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RESEARCH ARTICLE

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Physiological basis for growth and yield variation in Bt and non Bt cotton hybrids

K.N. PAWAR, B.C. PATIL AND PRAKASH KOLER

ABSTRACT

A field experiment was conducted under rainfed condition at Agriculture Research Station, Dharwad to compare the morpho physiological characters and yield potential of different Bt and non-Bt cotton hybrids. The experiment consisted of four Bt hybrids and their non Bt counter parts and one check hybrid laid out in a split plot design with two dates of sowing as a main plot and nine genotypes as subpots with three replication. There was no significant difference between the dates of sowing for many of the growth and yield. Among the Bt hybrids NHH-44 Bt produced significantly higher seed cotton yield (2256 kg ha^{-1}) and among non-Bt hybrids MRC-6322 non-Bt (1641 kg ha^{-1}). This was mainly attributed to its close association with number of bolls per plant and boll weight per plant. While Bt hybrids recorded less plant height, less LAI than non-Bt hybrids. Genotypes differed significantly in their growth pattern, morphological characters and phonological characters. Among the genotypes, non-Bt hybrids recorded more plant height, number of leaves and leaf area index compared to Bt cotton hybrids indicating their more vegetative growth. Bt hybrids matured five to eight days early compared to non-Bt hybrids. Bt hybrids recorded less boll damage than non-Bt hybrids.

KEY WORDS : Cotton, Bt, Non Bt , Date of sowing

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INTRODUCTION

Cotton is an important cash crop cultivated over an area of 34.2 m. ha in the country out of which 18 per cent area is under Bt cotton (Anonymous, 2006). India ranks first in the world cotton area and fourth in production of cotton. The productivity of cotton in the country is low (502 kg/ha) compared to other cotton growing countries. Moreover, cultivation of hybrids cotton has become a costly affair because of severe pest attack which has made it compulsory for indiscriminate use of pesticides and chemical fertilizers and thus polluting the entire agro ecosystem. The control of boll worms in cotton has become a psycho-socioeconomic tension of farmers and hence, there is a need to develop bollworm resistant varieties of hybrids.

The transgenic cotton containing cry genes responsible for crystalline, endotoxin of production in soil bacterium, *Bacillus theringenss.* var *kusrtaki* Berliner were transferred to cotton via. *Agrobacterium* with Ca MV 35S promoter (Umbeck *et al.,* 1987). Bt gene is harmful to the bollworm and the endotoxin produced by the bacteria has proved effective against lepidopteron insects. Bt cotton trials conducted at various places in India to know the yield potentiality of Bt as compared to non Bt hybrids have shown encouraging results and will be highly beneficial to the farmers (Khadi *et al.*, 2002). Studies on morpho-physiological character of Bt cotton are very less. Therefore, a study was under taken to evaluate the growth, phenology and yield of different Bt and non Bt cotton hybrids at two dates of sowing.

Correspondence to:
K.N. PAWAR, University of Agricultural Sciences, Agricultural Research Station, DHARWAD (KARANATAKA) INDIA

Authors' affiliations:
B.C. PATIL AND PRAKASH KOLER, University of Agricultural Sciences, Agricultural Research Station, DHARWAD (KARANATAKA) INDIA

MATERIALS AND METHODS

The experiment was laid out in split plot design, replicated three times on the medium black soil at Agriculture Research Station, Dharwad Farm (altitude of 678m, latitude of 15^0 26 N), Dharwad (Karnataka, India) during 2006-07 and 2007-08. The average annual rainfall of the location was 905.9 mm (2006-07) and 1086.7 mm (2007-08). Soil type was medium black with PH 8.0, EC. 0.33 dS/m. the treatment consisted of two dates sowing (main plots) and genotypes (subplots comprising of four Bt and their non Bt counter parts and one local check DHH-543). After the harvest of the previous crop, the

land was brought to a fine tilth. The fertilizer @ of 40 : 40 : 40 kg N, P_2O5 and K_2O, respectively were applied at the time of sowing. Cotton seeds were sown by hand dibbling with a spacing of 90 cm X 60 cm. A top dressing of 40kg N was given at 30 DAS. The plots were inter cultured twice after sowing and maintained weed free by hand weeding. The plant protection measures were taken throughout the crop growth period as per the recommended schedule.

The observation on different physiological parameters such as photosynthetic rate and water use efficiency (WUE) were made by LICOR-6400. The leaf area index was calculated at different growth stages by using plant canopy analyzer (LI-COR Inc, Lincon, NE, USA model LI-2000) and is defined as the assimilatory surface area per unit land area. The data were statistically analyzed as per Panse and Sukhatame (1967).

RESULTS AND DISCUSSION

The present experiment was conducted to know the different in Bt cotton hybrids with their non Bt counter parts. Four popular Bt hybrids and their non Bt forms including check hybrid DHH-543, were evaluated for 2 years, with 2 dates of sowing (normal sowing and late sowing by 20 days). The pooled data of 2 years showed significant difference between dates of sowing and genotypes (Table 1).

The mean data showed that among the genotypes NHH-44 (2063 kg/ha) recorded significantly more yield over non Bt check DHH-543 (1566 kg/ha). However, there was no significant difference between Bt hybrids. Between normal (D_1) sowing and late sowing (D_2), recorded significantly more yield (2291 kg/ha) in normal sowing (D_1) compared to late sowing (1570 kg/ha) (D_2).

Yield is the manifestation of various morphological, physiological, biophysical, biochemical and growth parameters in any crop. The genotypes may differ with respect to yield which could be attributed to both genetic and environmental factors. It is therefore, essential to evaluate Bt genotypes and non Bt genotypes for better yield potential suitable for rainfed farming. In general Bt

Table 1 : Yield components in Bt and non Bt cotton hybrids at two dates of sowing (Pooled 2006-07 and 2007-08)

Sr. No.	Genotypes	Yield			No of Bolls			Boll wt		
		Bt	Non Bt	Mean	Bt	Non Bt	Mean	Bt	Non Bt	Mean
D_1										
1	Bunny	2551	2049	2300	28.5	24	26.3	5.14	4.48	4.81
2	NHH-44	2629	2300	2465	35.4	29.2	32.3	4.71	4.26	4.49
3	MRC-6322	2568	1885	2227	32	25.1	28.6	5.69	5.38	5.54
4	RCH-2	2373	1969	2171	28	25	26.5	5.23	4.33	4.78
5	DHH-543	-	2115		-	28.2		-	4.63	
	Mean	2530	2063	2291	31	26.3	28.6	5.19	4.61	4.9
D_2										
1	Bunny	1713	1448	1581	28.2	25.2	26.7	4.9	4.57	4.74
2	NHH-44	1884	1527	1606	31.1	27.3	29.2	4.34	4.25	4.3
3	MRC-6322	1852	1398	1625	28.1	24.2	26.2	5.61	5.22	5.42
4	RCH-2	1581	1360	1471	31.3	26.1	28.7	5.09	4.65	4.87
5	DHH-543	-	1272		-	24		-	4.66	
	Mean	1707	1401	1570	29.7	25.4	27.5	4.98	4.67	4.83
Mean										
1	Bunny	2132	1749	1941	28.4	24.6	26.5	5.02	4.52	4.77
2	NHH-44	2256	1913	2084	33.3	28.3	30.8	4.52	4.25	4.39
3	MRC-6322	2210	1641	1926	30.1	24.7	27.4	5.65	5.3	5.48
4	RCH-2	1977	1665	1821	29.7	25.6	27.7	5.16	4.49	4.83
5	DHH-543	-	1566	-	-	26.1		-	4.64	
	Mean	2134	1707	1938	30.3	25.8	28.1	5.09	4.64	4.86
			S.E.±	C.D. (P=0.05)		S.E.±	C.D. (P=0.05)		S.E.±	C.D. (P=0.05)
	Dates		81.5	233.9		1.54	4.41		0.11	0.31
	Genotypes		164	470.7		1.51	4.33		0.15	0.42
	G x Same Date		189	542.4		2.2	6.31		0.16	0.45
	D x G		217.2	622.7		2.64	7.57		0.17	0.48

genotypes recorded higher seed cotton yield over non Bt genotypes. The higher seed cotton yield could be due to relatively higher biomass, better partitioning of assimilates towards reproductive structures and higher values of yield components. Buttar and Singh (2006) and also Weir *et al.* (1998) also reported higher seed cotton yield of Bt genotypes over their non Bt versions. Bt cotton hybrids produced increased seed cotton yield over their non Bt counter parts and check hybrids. Bt cotton hybrids recorded more than 10% increased seed cotton yield over non Bt and check hybrids (Anonymous, 2002).

The number of bolls per plant recorded at harvest is presented in Table 1. There was decrease mean in number of bolls per plant from 28 bolls to 26 bolls per plant as the date of sowing delayed. Among the genotypes NHH-44 recorded highest number of bolls per plant (30.8), while Bunny Bt recorded the least number of bolls per plant (26.5). Total number of bolls that cotton plant bears at maturity is an important yield component having the greatest effect on it, this character is greatly influenced both by environmental factors.

The boll weight per boll recorded at harvest is presented in Table 1. The boll weight differed significantly among the genotypes. The genotype MRC-6322 Bt recorded significantly more boll weight (5.69g) as compared to other genotypes. Bt hybrids recorded more boll weight as compared to non Bt. Hofs *et al.* (2006) also reported average boll weight was slightly higher in Bt cotton as result of better boll distribution, the bolls were concentrated at the plant base and the fruiting site.

The number of days to 50% squaring is presented in Table 2. In general early sowing (D_1) recorded 3 days early for on 50% squaring as compared to late sowing (D_2). There was no significant difference between dates of sowing on 50% flowering (Table 2). Among the genotypes Bt hybrids (79 days) flowered 7 days early as compared to non Bt (86 days). DHH-543, a non Bt hybrids took significantly more number of days to 50% flowering (85 days). The number of days to 50% boll opening is presented in Table 2. With delay in sowing the number of

Table 2 : Phenology in Bt and non Bt cotton hybrids at two dates of sowing (Pooled 2006-07 and 2007-08)

Sr. No.	Genotypes	50% squaring		50% flowering		50% boll opening	
		Bt	Non Bt	Bt	Non Bt	Bt	Non Bt
D_1							
1.	Bunny	57	62	80	88	129	133
2.	NHH-44	58	63	78	86	128	134
3.	MRC-6322	56	61	78	87	129	134
4.	RCH-2	55	61	79	86	126	132
5.	DHH-543	--	60	--	85	--	133
	Mean	56	61	78	86	128	133
D_2							
1.	Bunny	60	64	81	85	136	141
2.	NHH-44	59	62	80	84	137	141
3.	MRC-6322	61	64	80	86	137	141
4.	RCH-2	62	64	81	86	138	142
5.	DHH-543	--	62	--	85	--	139
	Mean	60	63	80	85	137	140
Mean							
1.	Bunny	58	63	80	87	132	137
2.	NHH-44	58	62	79	85	132	137
3.	MRC-6322	58	62	79	86	133	138
4.	RCH-2	58	62	80	86	132	137
5.	DHH-543	--	61	--	85	--	136
	Mean	58	62	79	86	132	137
		S.E.±	C.D. (P=0.05)	S.E.±	C.D. (P=0.05)	S.E.±	C.D. (P=0.05)
	Dates	0.10	0.60	0.30	1.90	0.42	2.52
	Genotypes	0.40	1.20	0.35	1.00	0.38	1.11
	G x Same Date	0.62	1.78	0.51	1.46	0.56	1.80
	D x G	0.61	1.75	0.58	1.66	0.59	1.69

days to 50% boll opening delayed by 8 days (137 days) as compared to normal sowing (132 days).

The genotype, RCH-2 Bt took less number of days for 50% boll opening as compared to other genotypes. Among the genotypes, Bt hybrids took relatively less number of days for 50 per cent squaring, 50 per cent boll opening and produced higher yield compared to non Bt hybrids. This was supported by the earlier studies of Ahlawat (1979), Fry (1985) and Yu and Huang (1990) who concluded that increased parentage of boll setting from earlier produced flowers increases the seed cotton yield. Thus earliness appear to have a distinct advantages under rainfed conduction, since early maturing genotypes were not prone to attack by boll worms and were exposed to less number of stress days compared to late maturing genotypes.

In general there was significant difference between dates of sowing, genotypes and their interaction for rate of photosynthesis Table 3. The rate of photosynthesis was more in D_1 [25.0 (µ mol Co_2 m^{-2} S^{-2})] compare to D_2 (23.76). The Bt cotton hybrids recorded significantly more rate of photosynthesis (26.16) compared to non Bt(23.95). Among the genotypes Bunny Bt recorded significantly more rate of photosynthesis (27.25) while RCH-2 non Bt recorded significantly less rate of photosynthesis (20.08).

There was significant difference between the dates of sowing, genotypes and their interaction. D_1 (2.93) recorded high LAI compared to D_2 (0.92) Bt hybrids recorded less LAI (1.77) than non Bt (2.07). The genotype NHH- 44 (2.25) recorded significantly more LAI while RCH-2 non Bt is the least LAI (1.83). In general non Bt genotypes recorded more LAI compared to Bt genotypes. But the yield was less in non Bt genotypes compared to Bt genotypes which may be due to competition between sink for photo assimilates thus leading to low yield.

The total chlorophyll content determines the photosynthetic capacity of the genotypes and influences the rate of photosynthesis, dry matter production and yield

Table 3 : Photosynthetic rate, LAI and SPAD reading in Bt and non Bt cotton hybrids at two dates of sowing (Pooled 2006-07 and 2007-08)

Sr. No.	Genotypes	Photosynthesis rate (µ mol CO_2 m^{-2} s^{-1})			Leaf area index			SPAD readings		
		Bt	Non Bt	Mean	Bt	Non Bt	Mean	Bt	Non Bt	Mean
D_1										
1	Bunny	27.96	26.26	27.11	2.72	2.95	38.63	38.63	39.77	39.20
2	NHH-44	26.45	24.03	25.24	3.30	3.42	39.73	39.73	41.10	40.42
3	MRC-6322	25.79	23.63	24.71	2.97	3.10	37.00	37.00	39.47	38.24
4	RCH-2	24.45	21.40	22.93	2.23	2.75	37.90	37.90	37.47	37.69
5	DHH-543	--	24.45	--	--	2.77	--	--	29.17	--
	Mean	26.16	23.95	25.00	2.81	3.00	2.93	38.32	37.40	38.88
D_2										
1	Bunny	26.54	20.03	23.29	0.50	1.17	0.84	34.80	35.70	35.25
2	NHH-44	26.07	23.64	24.86	0.92	1.08	1.00	35.10	36.20	35.65
3	MRC-6322	26.33	23.90	25.12	0.93	1.24	0.09	33.40	34.70	64.05
4	RCH-2	24.79	18.75	21.77	0.62	0.90	0.76	33.80	35.00	34.40
5	DHH-543	--	21.18	--	--	1.27	--	--	26.70	--
	Mean	25.03	21.50	23.76	0.74	1.13	0.92	34.28	33.66	34.84
Mean										
1	Bunny	27.25	23.15	25.20	1.61	2.06	1.84	36.72	37.74	37.23
2	NHH-44	26.26	23.84	25.05	2.11	2.25	2.18	37.42	38.65	38.04
3	MRC-6322	26.06	23.77	21.92	1.95	2.17	2.06	35.20	37.09	36.15
4	RCH-2	24.62	20.08	22.35	1.43	1.83	1.63	35.85	36.24	36.05
5	DHH-543	--	22.82	--	--	2.02	--	--	27.94	--
	Mean	26.04	22.73	24.38	1.77	2.07	1.93	36.30	35.53	36.86
		S.E.±	C.D. (P=0.05)		S.E.±	C.D. (P=0.05)		S.E.±	C.D. (P=0.05)	
	Dates	0.78	NS		0.07	0.43		0.60	3.15	
	Genotypes	1.16	NS		0.14	0.41		0.75	2.12	
	G x Same Date	1.64	NS		0.2	NS		1.15	3.30	
	D x G	1.74	5.01		0.2	0.58		1.21	3.45	

NS=Non-significant

(Krasichkova *et al.,* 1989).

The SPAD reading (representing the relative greenness or the chlorophyll content) differed significantly for dates of sowing. However, there was no significant difference between Bt and non Bt genotypes but non Bt genotypes recorded less SPAD reading (35.53) compared to Bt hybrids (36.53). Among the genotypes NHH-44 (38.65) recorded highest SPAD readings while DHH-543 (27.94) recorded least. In present study among the Bt and non Bt genotypes, Bt genotypes recorded more SPAD reading (Chlorophyll content) compared to non Bt genotypes. The genotypes having the higher chlorophyll content also had higher seed cotton yield indicating a positive association between chlorophyll content and seed cotton yield. These results are in agreement with the findings of Krasichkova *et al.* (1989).

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