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Productivity and profitability of Bt cotton (*Gossypium hirsutum*) under various plant geometry and fertilizer levels

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ABSTRACT

Field experiments were conducted for 3 years at Akola during *kharif* 2006-07 to 2008-09, to find out the impact of plant geometry and levels of N, P and K fertilization on performance of Bt cotton. From the pooled analysis of 3 years data, it was observed that 90 cm x 45 cm spacing recorded 50.5 and 17.7% higher seed cotton yield than 90 cm x 90 cm and 90 cm x 60 cm spacing, respectively. Wider spacing plants had more boll/plants (23.1) than closer spaced (20.8 bolls/plant). Application of 125% recommended dose of fertilizer/ha was at par with recommended dose of fertilizer (RDF) *i.e.* 50-25-25 kg N-P-K/ha and significantly higher than 75% RDF. Increase in yield was due to improvement in bolls/plant. There was increasing trend in N, M and R with increasing N, P and K levels. Monetary returns showed increasing trend with decreasing intra row spacing. Consequently spacing of 90cm x 45 cm and recommended dose of fertilizer of non Bt (50-25-25 kg N-P-K /ha) were found suitable for RCH-2 Bt cotton also under rainfed conditions.

***Key words**:* Economics, Fertilizer combination, Plant Population, Transgenic plants

Cotton crop assumes a place of special significance in Indian economy. India is the only country in the world, which grows four types of cultivated species of cotton. Presently the Bt cotton hybrids (*Gossypium hirsutum* L.) occupy about 80% of the area. *Gosyppium hirsutum* cotton hybrids have high yield potential along with better fibre properties compared to the diploid Asiatic cottons under rainfed as well as irrigated conditions. By introducing the Bt gene in *hirsutum* species for control of bollworms, Bt hybrids have become popular among farmers. Cotton is grown on different land holdings under rainfed situation on large area. Release of Bt cotton hybrids (2002) on commercial scale, marks the beginning of transgenic era in the country. In the span of 5 years the cotton production in the country has reached to 31 million bales with average productivity of 550 kg lint/ha (AICCIP 2008). James (2000) recorded 40% higher yield of Bt cotton hybrids over their non-Bt counterparts. Spacing of 120 cm x 90 cm and 90 cm x 60 cm were adopted for non-Bt cotton hybrids under irrigated and rainfed condition, respectively. Non-Bt cotton hybrids having the indeterminate growth habit, however, in Bt cotton vegetative growth is restricted due to 100% setting of fruiting bodies on the plant, which require closer spacing for better yield. Thus agronomic requirement like, plant density and fertilizer management may vary for Bt cottons. RCH-2 Bt cotton hybrid is the most popular among the farmers in central zone, especially in Maharashtra. In view of this the present study was conducted to find out suitable spacing and fertilizer needs for RCH-2 Bt cotton hybrid under rainfed conditions.

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MATERIALS AND METHODS

The field experiment was conducted at Cotton Research Unit of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola between 2006-07 and 2008-09 in the same field with changing site every year. The experimental soil contains 0.36% organic carbon, 142-9.69-296.2 kg/ha available N-P-K. The experiment consisted of 9 treatment combinations *viz.,* 3 spacings (90 cm × 90 cm, 90 cm × 60 cm and 90 cm × 45 cm) as main plot treatments and 3 fertilizer levels *i.e.*75% RDF, 100% recommended dose (RDF 50-25-25 kg N-P-K kg/ha) and 125% RDF as subplot treatments. Recommended spacing and fertilizer dose for non-Bt hybrids are 90 cm x 60 cm and 50-25-25 kg N-P-K/ha, respectively. While deciding the spacing and fertilizer levels lower and higher levels of both the factors were considered for comparison to recommended spacing and fertilizer dose. The experiment was laid out in a split plot design and replicated four times. The Bt cotton hybrid (RCH-2) was sown on 29 June, 2006, 5 July, 2007 and 3 July, 2008. The fertilizers were applied as per treatments

through urea, single super phosphate and muriate of potash for N, P and K, respectively. Half-N and full dose of P and K were applied as basal and remaining half N were applied at square formation stage. Necessary plant protection measures of systemic insecticides were applied for control of sucking pests. Total rainfall of 985.1 mm in 2006-07, 771 mm in 2007-08 and 528.2 mm in 2008-09 was received. Rainfall received during 2006-07 was 28.4% more than normal (762.2 mm) which resulted in higher yield of cotton. During 2008-09 rainfall was 30.7% less than normal.

RESULTS AND DISCUSSION

Growth parameters and yield attributes

Pooled data of 3 years (Table 1) indicated that plant height did not differ significantly with different spacings. Highest dry matter accumulation/plant (at 50% boll brusting) was recorded with wider spacing of 90 cm × 90 cm that was at par with 90 cm × 60 cm and was significantly superior to closer spacing of 90 cm × 45 cm. These results support the findings of Anand (2006). During the first year of study (2006-07) number of bolls were more in 90 cm × 90 cm (31.01) but differences among various spacing were not significant (Table 1). Higher values of number of bolls/plant (16.15) were found in wider spacing between two plants (90 cm × 90 cm) that was at par with 90 cm x 60 cm but was significantly superior to 90 cm × 45 cm spacing during 2007-08. Highest number of bolls/plant were recorded with 90 cm × 90 cm spacing (21.98) which was significantly more than 90 cm x 60 cm (18.45) and 90 cm × 45 cm in the third year of study. Pooled over years wider spaced plants (90 cm × 90 cm) recorded significantly more number of bolls/plant (20.8) than other two closer spacing. Differences between later two spacings were not significant. However, boll weight was not significantly influenced by plant geometry.

There was increasing trend in plant height with increase in NPK levels but differences between 125% RDF and 100% RDF were not significant. The 100% RDF and 75% RDF were statistically equal in plant height. Dry matter/plant was not significantly influenced by various N, P and K levels. Three years pooled data showed maximum number of bolls/plant with 125% RDF that being at par with RDF was found to be significantly superior to 75% RDF.

Seed cotton yield

In 2006-07, closer spaced (90 cm × 45 cm) cotton recorded significantly higher seed cotton yield than wider spaced (90 cm × 90 cm) and it was at par with 90 cm × 60 cm spacing (Table 2). In the second year of study, there was a significant increase in seed cotton yield with a decrease in intra-row spacing from 90 cm to 45 cm. Results were similar during 2008-09. Pooled data indicated that closer spacing of 90 cm × 45 cm recorded significantly higher seed cotton yield than wider spacing of 90 cm × 90 cm and 90 cm × 60 cm. This indicated that higher plant population in closer crop geometry gave higher yield even though less yield per plant. It was because of more bolls produces per unit area (Venugopalan and Blaise, 2001). Spacing of 90 cm × 60 cm was significantly superior to 90 cm × 90 cm spacing. There was an increase in net returns and B:C ratio with decreasing intra-row spacing from 90 cm to 45 cm. Increasing trend might be due to increasing trend in seed cotton yield with decreasing plant to plant spacings. Anand (2006) also observed increasing trend in returns with increasing plant density. Crop geometry × N-P-K levels interaction were not significant in respect of seed cotton yield (Table 3). Higher values of returns and

Table 1. Growth parameters and yield attributes as influenced by various treatments

Treatment	Plant height (cm)*	Dry matter (g/plant)*	Bolls/ plant				Boll weight (g)*
			2006-07	2007-08	2008-09	Mean	
Spacing (*population/ha*)							
90 cm x 90 cm (12,346)	82.1	99.6	31.01	16.15	21.98	23.10	3.0
90 cm x 60 cm (18,518)	83.5	95.4	27.93	15.92	18.45	20.80	2.9
90 cm x 45 cm (24,619)	82.5	89.4	27.35	14.32	16.88	19.50	2.9
SEm ±	1.1	1.5	0.90	0.36	0.73	0.37	0.1
CD (P=0.05)	NS	5.1	NS	1.26	2.54	1.27	NS
N-P-K level (kg/ha)							
37.5 + 18.75 + 18.75	80.7	94.4	27.75	14.40	17.48	19.90	2.9
50 + 25 + 25 (RDF)	82.6	94.3	28.75	15.78	19.46	21.30	2.9
62.5 + 31.25 + 31.25	84.3	95.7	29.80	16.20	20.36	22.10	3.0
SEm ±	1.3	1.5	0.61	0.66	0.68	0.39	0.1
CD (P=0.05)	3.3	NS	NS	NS	2.03	1.17	NS

*Mean data of 3 years.

B:C ratio were found with maximum plant density might be due to higher seed cotton yield.

In the first year of experimentation application of 125% RDF recorded significantly higher seed cotton yield than 75% RDF but it was at par with RDF. Similar type of results were also observed in second and third year of experimentation and in pooled analysis of 3 years data. These results indicated that Bt cotton hybrid did not require higher fertilizer dose than non-Bt cotton .The above findings are in accordance to the results reported by Hulihalli and Patil (2006). There was increasing trend in returns and B:C ratio with increasing NPK levels from 75% to 125 % RDF. Increasing trend in net returns and B:C ratio might be due to increased seed cotton yield with

Table 2. Seed cotton yield, net monetary returns and B:C ratio as influenced by planting geometry and fertilizer levels

Treatment	Seed cotton yield (kg/ha)			Mean (kg/ha)	Stalk yield (kg/ha)	Net returns (Rs/ha)	Net B:C ratio
	2006-07	2007-08	2008-09				
Spacing (*Plant population*)							
90 cm x 90 cm (12,346)	950	467	639	685	1,121	441	0.03
90 cm x 60 cm (18,518)	1,132	553	942	876	1,665	1,974	0.11
90 cm x 45 cm (24,619)	1,210	821	1,063	1,031	2,100	4,240	0.22
SEm±	26	19	17	38			
CD (P=0.05)	90	65	58	113			
NPK level (*kg/ha*)							
37.5 + 18.75 + 18.75	1,033	551	812	798	1,630	1,001	0.06
50 + 25 + 25 (RDF)	1,109	611	900	873	1,606	2,125	0.12
62.5 + 31.25 + 31.25	1,149	649	932	910	1,650	2,529	0.14
SEm ±	22	11	21	23			
CD (P=0.05)	64	33	61	68			

Price: Seed cotton: Rs 23,000/tonne (2006-07), 30,000/tonne (2007-08 and 2008-09); Stalk: Rs.500/tonne; N: Rs 10.87/kg; P: Rs 24.62/kg and K: Rs 7.67/kg.

Table 3. Seed cotton yield as affected by spacing and fertilizer levels

Spacing	Fertilizer levels											
	2006-07			2007-08			2008-09			Pooled		
	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3
90 cm × 90 cm (12,346)	916	937	991	438	484	478	591	648	679	648	690	716
90 cm × 60 cm (18,518)	1,069	1,154	1,172	484	584	626	837	980	1,011	797	906	936
90 cm × 45 cm (24,619)	1,110	1,237	1,283	757	834	872	1,010	1,073	1,110	959	1,048	1,088
SEm ±		52			19			36			36	
CD (P=0.05)		NS			NS			NS			NS	

F_1: 75% RDF; F_2: RDF; F_3: 125% RDF

Table 4. Biological yield, harvest index and nutrient uptake (kg/ha) as influenced by planting geometry and fertilizer levels

Treatment	N	P	K	Biologicalyield (kg/ha)	Harvest index
Spacing (*Plant population*)					
90 cm x 90 cm (12,346)	43.5	14.3	46.1	1,795	37.56
90 cm x 60 cm (18,518)	46.1	18.1	50.5	2,541	34.43
90 cm x 45 cm (24,619)	54.6	22.1	58.5	3,132	32.91
SEm ±	0.6	0.2	0.8		
CD (P=0.05)	1.9	0.8	2.8		
NPK level (kg/ha)					
37.5 + 18.75 + 18.75	43.8	17.7	49.0	2,428	33.33
50 + 25 + 25 (RDF)	50.0	18.3	52.8	2,479	35.65
62.5+ 31.25 + 31.25	50.3	18.5	53.2	2,560	35.62
SEm ±	0.6	0.2	0.5		
CD (P=0.05)	1.8	0.5	1.5		

increasing NPK levels.

Nutrient uptake

Higher plant population (90 cm × 45 cm) recorded significantly higher total N, P and K uptake than 90 cm × 60 cm and 90 cm × 90 cm spacing. Lower plant population under 90 cm × 90 cm had the least uptake because of lower biomass accumulation (Table 4). Anand (2006) also reported increased trend in nutrient uptake with increasing plant density of cotton.

Application of 125% RDF showed maximum uptake of N being at par with RDF but significantly superior over 75% RDF. In respect of P uptake 125 and 100% RDF were statically equal but both the levels were significantly superior over 75% RDF. Similar type of trend was also observed in K uptake.

It is concluded that a spacing of 90 cm x 45 cm and recommended dose of fertilizer of non-Bt (50-25-25 kg N-P-K/ha) were found suitable for RCH-2 Bt cotton also under rainfed conditions of Akola, Maharashtra.

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