and Methods

Experimental detail

A field experiment was conducted to determine the effect of sowing dates and nitrogen levels on the performance of Bt and non-Bt cotton at students' farm, University of Agriculture, Faisalabad, Pakistan for two consecutive years (2009 and 2010) located at 73.09^{o} East longitude, 31.25^{o} North latitude and at an altitude of 183 meters above sea level. Experiment was conducted in randomized complete block design with split-split arrangement and replicated thrice. The experiment included two cotton cultivars; FH-113 (Bt) and CIM-496 (non-Bt) that were planted at two different times (mid March and mid May) using three nitrogen levels (115, 145 and 175 kg ha^{-1}). Planting times were placed in main plots, varieties in sub plots and N levels in sub sub plots. Net plot size was 6m × 3m having plant to plant distance 0.30 m and row to row distance 0.75 m. Soil samples were taken before sowing of crop to a depth of 0.15 cm and 0.30 cm for physio-chemical analysis (Table 1).

Crop husbandry

The cotton crop was sown on well prepared ridges on March 13 and May 15, 2009 and on March 15 and May 14 during 2010 manually using seed rate of 15 kg ha^{-1}. Thinning was done to maintain plant to plant spacing at third true leaf stage with the help of man power. At planting time full dose of P (115 kg ha^{-1}) was applied while N was applied in three equal splits viz. at planting, after 35 days of planting and after 65 days of planting. On the whole nine irrigations were applied and two hoeings at 30 and 65 days after planting were done for weeds control. Insecticides Imidacloprid 20 SL at 200 mL ha^{-1} and Diafenthiuron 500 EC at 500 mL ha^{-1} were applied to control the sucking insects (Whitefly, Aphid, Thrips, Jassid and Mites) while Amamectin benzoate 19% EC at 500 ml ha^{-1} and Bifenthrin 10% EC at 600 mL ha^{-1} were sprayed for bollworms (Pink bollworm, Spotted bollworm and Army worm). The entire agronomic practices were kept uniform and normal for all the treatments. Ten guarded representative plants were selected randomly in each plot when seedlings had been established, and observation were recorded as follows:

Measurements

Days to first square, first flower or first boll splition were recorded on ten guarded plants and average was calculated. Vertical flower interval (days) was calculated by recording number of days between flowering at corresponding nodes on successive fruiting branches, upto the main stem while horizontal flower interval was measured by counting number of days between anthesis of flower at the first and second position on the same fruiting branch. Boll maturation period (days) was calculated by deducting number of days taken to flowering from number of days taken for boll splition. Node above white flower measurements were initiated from ten selected plants with the appearance of first flower and continued until physiological cutout stage (NAWF=4) on week basis, then average node above white flower was calculated.

Node number for first fruiting branch was measured by number of the main stem node at which first fruiting branch arose. It was determined by designating node immediately above the cotyledonary scars as number two, and counting the successive ascending nodes until the one that gave rise to the first fruiting branch was reached. Height of first fruiting branch (cm) was measured from pseudonode of ten selected plants and finally average height of first fruiting branch was calculated. Earliness index (%) was measured with the help of following formula. This index is referred as maturity coefficient.

$$\text{Earliness index (\%)} = \frac{\text{Weight of seed cotton from first pick}}{\text{Total seed cotton weight from all picks}} \times 100$$

Monopodial and sympodial branches of ten randomly selected plants from each plot were counted and average number of monopodial and sympodial branches per plant was calculated. Average boll weight (g) was calculated by dividing the total plant seed cotton yield with respective number of bolls per plant. Seed cotton yield (kg) per hectare was computed from seed cotton yield per plot. Plant height (cm) of ten randomly selected plants from each plot was measured at the time of last picking and average height was calculated.

Statistical analysis

Data on all mentioned measurements were statistically analyzed by using MSTAT-C programme (Anonymous, 1986) and means were compared using least significant difference (LSD) test at $p \geq 5$ (Steel *et al*., 1997). Figures were drawn by using Excel program.

Results

Phenological traits of cotton

Data pertaining to days taken to squaring, days to flower and days to first boll splition as influenced by planting time, varieties and N rates are presented in Table 2. Planting time and N rates significantly influenced phenological characters under discussion, while varieties were least influenced and interactions between sowing dates x varieties, sowing dates x nitrogen levels, varieties x nitrogen levels, sowing dates x varieties x nitrogen levels were found to be non-significant. Maximum days to first squaring, first flowering and first boll splition were recorded in S_1 (mid March planting) whereas minimum number was observed in S_2 (mid May planting). More number of days taken to appearance of first flower and first boll splition was recorded in V_2 (CIM-496) than V_1 (FH-113). Among nitrogen levels maximum number of days to squaring, flowering and first boll splition were observed with high N rate (175 kg ha^{-1}) and was at par with medium dose of N (145 kg ha^{-1}) while minimum in N_1 (115 kg ha^{-1}) during both the year of study ($p \geq 0.05$).

Data (Table 3) pertaining to the vertical flower interval (days) and horizontal flower interval (days) were significantly altered only by varieties recording more days in CIM-496 than in FH-113.

Effect of sowing date on boll maturation period was significant; more boll maturation period (41.18 & 40.73) was observed with mid May planting than in March planting (31.85 & 30.32) during both study years. Varieties differed significantly in 2009 with more boll maturation period (38.70) in FH-113 and less (34.34) in CIM-496; while in 2010 boll maturation period remained similar in both varieties. Other factors as varieties, nitrogen levels and their first and second order interactions showed non-significant effect (Table 3).

Node above white flower was significantly affected by sowing dates x varieties and nitrogen levels as shown in Tabe 3. Comparison of treatments means showed that maximum number of nodes above white flower (5.95 & 5.82) was observed in S_1 x V_1 (FH-113 sown during mid March), it was closely followed by S_2 x V_2 (CIM-496 when sown in mid May) while minimum number of nodes above white flower (4.49 & 4.73) was recorded in S_2 x V_1 (FH-113 sown in mid May). While among nitrogen levels maximum number of nodes above white flower (5.45 & 5.94) was observed in N_3 (175 kg N ha^{-1}) which was statistically at par with N_2 (145 kg N ha^{-1}) and minimum nodes above white flower (4.59 & 4.77) was recorded in N_1 (115 kg N ha^{-1}).

Data in Table 4 indicate that significantly more node number for first fruiting branch as well as more first fruiting branch height (cm) were observed in FH-113 than in CIM-496; while sowing dates, nitrogen rates and their interactions showed non-significance. On the other hand earliness index (%) was influenced only by nitrogen rates, while sowing dates, varieties and all possible interactions were found to be non-significant. Statistically maximum earliness index (53.50 and 51.89%) was recorded with115 kg N ha^{-1} that was at par with nitrogen dose of 145 kg ha^{-1} and minimum earliness index (46.30 and 45.47%) was recorded with 175 kg N ha^{-1} during 2009 and 2010 (Table 4).

for number of sympodial branches (Table 5). Effect of nitrogen rate also significant; the number of monopodial as well as sympodial branches increased with increasing nitrogen.

Significantly more boll weight (4.04 g) was observed in V_1 (FH-113) and less (2.99 g) in V_2 (CIM-496); while sowing dates, nitrogen levels and their interactions, sowing dates x varieties, sowing dates x nitrogen levels, varieties x nitrogen levels, sowing dates x varieties x nitrogen levels showed non-significant effects on average boll weight (Table 5).

Comparison of treatments means indicated that maximum seed cotton yield (3072 & 3035 kg ha^{-1}) was recorded in V_1 (FH-113) at S_1 (mid March planting) and minimum (1761 & 1724 kg ha^{-1}) was recorded in V_2 (CIM-496) at S_2 (mid May planting), while V_2 (CIM-496) at S_1 (mid March planting) was at par with V_1 (FH-113) at S_2 (mid May planting). Amongst the nitrogen levels, N_2 (145 kg ha^{-1}) gave maximum seed cotton yield (2833 &

Table 2: Effect of sowing dates, varieties and nitrogen levels on phenological traits of cotton

	DTS		DTF		DTBS	
	2009	**2010**	**2009**	**2010**	**2009**	**2010**
Sowing dates (S)						
Mid March (S_1)	43.12 a	32.86 a	63.78 a	45.14 a	95.64 a	82.77 a
Mid May (S_2)	34.16 b	30.22 b	44.24 b	42.04 b	85.43 b	75.46 b
LSD (p=0.05)	2.42	2.07	1.36	3.01	3.10	1.73
MSE	2.85	2.08	0.90	4.41	4.67	1.47
Variety (V)						
FH-113 (V_1)	38.32	32.08	53.01 b	42.15 b	89.36 b	77.73 b
CIM-496 (V_2)	38.96	31.00	55.02 a	45.03 a	91.71 a	80.51 a
LSD (p=0.05)	NS	NS	0.87	2.50	1.81	2.41
MSE	5.25	1.75	0.90	7.32	3.85	6.82
Sowing date x Variety						
S_1 x V_1	41.84	33.46	62.80	42.84	96.77	82.02
S_1 x V_2	44.40	32.26	64.77	47.44	94.51	83.53
S_2 x V_1	34.80	30.71	43.22	41.46	86.64	73.44
S_2 x V_2	33.53	29.73	45.26	42.62	84.22	77.48
LSD (p=0.05)	NS	NS	NS	NS	NS	NS
MSE	5.25	1.75	0.90	7.32	3.85	6.82
Nitrogen rate (kg ha^{-1}) (N)						
115 (N_1)	36.45 b	29.95 b	51.83 b	41.40 b	88.51 b	76.50 b
145 (N_2)	38.81 ab	31.51 ab	55.08 a	43.88 a	90.96 a	79.46 a
175 (N_3)	40.66 a	33.16 a	55.13 a	45.50 a	92.13 a	81.40 a
LSD (p=0.05)	2.62	1.85	1.53	1.35	1.78	1.68
MSE	9.16	4.58	3.14	2.45	4.25	3.77
S x N, V x N, S x V x N,			NS			

Means not sharing a letter in common within a column differ significantly at 5% probability level. NS= Non-significant; DTS: Days taken to squaring, DTF: Days taken to flowering, DTBS: Days to first boll splition. MSE: Mean squares of error

Yield and yield components

Interactive effect of sowing date and variety was significant on number of monopodial branches. Statistically ($p \geq 0.05$) maximum monopodial branches were recorded in CIM-496 when it was planted in May against minimum in FH-113 planted in March. The result were exactly opposite

2797 kg ha^{-1}) which was at par with N_3 (175 kg ha^{-1}) attaining seed cotton yield of 2677 and 2640 kg ha^{-1} while N_1 (115 kg N ha^{-1}) gave minimum seed cotton yield of 2016 and 1979 kg ha^{-1} in 2009 and 2010, respectively (Table 5).

Table 3: Effect of sowing dates, varieties and nitrogen levels on phenological traits of cotton

	VFI		HFI		BMP		NAWF	
	2009	**2010**	**2009**	**2010**	**2009**	**2010**	**2009**	**2010**
Sowing dates (S)								
Mid March (S_1)	4.16	4.03	7.19	7.15	31.85 b	30.32 b	5.51	5.72
Mid May (S_2)	4.16	4.04	7.18	7.04	41.18 a	40.73 a	4.79	5.15
LSD (p=0.05)	NS	NS	NS	NS	3.23	1.65	NS	NS
MSE	0.15	0.67	2.59	2.44	5.08	1.33	0.64	0.33
Variety (V)								
FH-113 (V_1)	3.79 b	3.64 b	6.79 b	6.73 b	38.70 a	35.47	5.22	5.28
CIM-496 (V_2)	4.52 a	4.44 a	7.58 a	7.47 a	34.34 b	35.57	5.08	5.60
LSD (p=0.05)	0.66	0.47	0.46	0.49	2.20	NS	NS	NS
MSE	0.50	0.26	0.25	0.28	5.66	0.10	0.15	0.16
Sowing date x Variety								
S_1 x V_1	3.80	3.61	6.79	6.74	33.97	30.04	5.95 a	5.82 a
S_1 x V_2	4.52	4.45	7.58	7.56	29.73	30.60	5.08 bc	5.62 a
S_2 x V_1	3.79	3.66	6.78	6.72	43.42	40.91	4.49 c	4.73 b
S_2 x V_2	4.53	4.42	7.58	7.37	38.95	40.55	5.08 ab	5.57 a
LSD (p=0.05)	NS	NS	NS	NS	NS	NS	0.51	0.53
MSE	0.50	0.26	0.25	0.28	5.66	0.10	0.15	0.16
Nitrogen rate (kg ha^{-1}) (N)								
115 (N_1)	4.15	4.15	7.20	7.22	36.68	35.10	4.59 b	4.77 b
145 (N_2)	4.18	3.71	7.20	6.77	35.88	35.58	5.41 a	5.60 a
175 (N_3)	4.15	4.24	7.15	7.30	37.00	35.90	5.45 a	5.94 a
LSD (p=0.05)	NS	NS	NS	NS	NS	NS	0.47	0.52
MSE	0.22	0.17	1.50	0.93	8.68	0.65	0.29	0.37
S x N, V x N, S x V x N,			NS					

Means not sharing a letter in common within a column differ significantly at 5% probability level. NS= Non-significant; VFI: vertical flower interval (Days), HFI: Horizontal flower interval (Days), BMP: Boll maturation period (Days), NAWF: Node above white flower. MSE: Mean squares of error

Discussion

Phenological events

The appearance of first floral bud can be used as an estimator of earliness (Richmond and Radwan, 1962) but recent research revealed that appearance of first floral bud (squaring) was not standard criterion to estimate the earliness of a cultivar (Saleem *et al*., 2009). Squaring varied with differences in sowing time as the effect of temperature on days to squaring are well documented (Jost and Cothren, 2001). The effect of sowing dates on the appearance of first floral bud may be due to the effect of prevailing weather conditions during the cotton crop growth period. During mid March, low temperature, less sunshine hours and rainfall (Figure 1) might have delayed the appearance of first floral bud than mid May sowing during 2009 than 2010. Appearance of first flower can be altered by various factors like prevailing temperature during the cotton crop growth period (Shaheen *et al*., 2001) and cultivars (Anjum *et al*., 2001). First boll splition is a key trait for determination of early maturity in cotton crop (Iqbal *et al*., 2003), while first boll splition might be influenced by genetic blood of cotton cultivars (Shakeel *et al*., 2008) and temperature (Hussain *et al*., 2000). Excess of nitrogen promotes vegetative tendencies and delays maturity (Meconnell *et al*., 1996).

Vertical flower interval did not prove to be an important criterion for selection of rapid fruiting genotype (Smith, 1984) but it was clearly suggested that by modification in flowering intervals early cotton crop maturity may be possible (Bednarz and Nichols, 2005). Horizontal flower interval ranged from 5.33 to 6.25 in field conditions (McClelland and Neely, 1931), while even longer horizontal flower interval (9.4) has also been recorded (Munro, 1971). As against the non-significant effects of sowing time in present study, horizontal flower interval was significantly affected by temperature variation during the growing season of cotton crop (Hesketh *et al*., 1975); however, we found varietal differences as it can be improved during the breeding program (Godoy and Palomo, 1999) whereas the cultivars having less horizontal flower interval are early maturing (Bednarz and Nichols, 2005).

maturation period decreased which ultimately might have reduced the crop maturity.

Our results are supported with the earlier finding that cultivars differed with respect to node number for first fruiting branch (Babar *et al*., 2002). Increase in first fruiting branch height in second sowing date (mid May planting) may be due to varying environmental conditions; during crop growth period of March sown crop cloudy environment might have decreased or even ceased the growth of cotton crop so internodal distance was less in mid March planting than mid May planting during both years of study (Figure 1 and 2).

Table 4: Effect of sowing dates, varieties and nitrogen levels on earliness indicators of cotton

	NNFFB		FFBH		EI	
	2009	**2010**	**2009**	**2010**	**2009**	**2010**
Sowing dates (S)						
Mid March (S_1)	6.54	6.65	19.07	18.38	52.24	48.66
Mid May (S_2)	6.63	6.76	24.02	18.40	48.00	48.60
LSD (p=0.05)	NS	NS	NS	NS	NS	NS
MSE	0.30	0.13	3.23	0.96	50.14	154.19
Variety (V)						
FH-113 (V_1)	7.18 a	7.20 a	23.32 a	19.57 a	48.79	47.73
CIM-496 (V_2)	5.98 b	6.33 b	19.78 b	17.20 b	51.45	49.52
LSD (p=0.05)	0.68	0.38	2.22	1.10	NS	NS
MSE	0.55	0.17	5.77	1.41	16.34	28.50
Sowing date x Variety						
S_1 x V_1	7.20	7.13	20.88	19.38	51.88	47.67
S_1 x V_2	5.88	6.40	17.27	17.38	52.60	49.65
S_2 x V_1	7.17	7.26	25.75	19.77	45.70	47.80
S_2 x V_2	6.08	6.26	22.29	17.03	50.30	49.40
LSD (p=0.05)	NS	NS	NS	NS	NS	NS
MSE	0.55	0.17	5.77	1.41	16.34	28.50
Nitrogen rate (kg ha^{-1}) (N)						
115 (N_1)	6.55	6.63	21.39	18.01	53.50 a	51.89 a
145 (N_2)	6.55	6.86	21.31	18.66	50.55 ab	48.53 ab
175 (N_3)	6.66	6.80	21.94	18.48	46.30 b	45.47 b
LSD (p=0.05)	NS	NS	NS	NS	4.69	3.81
MSE	0.37	0.42	5.08	3.05	29.48	19.42
S x N, V x N, S x V x N,		NS				

Means not sharing a letter in common within a column differ significantly at 5% probability level. NS= Non-significant; NNFFB: Node number for first fruiting branch, FFBH: First fruiting branch height (cm), EI: Earliness index (%),MSE: Mean squares of error

Vertical and horizontal flower intervals are genetically induced characters that are least influenced by the abiotic factors. Inheritance of certain phenological variables like vertical and horizontal flower interval would not be appropriate plant traits for selection of early crop maturity; whereas number of days elapsed from white flower to cracked boll (BMP) that has been suggested as possible criterion for measuring maturity of cotton crop (Godoy and Palomo, 1999). Similar trend was observed in our study, as node above white flower increased the boll maturation period decreased which ultimately might have reduced the crop maturity.

Height of first fruiting branch was significantly affected by environmental conditions during the crop growth (Saeed *et al*., 2005) and by cultivars (Saleem *et al*., 2009) as well. Our results are supported by the earlier findings that earliness significantly decreased with increasing nitrogen rates (Ali and El-Sayed, 2001).

Table 5: Effect of sowing dates, varieties and nitrogen levels on seed cotton yield and its components

	MB		SB		BW		SCY	
	2009	**2010**	**2009**	**2010**	**2009**	**2010**	**2009**	**2010**
Sowing date (S)								
Mid March (S_1)	3.45 b	3.45 b	21.23 a	20.34 a	3.63	3.66	2829 a	2792 a
Mid May (S_2)	4.45 a	4.53 a	13.38 b	11.88 b	3.40	3.49	2189 b	2152 b
LSD (p=0.05)	0.94	0.98	1.37	1.90	NS	NS	344.8	343.9
MSE	0.43	0.46	0.91	1.76	0.56	1.12	57800	57497
Variety (V)								
FH-113 (V_1)	3.37 b	3.43 b	19.62 a	18.42 a	4.04 a	4.06 a	2844 a	2807 a
CIM-496 (V_2)	4.53 a	4.55 a	15.00 b	13.81 b	2.99 b	3.09 b	2173 b	2136 b
LSD (p=0.05)	0.57	0.54	2.66	1.16	0.40	0.56	173.8	173.3
MSE	0.38	0.38	8.27	1.57	0.19	0.37	35294	35076
Sowing date x Variety								
S_1 x V_1	3.31 b	3.22 b	24.40	23.73 a	4.25	4.13	3072 a	3035 a
S_1 x V_2	3.60 b	3.68 b	18.06	16.95 b	3.01	3.19	2585 b	2548 b
S_2 x V_1	3.44 b	3.64 b	14.84	13.11 c	3.84	3.98	2616 b	2579 b
S_2 x V_2	5.46 a	5.42 a	11.93	10.66 d	2.97	3.00	1761 c	1724 c
LSD (p=0.05)	0.81	0.79	NS	1.64	NS	NS	245.8	245.1
MSE	0.38	0.38	8.27	1.57	0.19	0.37	35294	35076
Nitrogen rate (kg ha^{-1}) (N)								
115 (N_1)	3.51 b	3.51 b	15.35 b	13.93 c	3.54	3.56	2016 b	1979 b
145 (N_2)	3.90 b	3.90 b	17.65 a	16.33 b	3.49	3.54	2833 a	2797 a
175 (N_3)	4.45 a	4.56 a	18.93 a	18.08 a	3.51	3.62	2677 a	2640 a
LSD (p=0.05)	0.40	0.43	2.01	1.54	NS	NS	393.3	393.1
MSE	0.21	0.24	5.43	3.19	0.11	1.14	206544	206358
S x N, V x N, S x V x N,				NS				

Means not sharing a letter in common within a column differ significantly at 5% probability level. NS= Non-significant; **MB:** Number of monopodial branches per plant, **SB:** Number of sympodial branches per plant, **BW:** Average boll weight per plant (g) , **SCY**: Seed cotton yield kg ha^{-1}, **MSE:** Mean squares of error

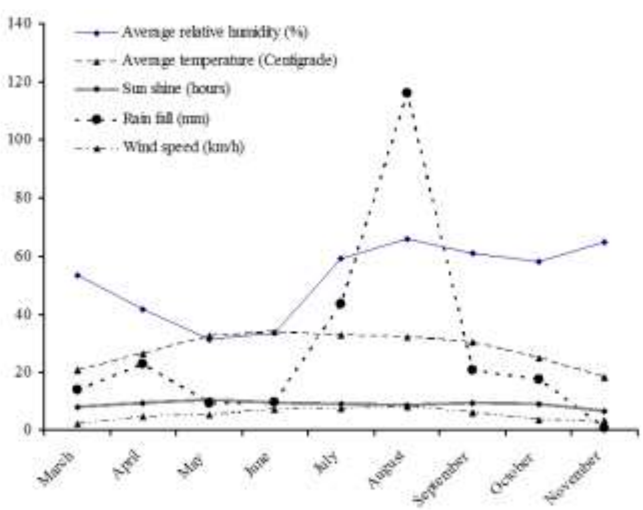

Figure 1: Weather conditions during cotton crop growth period (2009)

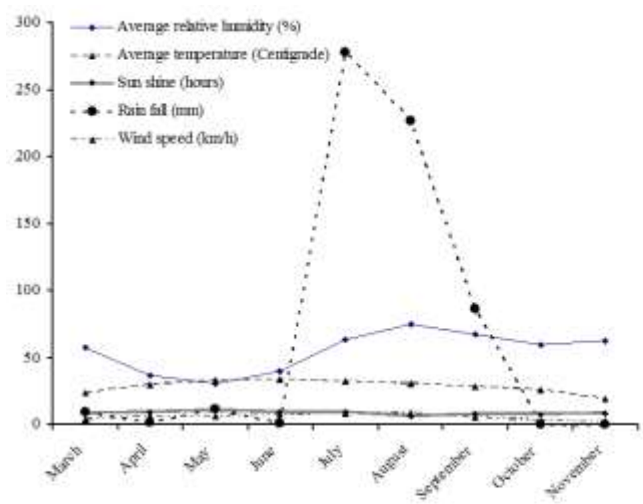

Figure 2: Weather conditions during cotton crop growth period (2010)

Yield and yield components

More number of monopodial branches per plant was produced in early sowing than late sowing (Butter *et al*., 2004) and with higher nitrogen levels (Kumbhar *et al*., 2008). Less number of sympodial branches per plant was recorded in late sowing (El-Shahawy, 1999). Average boll weight was significantly affected by cultivars (Afiah and Ghoneim, 1999) and nitrogen application rate (Ram *et al*., 2001). Our results are supported by the earlier findings that seed cotton yield per hectare was decreased as a result of N application above an optimum level (Howard *et al*., 2000) or with delay in sowing (Ali *et al*., 2004).

Conclusion

Higher seed cotton yield with optimum earliness can be achieved by applying 145 kg N ha^{-1}. Planted earlier (March) or late (May), Bt cotton performed better than non Bt cultivar.

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